Physical Activity and Osteoarthritis;

Fostering Autonomous Motivation and Self-Efficacy

via a Digital Intervention

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Abstract

Osteoarthritis (OA) is a chronic musculoskeletal disease affecting approximately 8.75 million people in the UK alone. Symptoms include pain, joint stiffness, and muscle weakness, as well as psychological and emotional limitations such as depression and anxiety. Physical activity (PA) is recommended as a core treatment irrespective of disease severity, pain and function, yet nearly half of people with OA report doing no PA at all. Low-cost, accessible, and user-friendly interventions are needed to motivate people with OA to become and stay active over the long-term. Digital behaviour change interventions (DBCIs) might offer an opportunity to support people with OA to self-manage, and monitor their own levels of PA.

A pragmatic, sequential explanatory mixed methods design was adopted to develop and test a DBCI to motivate people with OA to become and stay active. Four phases of research were undertaken: A systematic literature review assessed the effectiveness of existing digital interventions; a survey and secondary data analysis explored beliefs and motives for PA in this population; a design and production phase adopted the intervention mapping approach to develop a prototype website; and a testing phase utilised interviews and a think-aloud approach to explore acceptability and usability with potential users.

The systematic literature review revealed that existing DBCIs provided small, positive outcomes for increasing PA in this population. The survey and secondary data analysis showed that higher levels of both self-efficacy and more autonomous forms of motivation were associated with higher levels of PA. Use of the intervention mapping approach enabled the development of a prototype website to be illustrated in a clear and transparent way, showing a clear link between the practical materials adopted within the website and the theoretical constructs they were attempting to change. Interviews and think-aloud sessions explored attitudes, values, and the perceived effectiveness of the website, and potential users highlighted the importance of clear, easy to understand information, focusing on enjoyment, and the importance of social connectedness. These findings highlight the potential that DBCIs have to engage people with OA to become and stay active. A greater utilisation of such interventions would take pressure off scarce NHS resources. It illustrates the value of identifying motivational factors associated

with engagement in PA and describes how these findings can be used to build the theoretical foundations of a DBCI. Future development of similar interventions should be based on theory, adequately described, and thoroughly tested with potential users to further understand how they might integrate the use of a digital intervention into their everyday lives.

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List of Abbreviations

ACR	American College of Rheumatology
ARUK	Arthritis Research UK (Now 'Versus Arthritis' from 2018)
ASES	Arthritis Self-Efficacy Scale
ASMP	Arthritis Self-Management Programme
BCT	Behaviour Change Technique
BCTTv1	Behaviour Change Technique Taxonomy V1
BCW	Behaviour Change Wheel
BIT	Behavioural Intervention Technology Model
cRCT	Cluster Randomised Controlled Trial
CDSMP	Chronic Disease Self-management Programme
DBCI	Digital Behaviour Change Intervention
DOB	Date of Birth
EMI-2	Exercise Motivations Inventory
EMGI	Exercise Motives and Gains Inventory
ESE	Exercise Self-Efficacy Scale
EULAR	European League against Rheumatism
HAPA	Health Action Process Approach model
HCI	Human-Computer Interaction
IM	Intervention Mapping
KOOS	Knee Injury and Osteoarthritis Outcome Score
MET	Metabolic equivalent of task
MPAM-R	Motivation for Physical Activity Measure
MRC	Medical Research Council
MSK	Musculoskeletal
MVPA	Moderate to vigorous physical activity
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NIHR	National Institute for Health Research
OA	Osteoarthritis
PA	Physical Activity

PAM	Physical Activity Maintenance model
PASE	Physical Activity Scale for the Elderly
PIP	Patient Insight Partner
RCT	Randomised Controlled Trial
SCT	Social Cognitive Theory
SDT	Self Determination Theory
SE	Self-Efficacy
SQUASH	Short Questionnaire to Assess Health-enhancing PA
SUS	System Usability Scale
TA	Thematic Analysis
TFA	Theoretical Framework of Acceptability
TPB	Theory of Planned Behaviour
TTM	Transtheoretical Model
UK	United Kingdom
UWE	University of the West of England
VAS	Visual analogue scale
WHO	World Health Organisation
WOMAC	Western Ontario and McMaster Universities Arthritis Index

Chapter 1: Introduction

1.1 Overview

This chapter introduces osteoarthritis, the impact that it can have on everyday life, and management options for the condition. The benefits of physical activity (PA) for osteoarthritis (OA) are described and the determinants of PA behaviour explored. An overview of the design, aims and objectives, and structure of the thesis is then presented.

1.1.1 Definition and Impact of Osteoarthritis

OA is a musculoskeletal condition that causes joint pain, functional limitations and reduced quality of life. It is the most common form of arthritis, affecting approximately 8.75 million people in the UK (Arthritis Research UK, 2018), and is one of the leading causes of pain and disability worldwide (NICE, 2014). It can affect any joint in the body; but the knee, hip and joints in the hand are most commonly affected. Patients present with a range of physical impairments such as pain, joint stiffness, and muscle weakness, as well as psychological and emotional limitations such as depression, anxiety and low self-confidence (Bennell, Dobson and Hinman, 2014; Hurley *et al*, 2010).

More women than men are affected by the condition, and the risk of developing OA increases with age. A third of women and nearly a quarter of men between 45 and 64 have sought treatment for OA, and this rises to almost half of people aged 75 and over (Arthritis Research UK, 2013). The economic burden of OA is vast, with estimated figures from 2010 indicating that OA cost the UK economy around £16.8 billion in direct (formal medical care) and indirect (lost working days, informal care) costs (Arthritis Research UK, 2017).

Contrary to popular belief, OA is not caused by ageing and does not necessarily deteriorate over time (NICE, 2014). It results from a combination of the breakdown of the joint and the body's attempted repair processes (Arthritis Research UK, 2018). It is

characterised pathologically by localised loss of cartilage, remodelling of adjacent bone, and associated inflammation (NICE, 2014). There is often extreme variability in clinical presentation and outcomes that can be observed between people, as well as a poor link between changes visible on X-ray and symptoms: minimal changes can be associated with a lot of pain, or modest structural changes can occur with minimal accompanying symptoms (NICE, 2014).

OA can be diagnosed clinically (without further investigations) if a person is:

- 45 or over **and**
- has activity-related joint pain **and**
- has either no morning joint-related stiffness or morning stiffness that lasts no longer than 30 minutes.

(NICE, 2014)

The wider impact that OA can have on a person's day to day life can be significant, affecting their independence, family and work life, and emotional well-being (ArthritisCare, 2012). At least four out of five people with OA have at least one other long-term condition such as hypertension or cardiovascular disease. The pain and functional limitations associated with OA can make it harder to cope with multimorbidity, which in turn can cause fatigue and depression (Arthritis Research UK, 2017).

There are a number of effective management and treatment options for controlling the symptoms of OA and these are discussed in more detail in the next section.

1.1.2 Management of Osteoarthritis

The management of OA is generally carried out within primary care, and consists of interventions aimed at pain management with simple analgesia, and maximising function and enhancing quality of life through non-pharmacological approaches (Dutta, Sharma and Abbott, 2018). Most people who receive interventions for their OA are either managed by their GP (pharmacological) or physiotherapists (non-pharmacological approaches), with treatment generally consisting of: exercise with or without self-management interventions; manual therapy, including joint mobilization and

manipulation; and transcutaneous electrical neuromuscular facilitation (Walsh, Pearson and Healey, 2017).

PA and exercise for osteoarthritis is discussed in more detail in section 1.2.

1.1.3 Self-management of Osteoarthritis

The importance of engaging individuals to self-manage their own condition is becoming recognised as a valuable tool to change behaviour. Self-management can be defined as 'an individual's ability to manage the symptoms, treatment, physical and psychosocial consequences and lifestyle changes inherent in living with a chronic condition' (Barlow *et al.*, 2002, p178). Empowering people with long-term conditions means giving them support to manage their own health, to make healthy choices, avoid complications, and above all recognising that they are experts in their own condition (McDonald, 2014; NHS England, 2014).

There is a growing body of evidence showing that when compared to standard care, self-management approaches can provide benefits to participants particularly in terms of knowledge, performance of self-management behaviours, and self-efficacy (confidence in one's ability to carry out a behaviour) (Barlo*w et al*, 2002).

Within treatment guidance specifically for people with OA, individualised self-management strategies are encouraged, and an emphasis is placed on the importance of incorporating exercise and PA into any self-management programmes (NICE, 2017). The literature on self-management in arthritis is dominated by the Arthritis Self-Management Programme (ASMP) (Lorig, Ritter and Plant, 2005). Designed as a community-based, group approach led by lay tutors and accompanied by a manual for participants and tutors, it has shown consistent improvements on knowledge, self-efficacy, and the use of self-management behaviours (Barlow *et al.*, 2002).

The ASMP has been tested in different settings (such as via mail and on the internet) over a number of years (Lorig et al, 2008). Despite positive outcomes being reported for reduction of fatigue, pain, and increased self-efficacy, there have been mixed outcomes for increasing levels of PA. Improvements in levels of exercise were seen at 4 months in one study (Lorig, Ritter and Plant, 2005) however, significant improvements were only maintained for stretching/strengthening exercises at 12 months, and not aerobic

exercise. A further study evaluated the effectiveness of an internet-based version of the ASMP and showed positive outcomes for health indicators including health distress, activity limitation, self-reported global health, and pain. However, health behaviours including levels of PA were not significantly improved (Lorig *et al*, 2008b).

Enthusiasm is growing for the role of self-management programmes in managing chronic musculoskeletal pain conditions. A systematic review of the effectiveness of existing self-management programmes on pain and disability for chronic musculoskeletal pain found small to moderate effects in improving pain and disability at the long-term level (Du *et al*, 2011). Self-management is a safe and effective way for patients with arthritis to manage pain and disability, and core skills of self-management should be delivered using multiple approaches (Du *et al.*, 2011).

Further investigations should explore the most appropriate and effective components of self-management interventions, including documentation of techniques employed, and mapping content against recognised behaviour change taxonomies (Michie *et al.*, 2013). This will allow for better implementation into practice (Walsh, Pearson and Healey, 2017), and could also produce more effective longer-term engagement with healthy behaviours.

1.2 Physical Activity and Osteoarthritis

Guidelines from Arthritis Research UK (ARUK), the American College of Rheumatology (ACR), the European League Against Rheumatism (EULAR), and the World Health Organisation (WHO) all support the effectiveness, feasibility, and safety of PA for OA, recommending that PA should be an integral part of standard care (Arthritis Research UK, 2018; Hochberg *et al*, 2012; Rausch Osthoff *et al*, 2018; Walsh, Pearson and Healey, 2017). More specifically, management guidelines for lower limb OA exclusively recommend exercise as the most effective intervention, resulting in clinically meaningful outcomes for pain and function (Walsh, Pearson and Healey, 2017). In general, a combination of strengthening exercises with exercise aimed at increasing flexibility and aerobic capacity appears to the 'best' exercise option for people with OA (Rausch Osthoff *et al.*, 2018; Walsh, Pearson and Healey, 2017).

Despite PA and exercise being recommended as a core treatment for OA, irrespective of disease severity, pain levels, functional status, and comorbidities (Bennell, Dobson and Hinman, 2014; NICE, 2014), 44% of people with OA report doing no activity at all (ArthritisCare, 2012). The majority of these patients do not receive the correct support or encouragement to be physically active; low-cost, effective and accessible PA interventions are needed (Foster et al., 2013). Given the evidence for effectiveness, feasibility and safety, PA should be an integral part of standard care for people with OA (Rausch Osthof*f et al*, 2018).

1.2.1 Definition of Physical Activity and Exercise

PA and exercise can be defined in a number of ways, and the terms are often used interchangeably. For the purposes of this thesis it was considered important to define the terms, therefore the definitions below were adopted.

Throughout this thesis, PA is defined as:

'Any bodily movement produced by skeletal muscles that requires energy expenditure, and includes all forms of activity, such as everyday walking or cycling to get from A to B, work-related activity, active recreational activities (such as going to the gym), dancing, gardening or playing active games, as well as organised and competitive sport.'

(Caspersen and Christenson, 1985, p126; Department of Health, 2011, p9)

Exercise is viewed as a sub-category of PA, and defined as:

'A subcategory of PA that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective.'

(Caspersen and Christenson, 1985, p126)

The definitions above illustrate how the term 'physical activity' encompasses 'exercise'. Therefore, within this thesis the single term 'physical activity' is adopted, to cover all possible forms of activity, including exercise.

1.2.2 Determinants of Physical Activity

It is widely recognised that a complex array of factors influence a person's decision to commence and maintain participation in PA (Bennell and Hinman, 2011). Multiple studies have explored the determinants of PA in people with arthritis (Gyurcsik *et al.*, 2009; Holden *et al.*, 2012; Stubbs, Hurley & Smith, 2015) with a number of personal, social and environmental factors reported.

Determinants reported to have an effect on levels of PA in the OA population include: social support, self-efficacy (self-confidence), beliefs, past experience, knowledge and attitudes about PA, barriers (such as lack of time), PA skills, levels of pain, and level of motivation (Damush *et al.*, 2005; Hurley *et al.*, 2018; Kanavaki *et al.*, 2017; Peeters, Brown and Burton, 2014).

To help individuals maintain more active lifestyles, interventions are required that assess and address an individual's barriers and facilitators to PA, and are adaptable to suit their own needs and preferences (Holden et al., 2012). Interventions which enhance self-efficacy, social support, and skills in the long-term monitoring of progress have been recommended to foster exercise and PA adherence in OA (Marks and Allegrante, 2005).

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1.2.2.1 Motivation for PA in OA

Key psychological factors such as motivation and self-efficacy (the extent to which a person believes they are capable of carrying out a certain behaviour) are considered to be crucial factors in sustaining engagement with PA, which in turn is associated with important health outcomes (Teixeira *et al.*, 2012). A number of psychological theories have been used to understand the role that motivation has on the adoption of and adherence to behaviours such as PA.

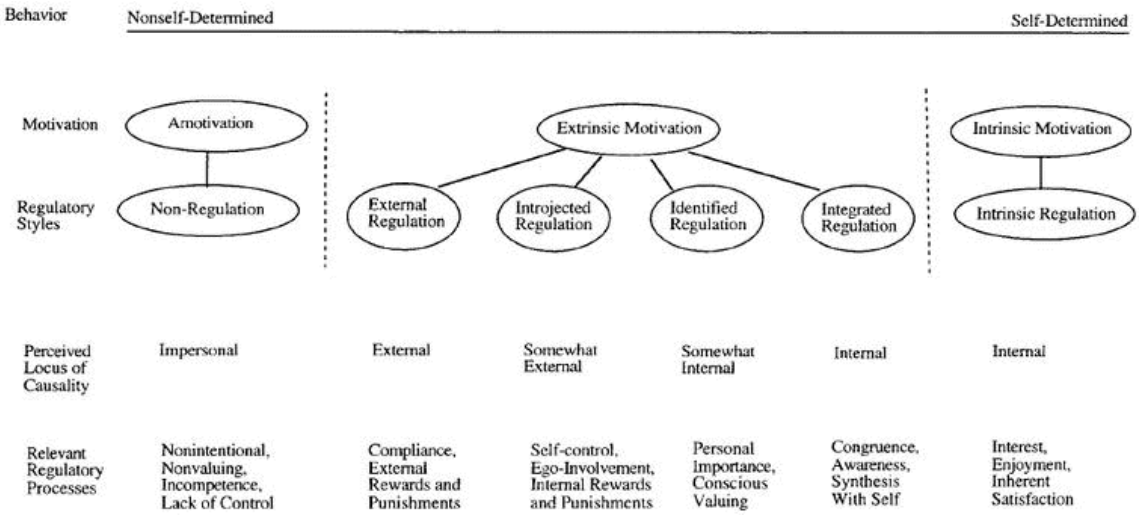
An example is Self-Determination Theory (SDT), a motivational theory that has received significant research attention and support in predicting PA as well as in the development of PA interventions (Fortier *et al.*, 2012). SDT draws a distinction between intrinsic motivation (engaging in a behaviour for its own sake i.e. for enjoyment), and extrinsic forms of motivation (doing an activity because of external reward), SDT maintains that an understanding of motivation requires a consideration of three innate psychological needs, that when satisfied yield enhanced motivation;

- Autonomy: Being fully engaged and feeling in control of one's actions
- Relatedness: Being connected and valued by others
- Competence: Having a mastery over one's actions, being competent.

(Deci and Ryan, 2000)

SDT posits that by using behaviour change techniques that satisfy all three needs, motivation will be sustained over a longer period of time. A continuum of motivation is used to describe the degree to which an individual is motivated, varying from extrinsic (controlled), to intrinsic (autonomous) as shown in figure 1-1 below. A systematic review of 66 empirical studies found a consistent association between autonomous motivation and PA (Teixeira *et al.*, 2012).

Figure 1-1: The Self-determination continuum , *(Ryan and Deci, 2000, permission not required - American Psychology Association)*



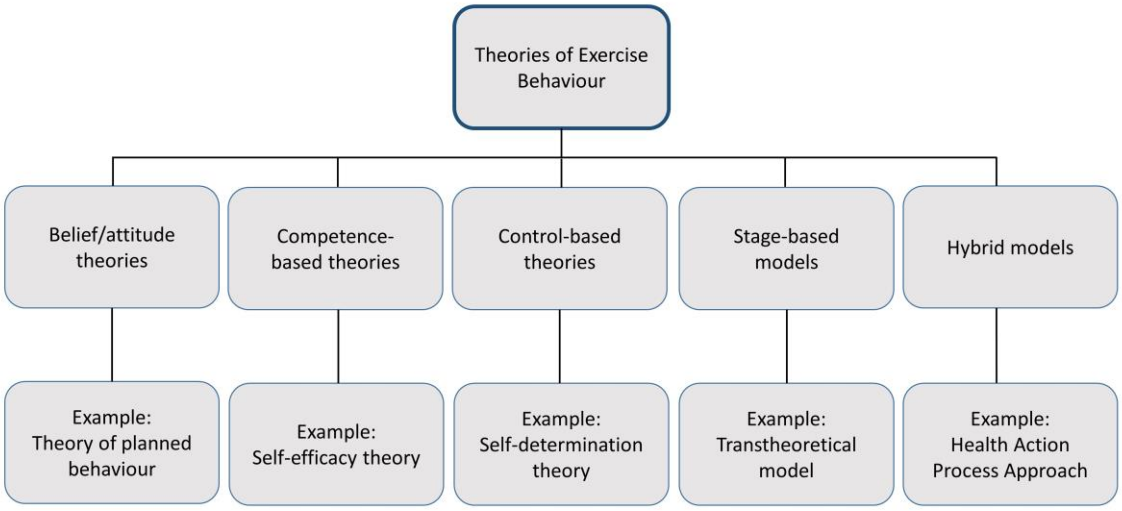
1.2.2.2 Self-efficacy for PA in OA

Whilst motivation is often seen as a crucial factor in affecting levels of PA, research has also focused on the impact of self-efficacy (Brosseau *et al.*, 2014; Gecht *et al.*, 1996; Gyurcsik *et al.*, 2009; Jackson, 2010; Olander *et al.*, 2013; Marks, 2014). First described in 1977 by Bandura, self-efficacy is the extent to which one believes they will be successful in carrying out certain behaviours such as PA. Gecht et al (1996) studied the influence of beliefs on exercise participation among people with arthritis and demonstrated that the higher one's self-efficacy for exercise, the greater the frequency and intensity of exercise participation (Gecht *et al.*, 1996). Furthermore, Marks (2014) conducted a review of the impact of self-efficacy in arthritis management, and found a consistent link between increased self-efficacy and reduced self-reported pain, disability and adherence to PA (Marks, 2014).

1.3 Behaviour Change Theories for physical activity in OA

A number of behaviour change theories and models have incorporated the constructs described above, in an attempt to explain behaviours associated with PA, and are categorised by Biddle and Mutrie (2007) in figure 1-2 below:

Figure 1-2: A Framework for classifying theories of physical activity
(Biddle and Mutrie, 2008, by permission of Routledge (Taylor and Francis Group))



Central to the Theory of Planned Behaviour (TPB), first described by Ajzen (1991) is the concept that the performance of any behaviour is determined by a combination of intention and control (Cashmore, 2008). TPB can be summarised into three sections: intention to perform; attitudes; and perceived behavioural control. Behavioural intention can be viewed as a central determinant of voluntary behaviour, with research assessing the effects of intention on exercise finding a strong, positive relationship between intention and overall levels of PA (Buckworth and Dishman, 2002).

In Social Cognitive Theory (SCT) (relating to 'self-efficacy theory' in figure 1-2 above) (Bandura, 1986) behaviour is determined by three factors: goals, outcome expectations, and self-efficacy. In this instance, goals are defined as plans to act, outcome expectations are beliefs about the perceived different outcomes of the behaviour, and self-efficacy is the confidence one has to carry out the behaviour (Prestwich, Kenworthy and Conner, 2018). The key construct within SCT is self-efficacy, and this important behavioural constructs is discussed in detail in Chapter 3, section 3.2.2.

As described in 1.2.2.1, Self-determination theory (SDT) hypothesises that the attainment of intrinsic life goals (doing something just for fun, or to learn new skills etc.) is associated with enhanced well-being, whereas the attainment of extrinsic life goals (performing an activity solely to achieve a desirable outcome such as weight loss) appears to have little effect on improving well-being (Deci and Ryan, 2000). SDT is discussed in more detail in Chapter 3, section 3.2.1.

The Transtheoretical Model (TTM) is a popular stage-based theory which proposes five distinct stages of behaviour change, including: pre-contemplation; contemplation; preparation; action; and maintenance (Prestwich, Kenworthy and Conner, 2018).

The Health Action Process Approach (HAPA) model (Schwarzer, 1992) incorporates coping and action planning, in an attempt to bridge the gap between intention and behaviour. It is a hybrid model sitting between stage- and non-stage models, and utilises three types of self-efficacy (task, copying and recovery) that predominate at different stages of the behaviour change process (Prestwich, Kenworthy and Conner, 2018).

The overview above illustrates how a number of theoretical models have been developed in an attempt to explain behaviour change, and that similarities exist between each of them such as the focus on regulating behaviour, building confidence (self-efficacy), and planning.

Theory can provide a framework within which to test hypotheses, and to identify constructs that influence behaviour, thereby providing evidence about which techniques should be incorporated into behavioural interventions (Prestwich, Webb and Conner, 2015). Theory can inform intervention development, and in return, interventions can test and refine the underlying theory, illustrating the reciprocal relationship between theory and interventions (Prestwich, Webb and Conner, 2015).

Despite it being recognised that health interventions are likely to be more effective if they target the causal determinants of behaviour (Michie *et al.*, 2008), a recent review of 190 PA and dietary interventions found that only 50% were based on theory. Furthermore, theory was rarely used to develop or evaluate the interventions, resulting in any links between intervention design and intervention effectiveness being poorly understood (Prestwich *et al.*, 2014).

1.3.1 Behaviour Change vs. Behaviour Maintenance

Interventions that target new PA habits often result in impressive rates of initial behaviour changes, but frequently are not translated into long-term adherence (Rothman, 2000). Systematic reviews reveal that the majority of literature on PA interventions only observe behaviour change over a short period of time, with very few assessing changes for longer than 12 months (Fjeldsoe et al, 2011; Marks and Allegrante, 2005).

The issue of maintenance of behaviour change is not receiving the attention it should. Reasons for this might potentially be due to a lack of research attention, or the fact that available funding for intervention research often does not allow sufficient resources or time to conduct extended post-intervention follow-up assessments (Fjeldsoe *et al.*, 2011).

A recent systematic review (Kwasnicka *et al.*, 2016) explored theoretical models most closely linked to behaviour maintenance, and reported that theoretical explanations of behaviour change maintenance focused on: the differential nature and role of motives; self-regulation; resources (psychological and physical); habits; and environmental and social influences. Commonly identified theoretical models most relevant to maintenance were the TTM, HAPA, SCT and SDT (all described in section 1.3 above). These theories typically include constructs that play important roles in behaviour maintenance including habits, satisfaction with the outcomes of behaviour and supportive environments (Prestwich, Kenworthy and Conner, 2018).

To better understand the independent effect of individual programme components and theoretical constructs adopted within interventions, longer term studies, with at least one year follow-up, are required (Foster *et al.*, 2013). Further research is also needed to determine how to facilitate long-term engagement with PA and exercise in the OA population, to sustain the beneficial effects on pain, function and quality of life (Walsh, Pearson and Healey, 2017).

More specifically, studies which investigate packages of care, combining interventions, require further investigation (Walsh, Pearson and Healey, 2017). One possible solution for improving long-term adherence to PA might be the initial use of supervised treatment by an appropriately qualified exercise practitioner, followed later by an internet facilitated self-management programme (Bennell and Hinman, 2011). Taking part in a face-to-face intervention allows participants to gain first-hand experience of what exercises to do, to learn that exercise is not harmful, that exercise can reduce pain and improve levels of physical function, as well as encourage positive health beliefs and increased self-efficacy (Hurley *et al.*, 2010). A supporting digital intervention holds the potential to encourage ongoing use of skills developed during a face-to-face intervention, as well as helping to develop autonomous motivation and increased self-efficacy for PA over the long term.

1.4 The use of technology to facilitate engagement with PA in OA

Interventions using digital technology to foster and support behaviour change are increasingly being adopted in the self-management of chronic diseases, and have been heralded as potentially revolutionising the ways in which individuals can monitor and improve their health behaviours, improving outcomes and reducing costs (Michie *et al.*, 2017). Such interventions are able to reach large populations, with minimal burden on scarce health resources (Barak, Klein and Proudfoot, 2009). Consistent evidence has supported the effectiveness of remote and digital interventions for promoting PA (Foster *et al.*, 2013), and digital interventions which have made greater use of theory have been found to be more effective in a review of internet-based health behaviour change interventions (Webb *et al.*, 2010).

However, developing and evaluating digital interventions presents new challenges (Michie *et al.*, 2017). Literature has reported high attrition in studies exploring digital interventions for chronic disease self-management in older adults, highlighting the need for more research to determine whether the long-term effectiveness of such programmes are sustainable, especially among larger, more diverse samples of patients (Stellefson *et al*, 2013).

The potential for digital interventions is clear, but success is dependent on acceptability and usability of the intervention in the intended population *(*Martorella, Gélinas and Purden, 2014; van Bruinessen *et al*, 2014; Hong *et al*, 2014). Further research is required to establish the most usable, acceptable and effective ways to encourage long-term adherence to PA in people with OA via digital interventions (Bossen *et al*, 2013b).

1.5 Rationale

Interventions are needed to promote engagement with PA for people with OA. Inactivity within this population is recognised as a problem, and integrating PA and exercise is considered an essential part of condition management. Development of interventions are needed where the primary focus is not only on increasing, but also maintaining adequate levels of PA. People should be adequately equipped with the necessary skills, knowledge and self-efficacy to enable them to remain physically active

over a long period of time (Hurley *et al.*, 2010). In addition, the use of health behaviour change techniques used in an intervention should link clearly to a theoretical framework (Michie *et al*, 2008; Cane, O'Connor and Michie, 2012). Alternative modes of delivery for self-management interventions include the utilisation of technology to encourage behaviours such as increasing PA, and further research is needed to understand how such interventions might be adopted by the OA population.

The purpose of this thesis was to address the issue of inactivity within the OA population, exploring key behavioural determinants affecting sustained engagement with PA. The intent was to develop and test a digital behaviour change intervention for the OA population, which would foster optimal forms of motivation to facilitate sustained engagement with PA.

To better understand the problem of inactivity in this population, a mixed methods design was adopted, and is described in more detail below in section 1.7.2.

1.6 Aim of the Thesis

The overall aim of this thesis was to develop and pre-test a digital behaviour change intervention to motivate people with OA to become and stay active.

1.6.1 Objectives

Four objectives were identified:

1) To determine the effectiveness of existing digital interventions for promoting PA in people with OA.
2) To explore the beliefs and motives associated with PA in people with OA.
3) To design and produce a prototype digital behaviour change intervention.
4) To explore the usability and acceptability of a prototype digital behaviour change intervention.

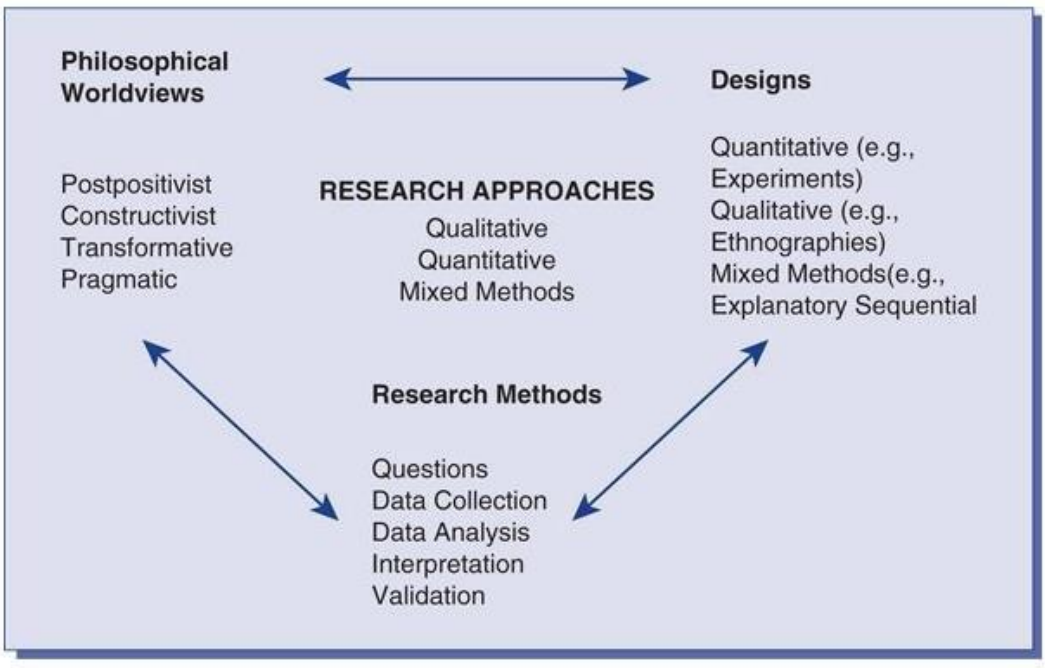
1.7 Research Design

1.7.1 Epistemological Position

All research needs a foundation for its inquiry, and inquirers need to be aware of the implicit worldviews they bring to their studies (Creswell and Plano Clark, 2007). The worldview, or paradigm, of a research project, is a description of the basic set of beliefs or assumptions that underpin the inquiry, or more simply, how the researcher views the world. They are a philosophy deeply rooted in our own personal experiences and culture, being shaped by new experiences and thoughts over time (Creswell and Plano Clark, 2007).

For this thesis, the researcher adopted a pragmatic approach where the focus was firmly placed on the research problem. Pragmatism is a problem-oriented philosophy that takes the view that the best methods to use are those that help to best answer the research question. The concern is with identifying what works, and focusing on the solution to problems, using a number of different methods to learn about, and understand the problem (Creswell, 2007). Figure 1-3 below illustrates the link between worldviews, methods, and research designs.

Figure 1-3: The Interconnection of Worldviews, Design, and Research Methods
(Creswell, 2014, with permission from SAGE Publications)



1.7.2 Methodology – A Mixed Methods Strategy

When defining a research methodology it is important to understand that across all methodologies, the approach to research involves philosophical assumptions as well as distinct methods or procedures (Creswell, 2007). The pragmatic epistemological position of the researcher described above, is typically associated with mixed methods research, where a number of different methods can inform the problem under study, and where the contextual nature of qualitative findings can complement the representativeness of quantitative findings.

This thesis adopted a mixed methods design to explore 'what works' in practice (Creswell and Plano Clark, 2007). This approach combines qualitative and quantitative methods to enable the researcher to design confirmatory and exploratory questions simultaneously, and verify and generate theory in a single study (Teddlie and Tashakkori, 2012).

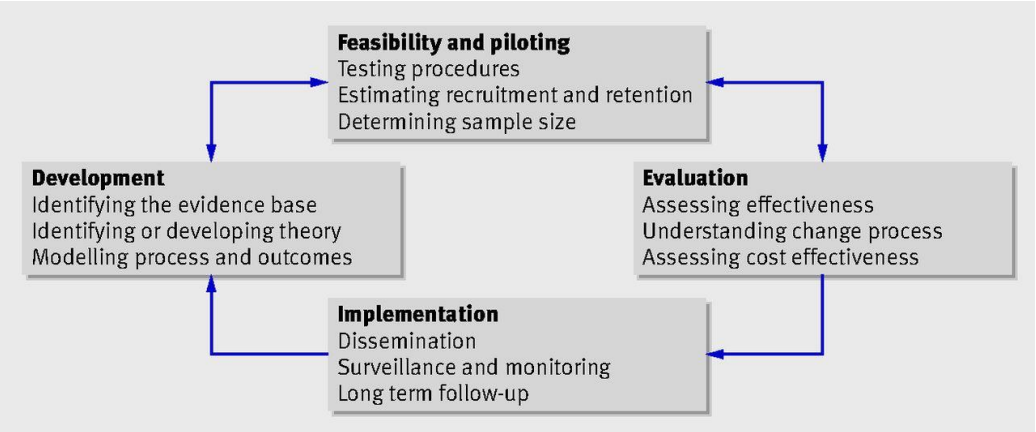
Within this thesis, the quantitative data provided a general understanding of the problem, and the qualitative data began to refine and explain the statistical results by exploring participant's views in more depth (Creswell and Plano Clark, 2007).

More specifically, this thesis adopted a Sequential Explanatory Design, a two-phase mixed methods design which used qualitative data to help explain, or build upon, earlier quantitative results (Creswell and Plano Clark, 2007). Within this thesis, each set of data is considered to have an equally important role in addressing the research question, and is therefore given equal weighting.

1.7.3 Complex Health Intervention Development

A mixed methods approach sits well within the multiphase model of complex intervention development advocated by the Medical Research Council (MRC) framework (Craig *et al.*, 2008; Farquhar *et al.*, 2013). This thesis is primarily concerned with the development stage, illustrated in Figure 1-4 below.

Figure 1-4: Intervention Development and Evaluation Phases *(Craig et al, 2008, with permission from BMJ Publishing)*

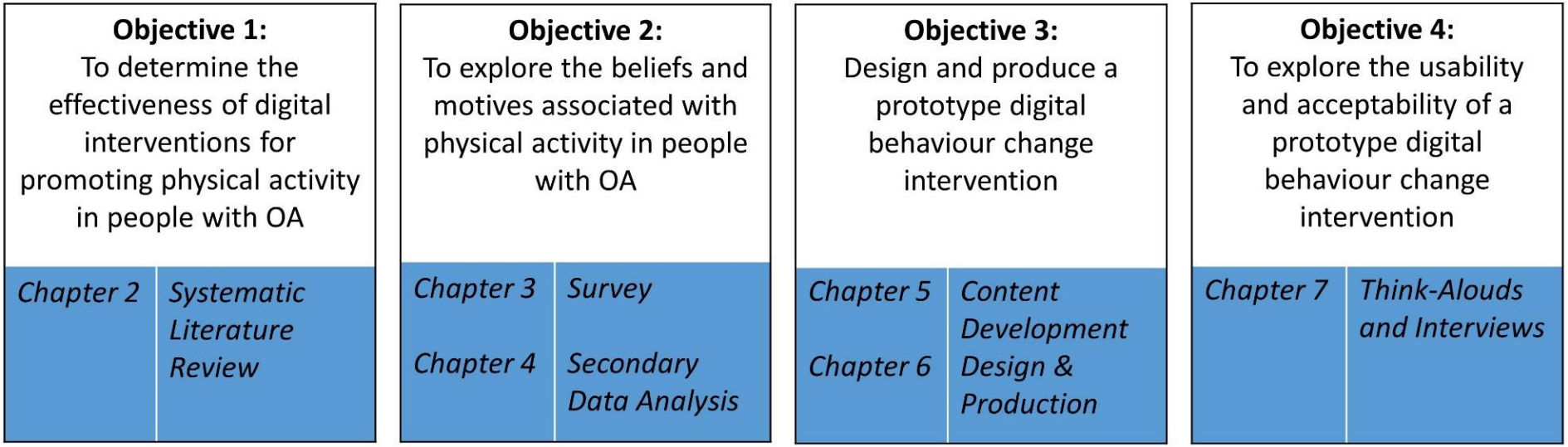


1.7.4 Thesis structure

This thesis was made up of four main phases. Figure 1-5 below illustrates how each phase (and corresponding objective – see section 1.6.1) is described within each chapter.

- Phase 1) A systematic literature review was carried out to explore the effectiveness of existing digital interventions for promoting PA in people with OA.
- Phase 2) A survey and secondary data analysis explored the beliefs, motives, and gains associated with PA in people with OA.
- Phase 3) The design and production of a prototype digital behaviour change intervention, demonstrating how theoretical constructs were linked to practical materials used within the prototype website, and describing the co-development process of website production with patient insight partners.
- Phase 4) A usability and acceptability study, using a think-aloud approach and semi-structured interviews to explore the attitudes and opinions of a sample of potential users.

Figure 1-5: Overview of the Thesis



1.8 Patient Partner Involvement

Patient insight partners (PIPs) were involved during a number of stages within the thesis. During the survey study (Chapter 3), a PIP (JA) gave advice regarding the design and layout of the questionnaire. They trialled the questionnaire on a number of occasions (along with other team members). Comments were made on ease of use, duration of completion, and flow of the questionnaire. Two PIPs (JB, DJ) were also involved during the design, production, and testing of the prototype website. Details of their valuable contributions can be found within chapters 5-7.

Optimising the acceptability and feasibility of a behaviour change intervention can be best achieved through the active involvement of potential users working towards co-design and joint ownership during all stages, from development through to initial pilot/feasibility studies as well as subsequent efficacy/effectiveness, implementation and maintenance evaluations (Araujo-Soares *et al.*, 2018; Craig *et al.*, 2008).

This chapter introduced OA, provided an overview of the management options for OA, and considered the range of determinants that might affect levels of PA in this population. It provided an overview of the range of behaviour change models and theories that have been developed to further understand optimal ways of initiating and maintaining PA behaviour change, as well as describing opportunities for utilising technology to deliver modified self-management approaches.

The next chapter explores the effectiveness of existing digital behaviour change interventions in more detail, by identifying and exploring which behavioural theories and behaviour change techniques have been adopted to develop existing interventions.

Chapter 2: Systematic Literature Review - Digital Health Behaviour Change Interventions to Facilitate Physical Activity in Osteoarthritis

2.1 Overview

This chapter describes the process and results of a systematic literature review that was carried out to gain knowledge about the current landscape of digital behaviour change interventions (DBCIs) for people living with osteoarthritis (OA). Interventions with a specific aim of increasing levels of physical activity (PA) in this population were evaluated, and the effectiveness of these interventions considered.

A version of this systematic literature review was published in Physical Therapy Reviews in July 2018 (Berry *et al*, 2018) (Appendix F) and has subsequently been updated for this thesis. The published paper included studies up to July 2017. The updated results reported within this chapter include studies up to, and including, July 2018.

2.2 Rationale

Digital health behaviour change interventions can be defined as web-based therapeutic programmes which encourage positive cognitive, behavioural, and emotional change (Barak, Klein and Proudfoot, 2009). The content of such interventions is comprehensive, highly structured and most often informed by psychological theory (Barak, Klein and Proudfoot, 2009). Such interventions have the potential to overcome many of the barriers associated with traditional face-to-face or group-based PA programmes (Vandelanotte *et al*., 2007). Specifically, digital interventions can provide cost-effective and widely accessible information, which is convenient and anonymous (Bossen *et al*., 2014), as well as opportunities for interactive, tailored approaches (Norman *et al*., 2007).

A number of systematic reviews have evaluated the effectiveness of digital health behaviour change interventions on levels of PA in healthy adults (Davies *et al.*, 2012; Foster *et al*., 2013), adults with a chronic condition (Bossen *et al*., 2014; Davies *et al.*,

2012; Stellefson *et al*., 2013), and older adults (Aalbers, Baars and Rikkert, 2011; Stellefson *et al*, 2013). These reviews reported small (Davies *et al.*, 2012; Stellefson *et al.*, 2013), small to moderate (Aalbers, Baars and Rikkert, 2011), and moderate positive effect sizes (Foster *et al*., 2013). Interventions with populations including older adults, or those with a chronic condition typically produced smaller effect sizes. Considering the size of the population affected by OA, even small positive effects may have large public health consequences (Bossen *et al*., 2014).

A wide range of different characteristics and components are thought to influence the effectiveness of digital health behaviour change interventions. Previous reviews have described up to 18 different behaviour change techniques (BCTs) used in interventions (Aalbers, Baars and Rikkert, 2011), with social networking, online self-monitoring, goal-setting, and the use of email found to be those most commonly used (Aalbers, Baars and Rikkert, 2011). It is clear that there is a large variety in how and when different techniques are used in interventions. Further exploration is needed to learn more about which BCTs have been used in digital interventions specifically designed for people with OA, and to evaluate which components keep participants engaged, and which characteristics (e.g., pain, fatigue, or reduced physical performance capacity) might be related to attrition (Bossen *et al*., 2014).

It is also important to evaluate how behaviour change theory has been used to guide digital health behaviour change interventions. There is growing recognition that the development and implementation of behaviour change technologies is enhanced when behaviour change theory is applied (Michie and Prestwich, 2010), however, there continues to be a lack of reviews which include a detailed examination of how theory has been used to develop behaviour change interventions (Prestwich *et al.*, 2014). There is a need for future reviews to further explore how theory and specific behaviour change techniques have been used within digital interventions. If this is not done, it becomes difficult to draw conclusions as to whether findings (positive or negative) are due to a lack of theoretical fidelity, or other factors such as inaccurate or inappropriate intervention content (Norman *et al*., 2007).

Previous reviews also describe a lack of reporting of website usage data, such as number of log-ins, duration of log-in, and non-usage (Aalbers, Baars and Rikkert, 2011; Davies *et al*, 2012; Foster *et al*, 2013; Stellefson *et al*, 2013).

No systematic reviews have been published on the effectiveness of digital PA interventions for people with OA. This systematic review examined which BCTs and theories have been used in existing interventions, as well as evaluating if specific BCTs have been associated with positive engagement or attrition. It also explored which methods had been utilised to measure levels of PA, as well as website uptake and usage.

The main aim and objectives of this review are detailed below.

2.3 Aim

To determine the effectiveness of digital interventions for promoting PA in people with OA

2.3.1 Objectives

1) To determine whether engagement with PA is changed with a digital intervention.
2) To identify outcome measures used to measure PA.
3) To examine which BCTs and behaviour change theories are used to facilitate engagement with PA.
4) To document how uptake and usage of digital interventions has been reported.

2.4 Methods

2.4.1 Criteria for considering studies for this review

Details of the inclusion and exclusion criteria used to identify eligible studies are summarised in table 2.1 below.

Table 2.1: Overview of Inclusion and Exclusion Criteria

	Inclusion	**Exclusion**
Studies	RCTs / Quasi-experimental	Non-experimental
Population	Includes people with OA Adult population Male and Female	Does not include people with OA Children/Adolescent population
Intervention	Promotes increased PA	Does not promote increased PA
Mode of Delivery	Via a digital platform	Not via a digital platform
Outcome Measures	Includes primary or secondary measure of PA (subjective or objective)	Does not Include primary or secondary measure of PA (subjective or objective)
Language	English	Non-English language

2.4.1.1 Types of Studies

Included studies were randomised controlled trials (RCTs) and quasi-experimental trials. The search was purposely not limited to RCTs to provide a more comprehensive picture of published research in the evolving area of digital interventions for PA in OA.

2.4.1.2 Types of Participants

Male/female adults (18 years and above) with a clinical or self-reported diagnosis of OA.

2.4.1.3 Types of Interventions

All interventions aimed at increasing levels of PA were included. Studies focusing on general self-management (for OA) and other behaviour changes such as weight loss were included if they incorporated a PA element. Studies examining the effectiveness or feasibility of an intervention were included; publications of future research protocols were excluded.

2.4.1.4 Mode of Delivery

Studies were included if they evaluated an intervention which was delivered via a digital platform. In line with previous reviews of DBCIs (Bossen *et al.*, 2014; Murray, 2012) a definition and classification method (Barak, Klein and Proudfoot, 2009) was used to group the interventions (table 2.5). Barak *et al* (2009) proposed a term 'web-based interventions' to be the most inclusive when compared to a number of other terms previously used in literature such as e-health and online therapy. They defined web-based interventions as:

> *'a primarily self-guided intervention program that is executed by means of a prescriptive online programme operated through a website and used by consumers seeking health- and mental-health related assistance. The intervention programme itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive web-based components.'*
>
> (Barak, Klein and Proudfoot, 2009, p6)

2.4.1.5 Types of Outcome Measures

Studies were included only if they measured and reported levels of PA (subjective or objective measure).

2.4.2 Search Methods for identification of studies

Search terms (See table 2.2) were established following extensive reviewing of search terms used in similar literature reviews in the area of PA and self-management interventions (digital and non-digital) for arthritis, musculoskeletal pain and other chronic diseases. Keywords used in known published studies evaluating the effectiveness of digital PA interventions were also examined. Advice was given from the supervisory group, and a specialist librarian was consulted.

The full search strategy can be found in Appendix A1. The three key concepts for the search were:

1) OUTCOME - intervention aims to affect levels of PA,

2) MODE OF DELIVERY - intervention must be accessed primarily via a digital platform,

3) POPULATION - intervention must be aimed at people with OA.

Table 2.2: Search Strategy

Concept 1 (Outcome)		**Concept 2 (Mode of intervention delivery)**		**Concept 3 (Population)**
'physical* activ*'		internet		osteoarthritis
'active lifestyle'		'internet-based'		arthritis
leisure activit*		'computer-based'		
walk*	**AND**	'computer-delivered'	**AND**	
exercis*		digital		
bicycling		multimedia		
cycling		web* or web-based		
yoga		ehealth or e-health		
pilates		telehealth		
tai chi		email or e-mail		
swimming		e-learning or elearning		
sport*		online or on-line		
Self-management		'mobile health' or m-health or mhealth		
Self-care		'serious games' or gamification		
'behaviour change'				

2.4.3 Information Sources

A structured search was carried out for intervention studies published up to July 2018 (with no set start date to allow for any early digital interventions to be included) using the following databases: AMED, CINAHL Plus, Cochrane Library, Embase, Medline, PsycINFO, Pubmed, SPORTDiscus and Web of Science.

2.5 Data collection and analysis

2.5.1 Selection of Studies

Following the removal of duplicates, a preliminary screen was carried out of all study titles. All abstracts were then screened independently by two members of the research team (AB and either CM, NW, SM). Full-texts of the remaining articles were collected, and eligibility was again independently assessed by two members of the research team (AB and either CM, NW, SM). Any papers that were unable to be accessed (via UWE library and British Library services) were excluded from the study. Articles meeting all of the inclusion criteria at this point were included in the review. Any disagreements between reviewers were discussed with a third team member. Reference lists of the included studies were also checked (snowballing) for any other potentially eligible papers.

A PRISMA diagram (Liberati *et al.*, 2009) (figure 2-1 below) shows this process in more detail.

2.5.2 Data Extraction

Following screening, all eligible articles were collated and data extracted using a pre-defined data extraction form (See Appendix A2). The data extraction form was based on previous systematic reviews of digital PA interventions (Vandelanotte *et al.*, 2007; Broekhuizen *et al.*, 2012; Davies *et al.*, 2012; Bossen *et al.*, 2014), with focus given to the specific information required to meet the objectives of the review.

2.5.3 Assessment of risk of bias in included studies

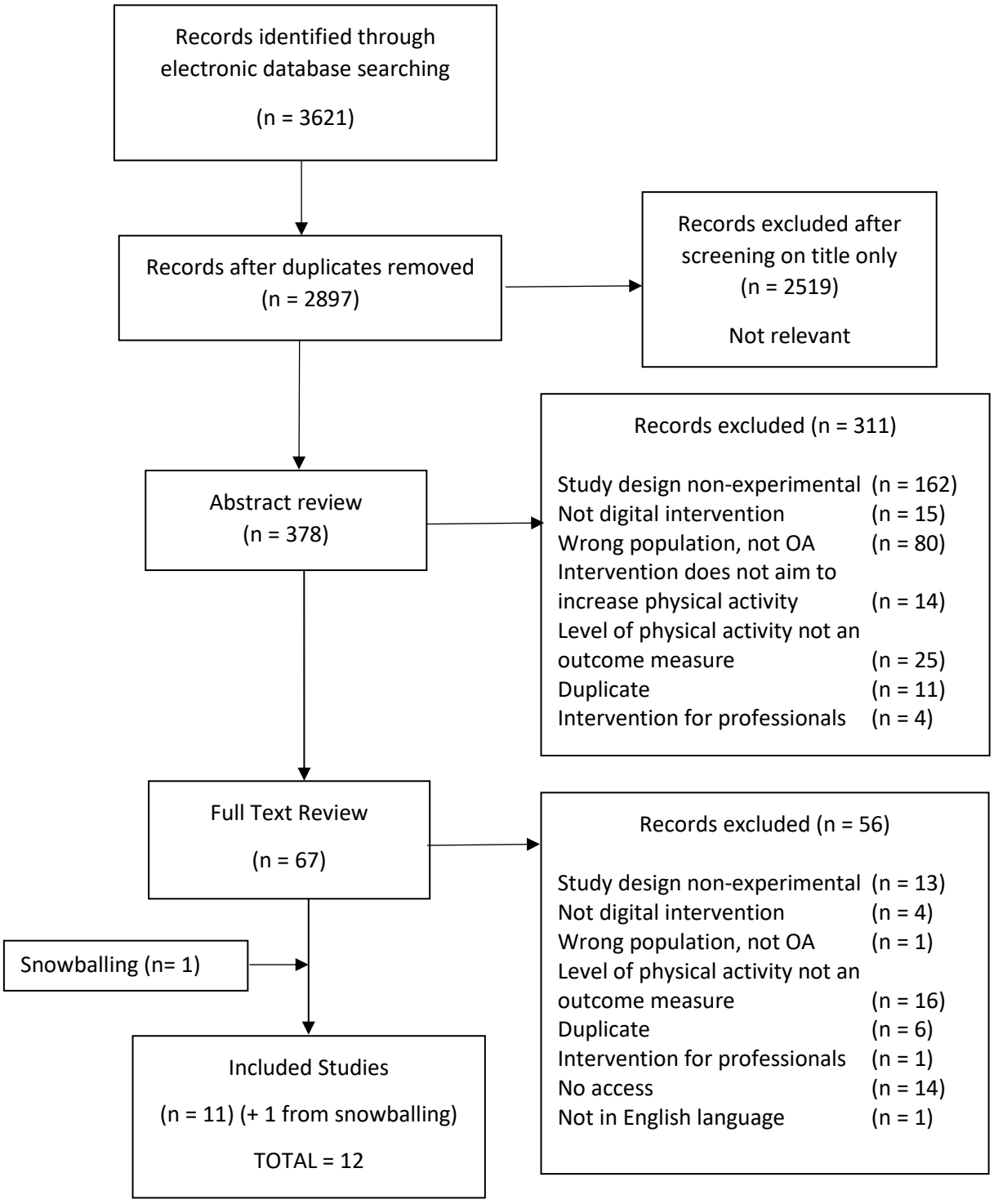
The risk of bias of included papers was assessed using the Cochrane Collaboration's tool for assessing risk of bias (Higgins *et al.*, 2011). A full assessment was carried out for those studies that adopted a randomised design. Studies adopting other designs such as pre-post-test were assessed for attrition bias, reporting bias, and for any other observed source of bias. Studies were assessed independently by two members of the research team (AB and either NW or SM) to ensure consistency.

2.6 Results

2.6.1 Results of the search

A PRISMA diagram (figure 2-1) shows the results of the study selection and screening procedures. Details are given of the number of references retrieved at each stage of the search. A total of 12 studies were eligible for review. Eleven of these were obtained from the original search, one additional study was found through a review of reference lists (snowballing).

Figure 2-1: Study selection and screening procedures



2.6.2 Characteristics of Studies and Populations

The included studies were carried out in Australia, Canada, the Netherlands, UK and USA. A mix of study designs were used including RCTs and Implementation studies. The sample size varied greatly from 20 to 958 participants, and females made up the majority of study samples. Eight studies focused solely on people with arthritis (rheumatoid arthritis, OA or other rheumatic condition such as fibromyalgia) or analysed the proportion of the sample with arthritis separately (Bossen *et al.*, 2013c, 2013b; Lorig *et al.*, 2008b; Skrepnik *et al.*, 2017; Trudeau *et al.*, 2015). The four other studies included participants with a number of different chronic conditions such as diabetes, heart disease, and arthritis (Jaglal *et al.*, 2013; Lorig *et al.*, 2006, 2008a, 2013). These studies failed to split the results into sub-groups, therefore, all outcomes reported are of the whole group.

Tables 2.3 and 2.4 show details of the main characteristics of the studies, including; the study aim, sample size, population, gender, and age range of participants. The studies have been tabulated into RCTs (A*llen et al*>, 2018; Bossen>*et al*>, 2013b; Kloek>*et al*>, 2018; Li>*et al*>, 2018; Lorig>*et al*>, 2006b, 2008b; Skrepnik>*et al*>, 2017; Trudeau>*et al*>, 2015), and non-randomised studies, which included implementation (digital programmes tested in a variety of settings such as rural areas) and pre-post-test designs (Bossen *et al.*, 2013c; Jaglal *et al.*, 2013; Lorig *et al.*, 2008a, 2013a).

Table 2.3: Characteristics of Included Studies (Randomised Controlled Trials – RCTs)

Author	Location	Design	Study Aim	Sample	Population	Gender	Age range
Allen et al, 2018	USA	RCT	To compare the effectiveness of physical therapy (PT) and internet- based exercise training (IBET), each vs a wait list (WL) control, among individuals with knee OA.	350	Knee OA	IBET group = 69% female, 31% male. PT gp = 71.4% female, 28.6% male. WL control = 77.9% female, 22.1% male.	65.3 (11.1) Mean (SD)
Bossen et al, 2013 (RCT)	Netherlands	RCT	Short (3 months) and long-term (12 months) effectiveness of the join2move intervention in patients with knee and/or hip OA in PA, physical function, and self-perceived effect.	199	Self-reported knee and/or hip OA	Intervention – 40% male, 60% female Control – 30% male, 70% female	Intervention mean = 61 Control group mean = 63
Kloek et al, 2018	Netherlands	Cluster-RCT	To investigate the short- and long- term effectiveness on physical functioning and free-living PA of e-Exercise compared to usual physical therapy in people with hip/knee OA.	208	Hip and/or Knee OA	e-Exercise gp = 67.9% female, 32.1% male. Usual PT = 67.7% female, 32.3% male.	e-Exercise gp = 63.8 (8.5), Usual PT = 62.3 (8.9) Mean (SD).
Li et al, 2018	Canada	Proof-of-concept RCT	To assess the efficacy of the program for improving PA participation, disease status, and perceived self-management capacity in people with knee OA.	61	Knee OA	Immediate gp: 73% female, 27% male. Delayed gp: 90% female, 10% male.	Immediate gp: 61.3 (9.4). Delayed gp: 62.1(8.5). mean (SD).

Lorig et al, 2006	USA	RCT	1-year outcomes (health status, health behaviour and health care utilization) of the Internet-based Chronic Disease Self-Management Program.	958	Arthritis: 24.9% (usual care), 24.9% (online intervention) Other: diabetes, hypertension, lung disease, heart disease	Female 71.6% usual care, 71.2% online intervention Male 28.4% usual care, 28.8% online intervention	Range 22 to 89) Control: 57.6 (SD ± 11.3) Intervention: 57.4 (SD ± 10.5)
Lorig et al, 2008	USA	RCT	6-month and 1-year outcomes (health status, health behaviour, self-efficacy, and health care utilisation) of the 1-year randomised trial of the Internet-based Arthritis Self-Management Programme (ASMP).	855	546 (63.9%) had OA. Usual care: 26.6% RA, 64.9% OA, 51.3% Fibromyalgia Intervention: 28.3% RA, 62.3% OA, 49.2% Fibromyalgia	Usual care: 9.5% male 90.5% female Intervention: 10.2% male 89.8% female	Usual Care: 52.5 (SD ± 12.2) Intervention: 52.2 (SD ± 10.9)
Skrepnik et al, 2017	USA	RCT	To evaluate the impact of a mobile app (OA GO) plus wearable activity monitor/pedometer (Jawbone UP 24) used for 90 days on the mobility of patients with knee OA treated with hylan G-F 20.	211	Adults with OA	Intervention: male = 45%, females = 55% Control: male = 55%, females = 45%	Total sample: mean 62.6 (SD = 9.4). Intervention: 61.6 (SD ± 9.5) Control: 63.6 (SD ± 9.3)
Trudeau et al, 2015	USA	RCT	To assess the efficacy of an online pain self-management programme with adults who had a self-reported doctor diagnosis of arthritis pain.	228	OA only (59%), RA or other arthritic condition (41%)	Female = 68.4% Male = 31.6%	49.9 (SD ± 11.6)

Table 2.4: Characteristics of Included Studies (Non-Randomised Studies)

Author	Location	Study Design	Study Aim	Sample	Population	Gender	Age range
Bossen et al, 2013 (pilot)	Netherlands	Pre-post test	What is the preliminary effectiveness (PA, physical function and self-perceived effect), feasibility and acceptability of join2move in patients with knee and/or hip OA?	20	Self-reported knee and/or hip OA	Female: 75% Male: 25%	Mean = 64 (SD ± 6.6)
Jaglal et al, 2012	Canada	Two-group, pre-post test	To examine whether access to tele-CDSMP in rural and remote communities improves self-efficacy, health behaviours, and health status and whether there are differences in outcomes between the two delivery models (single/multiple).	213	**Arthritis: 76.5%** Other: Heart, lung, diabetes, other MSK, stroke	Female: 158, Male: 52 (3 not known)	45-88, median = 67
Lorig et al, 2008	UK	Implementation study	To evaluate Expert Patients Programme Online (EPP Online) in the general English public.	593	**Arthritis: 30.5%** Other: Diabetes, hypertension, lung disease, heart disease, mental	Female = 77.9% Male = 22.1%	median age = 45

					health conditions, ME, MS, back problems		
Lorig et al, 2013	Australia	Implementation study	1: Could the ICDSMP be successfully implemented in South Australia? 2: Could the ICDSMP reach rural and aboriginal people less served by CDSMP? 3: Would the ICDSMP have an effect on health behaviours, health status, health care utilization, and reduction in lost workdays?	254	**Arthritis 40.1%** Other: Asthma, cancer, COPD, diabetes, heart disease, lung disease, mental health condition, Other chronic condition	Female = 68.5% Male = 31.5%	Median age = 45

2.6.3 Description of Digital Interventions

The included studies evaluated a number of digital health behaviour change interventions; some evaluated the same intervention but in different settings and populations. Across the 12 included studies, eight different interventions were evaluated:

- **e-Exercise** (Kloe*k et al*, 2018): A 3-month intervention in which approximately 5 face-to-face physical therapy sessions were integrated with an online application consisting of graded activity, exercise, and information modules (digital content similar to Join2Move below).
- **Internet-based Exercise Training Programme (IBET)** (Allen *et al.*, 2018): Features included - tailored exercises based on measures regarding pain, function and current activity; exercise routines including strengthening, stretching and aerobic activity recommendations; exercise progression; video display of exercises; automated reminders; progress tracking, including graphs of pain, function, and exercise over time.
- **Internet-based Arthritis Self-Management Programme (I-ASMP)** (Lorig *et al.*, 2008b): A six week internet-based course; peer moderators; email reminders to encourage participation; tailored information to participants.
- **Internet-based Chronic Disease Self-Management Programme (I-CDSMP):** (Lorig *et al.*, 2006, 2008a, 2013)**:** A six week internet-based course; peer moderators; email reminders to encourage participation; tailored information to participants. (Note: (Lorig *et al.*, 2008a) This study evaluated the Expert Patients Programme – an intervention based on the I-CDSMP).
- **Join2Move** (Bossen *et al.*, 2013b, 2013c): A fully-automated, web-based intervention containing automatic (tailored) functions (text messaging and e-mails) without human support; self-paced; nine week programme.
- **Monitor-OA** (Li *et al.*, 2018): Brief education session by a physical therapist, a Fitbit Flex, and four biweekly phone calls for activity counselling.
- **Telehealth-CDSMP** (Jaglal *et al.*, 2013): Same content as CDSMP programme described above, course ran via live video and audio communications between the participants and moderators.

- **OA GO App** (Skrepnik *et al.*, 2017): Mobile phone app providing motivational messages; goal setting (daily steps); linked to wearable activity monitor; self-monitoring (pain and mood); No moderator.
- **PainACTION** (Trudeau *et al.*, 2015): Web-based patient education, self-management intervention. Modular; No moderator.

The interventions evaluated by studies included in this review were identified as being either self-help web-based therapeutic interventions or human-supported web-based therapeutic interventions. Definitions were based on the programme content, multimedia choices, provision of interactive online activities, and provision of guidance and feedback.

Table 2.5 below describes in more detail the different subtypes of web-based internet interventions according to Barak *et al* (2009).

***Table 2.5*: Subtypes of web-based internet interventions**

Subtype of web-based therapeutic interventions	Programme Content	Multimedia use/choices	Interactive Online Activities	Feedback support provision
Web-based education interventions	Non-active educational content (largely generic and non-prescriptive)	Static/partially dynamic	Static/partially dynamic	No feedback or partially automated support such as access to online forum (peer support)
Self-guided web-based therapeutic interventions	'Active' Structured content (Attempting to create positive cognitive/ behavioural change)	Mainly moderate-highly dynamic (several multimedia formats)	Mainly moderate-highly dynamic (multiple online formats)	Automated feedback ranging from non-tailored (simple generic reminder) to highly tailored (corrective, diagnostic, prescriptive feedback)
Human-supported web-based therapeutic interventions	'Active' Structured content (Attempting to create positive cognitive/ behavioural change)	Mainly moderate-highly dynamic (several multimedia formats)	Mainly moderate-highly dynamic (multiple online formats)	Primarily supportive human guidance and feedback

2.6.4 Risk of bias in included studies

2.6.5 Risk of bias for RCTs

The eight included RCTs were found to have varying levels of risk of bias. The sections below describe the risk of bias assessment in more detail.

Figures 2-2 and 2-3 show the overall risk of bias for the included studies in this review as determined using the Cochrane Collaboration's tool for assessing risk of bias (Higgins *et al.*, 2011). Further details of how risk of bias was assessed within each study can be found in Appendix A3.

Figure 2-2: Risk of bias for RCT studies included in the review

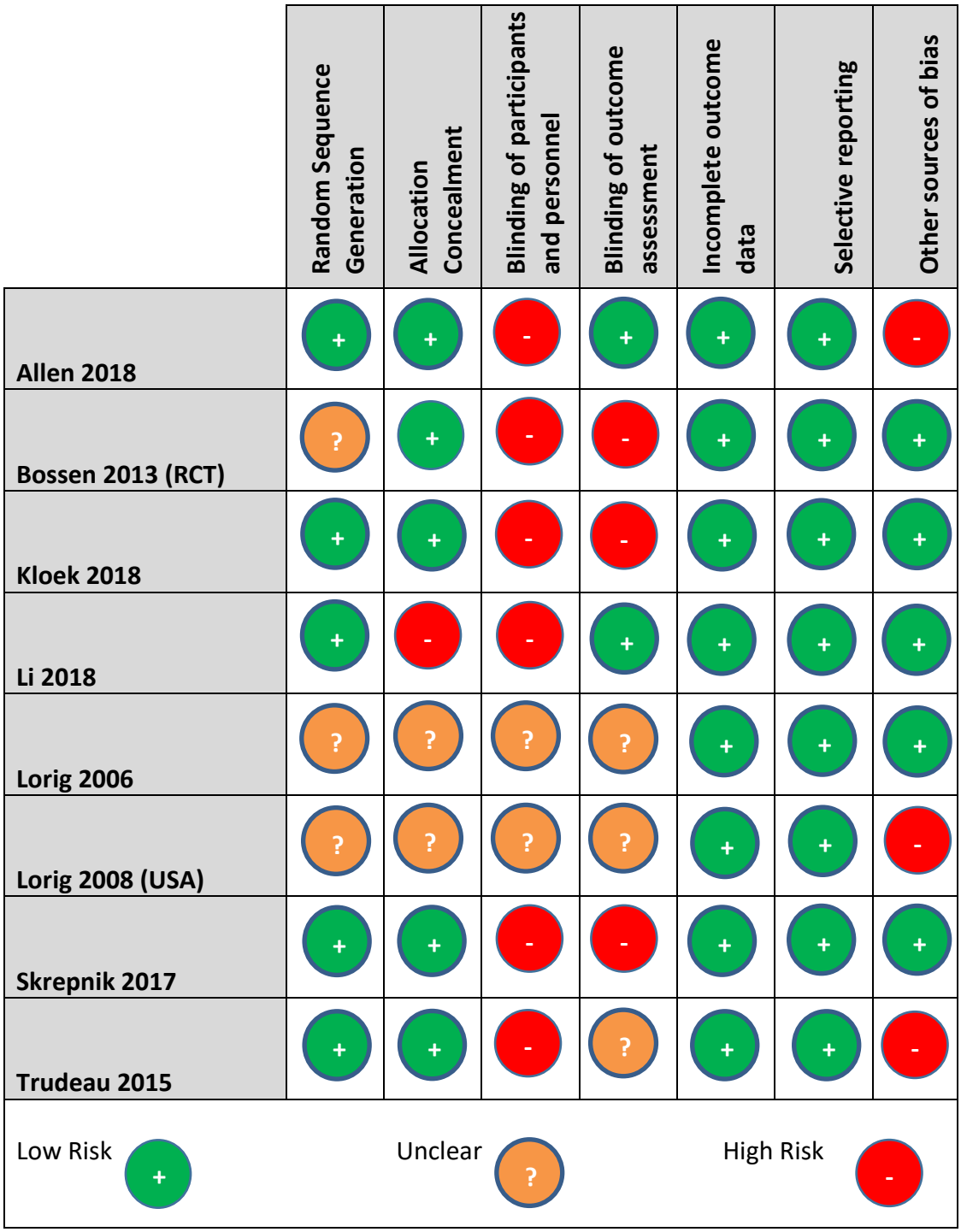


Figure 2-3: Risk of bias for implementation and pre-post-test studies

2.6.5.1 Random Sequence Generation

The majority of RCTs described clear random sequence generation (Allen *et al*, 2018; Kloek *et al*, 2018; Li *et al*, 2018; Skrepnik *et al*, 2017; Trudeau *et al*, 2015), and were therefore judged to have a low risk of bias. Randomisation factors within the Trudeau et al (2015) study included, gender, and type of arthritis, with equal allocation to both control and intervention groups. Skrepnik *et al* (2017) stratified patients by site. Lorig *et al* (2006, 2008b) and Bossen *et al* (2013a) described how their studies were randomised but did not state exactly how this was carried out, therefore they were reported as having an unclear risk of recruitment bias.

2.6.5.2 Allocation concealment

The majority of studies described how they concealed allocation (Alle*n et al*, 2018; Bossen *et al*, 2013b; Kloek *et al*, 2018; Skrepnik *et al*, 2017; Trudeau *et al*, 2015). A researcher not involved in the data collection, distributed sequentially numbered opaque sealed envelopes with details of the allocation in the Bossen (2013a) study. Skrepnik et al (2017) provided sealed envelopes to each site, and these were opened according to ascending sequence to ensure proper randomisation. Allocation was generated by the study data manager, and then the research coordinator enrolled and assigned participants to the relevant group in the Trudeau (2015) study. The two studies by Lorig *et al* (2006, 2008b) did not provide details of how participants were allocated to either control or intervention group.

2.6.5.3 Blinding of participants, personnel, and outcome assessors

Most studies did not blind participants and study personnel to allocation, largely due to the inherent nature of exercise intervention studies, so were therefore reported to have a high risk of bias for blinding. For example, Skrepnik *et al* (2017) blinded participants in the control group to data from the wearable PA monitor, but the intervention group were unblinded to this data. Because not all participants were fully blinded to outcomes, risk of bias was judged high within this study. The two studies by Lorig et al (2006, 2008b) did not provide details about blinding.

2.6.5.4 Incomplete outcome data

All of the RCTs were considered to have used appropriate methods to address any incomplete outcome data, with the majority using an intent-to-treat (ITT) analysis. The Cochrane principles for dealing with missing data describe how imputing missing data with replacement values, and treating these as if they were used (e.g. last observation carried forward, or imputing based on predicted values from a regression analysis) is a method commonly used in systematic reviews. However, they do recognise that this method fails to acknowledge uncertainty in the imputed values and results (Higgins *et al.*, 2011).

2.6.5.5 Selective reporting

All of the RCTs were considered to have adequately reported all pre-specified (a priori) analyses; therefore, all studies were judged to have a low risk of bias for selective reporting.

2.6.5.6 Other sources of bias

Allen *et al* (2018), Lorig *et al* (2008b) and Trudeau (2015) provided financial incentive/reward for participants in their studies. Allen et al (2018) provided participants with $30 for completion of assessments at each time point within the study. Lorig et al (2008b) sent $10 Amazon vouchers to control subjects for each completed questionnaire, and they sent participants in the intervention group a copy of the Arthritis Help Book in the post. Trudeau et al (2015) compensated all participants in their study with $250 for completing all assessments. Therefore, these studies were judged as having a high risk of bias. No other sources of bias were present in any of the other studies.

2.6.6 Risk of bias for Implementation and pre-post-test studies

Risk of bias assessments for random sequence allocation, allocation concealment, blinding of participants, personnel, and outcome assessment were not carried out on these studies, as they were not randomised controlled trials.

2.6.6.1 Incomplete outcome data

Bossen et al (2013b) recruited 20 participants at baseline, with 100% completing assessment points (4 weeks, and 12 weeks). This study was therefore judged as having a low risk of bias for incomplete outcome data. Jaglal *et al* (2013) reported attrition rates, but did not describe how any non-completers were accounted for during data analysis; therefore, an unclear risk of bias was reported. Lorig *et al* (2013) described how they used ITT analysis to account for any non-completers; however, they also reported a data collection error, where 58 participants failed to complete the 6-month assessments due to a computer programming error. This was considered high risk of bias because of this incomplete outcome data. Lorig (2008a) used ITT methods for missing data (last observation carried forward) and was therefore judged to have a low risk of bias.

2.6.6.2 Selective Reporting

No selective reporting was identified in any of the implementation and pre-post-test studies. All studies reported outcome measures at all of the time-points initially described, and were therefore considered to have a low risk of bias.

2.6.6.3 Other Sources of Bias

No other sources of bias were identified. All studies were assessed to have a low risk of bias in this category.

2.6.7 Effectiveness of Digital Behaviour Change Interventions

Outcomes of the twelve included studies are described below, in accordance with the aim and objectives of the review. Eight RCTs were included in the review, with the remaining four studies adopting implementation and pre-post-test type designs. Primary endpoints ranged from 2-12 months, and the sample size ranged from 20 to 958. Increases in levels of PA were demonstrated, though not all improvements were statistically significant (Tables 2.6 and 2.7 below).

A statistically significant difference between intervention and control groups were seen at post-intervention in four of the RCT studies (Bossen *et al*, 2013b; Li *et al*, 2018; Lorig *et al*, 2006; Skrepnik *et al*, 2017). Bossen et al (2013) noted significant improvements in both self-reported and objective (accelerometer) PA ($p = 0.02$, and $p = 0.045$ respectively). Li et al (2018) reported significant improvements in daily MVPA +3 METs ($p=0.02$), and on mean step count ($p=0.02$). Lorig *et al* (2006) observed significant improvements in minutes spent per week doing stretching and strengthening exercise ($p=0.024$), but not in aerobic activity ($p=0.701$). Skrepnik *et al* (2017) reported a significant improvement in minutes of PA between groups at three months ($p=0.02$).

The remaining RCTs reported non-significant findings. Lorig *et al* (2008) and Trudeau *et al* (2015) saw no significant improvements between control and intervention groups for PA at either 6 or 12 months. Allen *et al* (2018) saw no significant improvements between intervention group and wait list control at any time points for the PASE (PA scale for the elderly), or for self-reported aerobic or strengthening activity. They did report a significant difference between intervention and control at 12 months for weekly minutes of stretching ($p=0.00$). Kloek *et al* (2018) saw no significant differences between a blended (digital + face-to-face) intervention and usual physical therapy; however, both groups saw significant clinical improvements.

Table 2.6: Effectiveness of Interventions evaluated by RCTs

Author (year)	Sample Size	PA Outcome measures	Endpoints	P Value
Allen (2018)	350	(IBET vs. waitlist) PA Scale for the Elderly (PASE) Self-report aerobic (mins/wk) Self-report stretching (mins/wk) Self-report strengthening (mins/wk)	 4 months 12 months 4 months 12 months 4 months 12 months 4 months 12 months	(0.025 sig. level) 0.50 0.43 0.03 0.05 0.03 0.00* 0.22 0.06
Bossen (2013) RCT	199 (All OA)	PA Scale for the Elderly (PASE) Accelerometer	3 months 12 months 3 months 12 months	0.84 0.02* 0.83 0.045*
Kloek (2018)	208	(e-exercise vs. usual PT) Short Questionnaire to Assess Health-enhancing PA (SQUASH) Accelerometer	 3 months 12 months 3 months 12 months	 0.26 0.78 0.51 0.39
Li (2018)	61	Average daily MVPA (moderate-to-vigorous PA): 3+ METs (metabolic equivalents) (mins) Average daily MVPA: 4+ METs (mins) Average daily steps (mean)	Contrast 1 (Immediate vs. delayed All time points Contrast 1 (Immediate vs delayed)	0.02* NSD 0.02*
Lorig (2006)	958 (not split) 24.9% of	Stretching/strengthening (minutes per week)	12 months	0.024*

	sample had arthritis	Aerobic exercise (minutes per week)	12 months	0.701
Lorig (2008) (USA)	OA sample reported here = 292	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	12 months 12 months	0.999 0.260
Skrepnik (2017)	Total = 211 Group A = 107 Group B = 104	Least squares (LS) mean number of steps per day – change from baseline to 3 months	3 months	0.02*
Trudeau (2015)	228 (Not split arthritis – OA,RA, or other arthritic condition)	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	1 month 3 month 6 month 1 month 3 month 6 month	NSD NSD NSD NSD NSD NSD

*significance at p<0.05, NSD = No significant difference

The implementation studies and pre-post-test studies evaluated changes in levels of PA from 12 weeks to 12 months post-baseline.

Three out of four studies (Table 2.7) found self-reported levels of PA were significantly improved post-intervention (Jagl*al et al*>, 2013; Lorig>*et al*>, 2008a, 2013a). The fourth study showed a trend towards improvement in levels of PA over 12 weeks, but this was not statistically significant (Bossen *et al.*, 2013c).

Table 2.7: Effectiveness of interventions evaluated by Implementation/pre-post-test studies

Author (Non-RCTs)	Sample Size	Outcome measures	Endpoints	P Value
Bossen 2013 (Pilot)	20 (All OA)	Short Questionnaire to Assess Health-enhancing PA (SQUASH)	3 months	0.3
Jaglal 2013	213 (not split) 76.5% of sample had arthritis	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	4 months 4 months	<0.001* <0.001*
Lorig 2008 (UK)	593 (not split) 30.5% of sample had arthritis	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	6 months 12 months 6 months 12 months	<0.001* 0.009* 0.008* <0.001*
Lorig 2013	254 (not split) 40.1% of sample had arthritis	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	6 months 12 months 6 months 12 months	0.131 <0.001* 0.004* <0.001*

*significance at p<0.05

2.6.8 Physical Activity Outcome Measures

A number of outcome measures were used to capture levels of PA. The majority of interventions used self-report questionnaires (described in more detail below). Four studies utilised wearable PA monitors. Skrepnik *et al* (2017) gave Jawbone UP 24 activity monitors to all participants, in both control and intervention groups. Bossen *et al* (2013) and Kloek et al (2018) used ActiGraph GT3x triaxial accelerometers, and Li *et al* (2018) used the Fitbit Flex to record levels of objective PA.

Self-reported aerobic exercise (minutes per week – over last 7 days), and strengthening and stretching exercises (minutes per week – over last 7 days) were most commonly used (Tables 2.6 and 2.7). These measures were developed and validated by the Stanford Patient

Education Research Centre and have been used in a number of previous studies at Stanford University (Lorig *et al*, 1996) (See Appendix A4 for more details).

Other measures included the PA Scale for the Elderly (PASE) (Alle*n et al*, 2018; Bossen *et al*, 2013b), and Short Questionnaire to Assess Health-enhancing PA (SQUASH) (Bossen *et al.*, 2013c; Kloek *et al.*, 2018). The PASE questionnaire asked participants to report on activity over the last 7 days, whilst the SQUASH questionnaire asked participants to think about an average week over the last few months.

A number of studies (many of which evaluated the effectiveness of digital behaviour change and self-management programmes) included in the initial screening phase of the review, were excluded because they failed to adequately measure levels of PA at baseline and post intervention (n=41).

2.6.9 Behaviour Change Theories

Social Cognitive Theory (Bandura, 1986), or the construct 'self-efficacy' was used to guide the development of half of the interventions (n=6). Despite describing how the interventions were based on this theory, further details were lacking of exactly which 'active ingredients' of the intervention were intended to improve levels of self-efficacy.

Six studies did not report the use of any theoretical concept (Alle*n et al*, 2018; Bossen *et al*, 2013c, 2013b; Kloek *et al*, 2018; Li *et al*, 2018; Skrepnik *et al*, 2017). However, they did provide some information about behaviour change techniques employed within the interventions, such as goal setting and action planning. The use of behaviour change techniques is discussed in more detail below. Li et al (2018) described how their intervention, Monitor-OA, utilised the Brief Action Planning Approach and Motivational Interviewing.

2.6.10 Behaviour Change Techniques (BCTs)

The studies described the use of BCTs in different ways, and it was difficult to ascertain which BCTs were relevant to specific aspects of the intervention. The Behaviour Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques (Michie *et al.*, 2013) (found in Appendix A5) was used to identify which BCTs had been used in each intervention. Each intervention was coded by evaluating all descriptions of the interventions, as well as any other development papers identified (See Appendix A6). Table 2.8 and Figure 2-4 below show which BCT clusters were most commonly used across the interventions.

The Join2Move (and e-Exercise) intervention evaluated by three of the included studies (Bossen *et al.*, 2013c, 2013b; Kloek *et al.*, 2018) contained a range of different BCTs. Key areas included goals and planning, action planning, and reviewing the behaviour over the course of the programme. This was done by self-monitoring; no external human support was given. Tools such as performance charts were built into the programme to allow participants to visualise their performance.

The Arthritis Self-Management Programme (ASMP) and the Chronic Disease Self-Management Programme (CDSMP) had very similar content, with a large number of different techniques used including: goal setting, action planning and feedback on behaviour, information about health consequences and information about how to perform PA, emotional support, distraction, framing/re-framing, valued self-identity, and self-talk. These interventions were human-supported, with feedback provided by trained moderators. They also had interactive bulletin boards and an internal messaging centre where participants and facilitators could leave private messages for other users.

The OA GO app focused on goal setting, action planning, self-monitoring of goals, emotional and physical forms of social support, and information about health consequences. This intervention was self-guided, with personalised feedback, and made use of a wearable monitor, so that participants were able to see if personal step goals had been achieved.

The PainAction intervention made use of similar BCTs, with goal setting, action planning, information about health and emotional consequences, body changes, framing/re-framing, and discussion about incompatible beliefs all used. This intervention was largely self-guided, though did provide automated email reminders to log-on to the website.

Identification and mapping of BCTs was problematic, as detailed descriptions of BCTs were often not given, making it unclear exactly what and how information had been delivered across the interventions. A clear description of the functional relationships between components of an intervention and outcomes are essential (Michie *et al.*, 2009).

Figure 2-4: BCTs identified in the included interventions

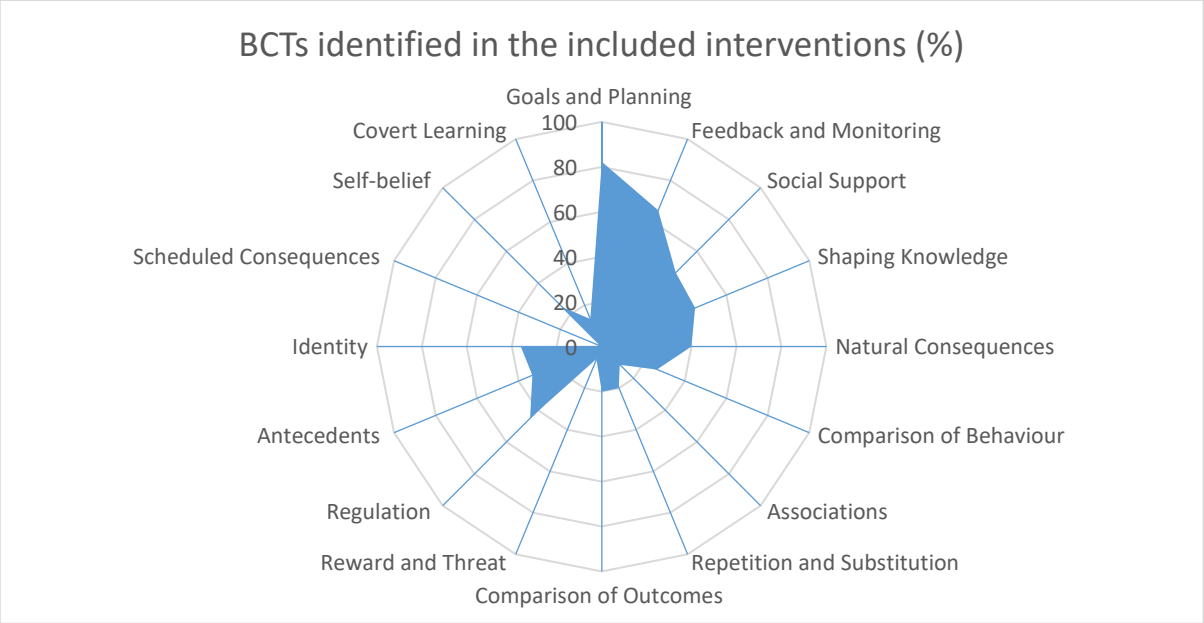


Table 2.8: BCTs used in the interventions

BCT Codings (BCTTv1)	Description	ASMP	CDSMP	IBET	Join2Move/E-exercise	Monitor-OA	PainAction	OA GO
1.1	Goal setting (behaviour)							
1.2	Problem solving							
1.3	Goal setting (outcome)							
1.4	Action planning							
1.5	Review behaviour (goals(s))	*	*		*		*	
1.6	Discrepancy between current behaviour and goal	*	*		*		*	
1.7	Review outcome (goals)							
1.8	Behavioural contract							
1.9	Commitment	*	*		*		*	
2.1	Monitoring of behaviour by others without feedback							
2.2	Feedback on behaviour							
2.3	Self-monitoring of behaviour							
2.4	Self-monitoring of outcome(s) of behaviour							
2.5	Monitoring of outcome of behaviour without feedback							
2.6	Biofeedback							
2.7	Feedback on outcomes of behaviour(s)							
3.1	Social support (unspecified)							
3.2	Social support (practical)							
3.3	Social support (emotional)							
4.1	Instruction on how to perform the behaviour							
4.2	Information about antecedents							
4.3	Re-attribution							
4.4	Behavioural experiments							
5.1	Information about health consequences							
5.2	Salience of consequences							

5.3	Information about social and environmental consequences							
5.4	Monitoring of emotional consequences							
5.5	Anticipated regret							
5.6	Information about emotional consequences							
6.1	Demonstration of the behaviour							
6.2	Social comparison							
6.3	Information about others' approval							
7.1	Prompts/cue							
7.2	Cue signalling reward							
7.3	Reduce prompts/cues							
7.4	Remove access to the reward							
7.5	Remove aversive stimulus							
7.6	Satiation							
7.7	Exposure							
8.1	Behavioural practice / rehearsal							
8.2	Behaviour substitution							
8.3	Habit formation							
8.4	Habit reversal							
8.5	Overcorrection							
8.6	Generalisation of a target behaviour							
8.7	Graded tasks							
9.1	Credible source							
9.2	Pros and cons							
9.3	Comparative imagining of future consequences							
10.1	Material incentive (behaviour)							
10.2	Material reward (behaviour)							
10.3	Non-specific reward							
10.4	Social reward (includes positive reinforcement)	*	*		*			
10.5	Social incentive							
10.6	Non-specific incentive							
10.7	Self-incentive							
10.8	Incentive (outcome)							
10.9	Self-reward							
10.10	Reward (outcome)							
11.1	Pharmacological support							

11.2	Reduce negative emotions (includes 'stress management')							
11.3	Conserving mental resources							
11.4	Paradoxical instructions							
12.1	Restructuring the physical environment							
12.2	Restructuring the social environment							
12.3	Avoidance/reducing exposure to cues for the behaviour							
12.4	Distraction							
12.5	Adding objects to the environment							
12.6	Body changes (strength training/relaxation)							
13.1	Identification of self as role model							
13.2	Framing/reframing							
13.3	Incompatible beliefs							
13.4	Valued self-identify							
13.5	Identity associated with changed behaviour							
14.1	Behaviour cost							
14.2	Punishment							
14.3	Remove reward							
14.4	Reward approximation							
14.5	Reward completion							
14.6	Situation-specific reward							
14.7	Reward incompatible behaviour							
14.8	Reward alternative behaviour							
14.9	Reduce reward frequency							
14.10	Remove punishment							
15.1	Verbal persuasion about capability							
15.2	Mental rehearsal of successful performance							
15.3	Focus on past success							
15.4	Self-talk							
16.1	Imaginary punishment							
16.2	Imaginary reward							
16.3	Vicarious consequences (e.g. positive stories)							

*= coded as linked in taxonomy to another BCT. (e.g. 2.7 feedback on outcome(s) of behaviour (if feedback of behaviour is evaluative e.g. praise, also code 10.4 social reward. NOTE: Following guidance from taxonomy when paper not clear if BCT used or not.

= BCT included in the intervention.

Despite the difficulty in identifying BCTs used within the interventions, certain areas of the taxonomy appeared to be represented much more than others. Goals and planning, feedback and monitoring, and shaping knowledge were widely used. Scheduled consequences (such as punishment and removing rewards), and reward and threat (such as material rewards and incentives) were used much less often.

2.6.11 Uptake and usage of digital interventions

Data were gathered about how each study had reported on user engagement and programme usage. This included information such as duration of log-ins, number of log-ins, and a review of completion percentages for each intervention (See tables 2.9 and 2.10 below).

Table 2.9: RCTs reporting of intervention usage

	Allen (2018)	**Bossen (2013**	**Kloek (2018)**	**Li (2018)**	**Lorig (2006)**	**Loriq (2008)**	**Skrepnik (2017)**	**Trudeau (2015)**
Duration of intervention	12 months	Self-paced 9-week programme	12 weeks	8 weeks	6 week	6 week	3 months (6 months for app adherence – intervention gp only)	6 months
No. of modules	Non-modular. Advice to perform strengthening /stretching 3 x weekly and aerobic as often as possible.	Weekly modules automatically generated. New module each week. Users encouraged	12 weekly incremental programme - 3 modules – Graded exercise, Strength and stability, Information.	Self-guided, plus 4 x biweekly 20-minute phone call with PT.	Participants asked to log on at least 3 times for a total of 1 to 2 hours and to participate in the weekly activities	Participants asked to log on at least 3 times for a total of 1 to 2 hours and to participate in the weekly activities	Participants requested to enter pain and mood data once daily	Two 20-min sessions on the site per week for 4 weeks (eight sessions in total),

		to log in once a week.	(weekly contact over 3 months) (+ 5 face-to-face PT sessions).					+ 5 x 20-min follow-up sessions (one per month for 5 months).
Website/ APP Usage	80% of IBET participants logged onto website. Baseline – 4 months: mean (SD) log on = 20.7 (24.6), median = 9. 4 months – 12 months: mean (SD) log on = 19.8	94% logged on to 1st module 80% completed first module 55% completed 2nd module Av. Completion – 5.6 modules out of 9	Adherence data available for 90/109 participants. 81.1% completed at least 8 out of 12 weekly modules.	No usage data for Fitbit online dashboard/ modification of SMART goals reported.	Eight intervention participants never logged in but completed their 12-month questionnaire .	No data .	91.0% of pts compliant (wore the activity monitor 80% or more of the time), in the 90 day period. Intervention gp - 96.3% compliant. Control gp - 76.9%	57.5 % used the site for at least 160 min during the study. 44,682 pages viewed in study: 8.6 % completing assessments (e.g., Daily Pain Tracker);

	(37.7), median = 0.	(19% completed all modules, 46% reached threshold of adherence (6 out of 9 modules)).					compliant. Of the patients in Group A who entered the 90 to 180 days period (80.2%), 36/101 (35.6%) were 80% or more compliant.	27.8 % accessing content via the personalized recommendation page 59.1 % were reviewing program content.
Other USAGE data reported	None.	Participants selected – walking (46%), cycling (32%), Nordic walking (4%), gardening (4%) and other	Additional study evaluated adherence (De Vries *et al*, 2017) Adherence highest for participants	None.	Intervention participants logged in an average of 26.5 times (SD _ 22.8, range of 0 to 177).	Each workshop of 25 participants generated between 400 and 600 posts to The Discussion	None.	None.

		activities (8%).	with middle education, 1-5 year OA duration, physio recruited.			Centre (No description of what key topics were).		

Table 2.10: Non-randomised interventions reporting of intervention usage

	Bossen 2013 (pilot)	**Jaglal 2013**	**Lorig (2008) UK**	**Lorig 2013**
Duration of intervention	Self-paced over 9-weeks	6 sessions (as CDSMP)	6 weeks	6 weeks
No. of modules	New module each week. Users encouraged to log in once a week.	Weekly group sessions (delivered via telehealth)	Participants logged on several times for a total of 1–2 h weekly.	Participants log on at will several times each week, for a total of 1 to 2 hours weekly
Website Usage	100% (n=20) of the users completed the introduction module. 55% (n=11) completed at least 75% of the program (≥7 week assignments). 70% (n=14) achieved 60% program exposure 30% (n=6) were exposed to at least 30% of the intervention.	71 (31.5%) attended all sessions, 158 (70.2%) attended 4 or more sessions, 20 (8.9%) dropped out of the programme.	Mean logons per participant was 40.1 (mean of 1288 visits to the various pages of the programme). 79% reached the final session. Mean number of sessions = 5.2, out of 6. In a sample of three random classes, the mean number of posts per participant was 44.6.	Percentage participated: 97% for Session 1, 65% for Session 6. Mean number of logins per session varied from: 4.6 (SD = 4.0) for Session 1 to 3.7 (SD = 5.5) Session 6.

Other USAGE data reported	The most listed reasons for skipping a weekly PA were other commitments/ lack of time.		Most frequently posted board was Problem Solving (mean 19.2 per participant), followed by Action Planning (14.4). Posts to Difficult Emotions and Celebrations were less frequent.	

The flow of participants through each study was frequently reported (in accordance with the CONSORT guidelines) as a percentage completing assessments at each time-point, giving a clear picture of attrition within each research study. However, a clear picture of how many participants completed each on-line session was often not provided, with only one study giving full details of the number of participants to complete each session (Bossen *et al.*, 2013b). Allen *et al*, (2018), Lorig *et al* (2006), Lorig *et al* (2008 USA), and Trudeau *et al* (2015) did not report on completion of sessions, but described information such as: average number of log-ins (Lorig *et al*, 2006), number of posts generated on the discussion boards (Lorig *et al,* 2008), total number of minutes using the intervention (Trudeau *et al,* 2015) and most frequently visited pages (Trudeau *et al*, 2015). Skrepnik *et al* (2017) reported the percentage of participants who were compliant (used the app 80% of the time), but did not give any further detail about which parts of the app were used most often (i.e. pain scores, mood scores, setting new goals etc.).

Trudeau *et al* (2015) reported how levels of user engagement were significantly associated with an improvement in outcome measures. Conversely, Bossen *et al* (2013) reported how higher levels of participation had no influence on either primary or secondary outcomes.

The percentage of people reported to participate in all sessions ranged widely from 31.5% to 79%. Most of the interventions described a mean number of web-pages visited but did not detail which pages were visited most often.

The rate of use declined over time in all of the intervention studies, at varying rates. There was also considerable variation in how usage was reported. For example, one study reported a mean number of log-ins for each session (Lorig *et al*., 2013), another reported the mean number of posts put up on the discussion board, and detailed the most popular subjects of discussion which included problem solving and action planning (Lorig *et al.*, 2008a). Bossen *et al* (2013) reported the reasons why people missed their planned PA for that week, with the most common reasons reported to be other commitments and a lack of time.

Conversely, Skrepnik *et al* (2017) reported relatively high compliance with the use of their app, with 96.3% of the intervention group using the app 80% of the time. A high

percentage of these (80.2%) also chose to continue using the app between days 90 – 180. However, only 35.6% were compliant in this phase, showing a drop in app use over this longer time period.

Other systematic reviews have reported similar findings of high attrition (Bossen *et al.*, 2014) describing how this issue may have contributed to the conflicting evidence of overall effectiveness of interventions. This review found two large-sample-size studies with high attrition rates (>50%) with both reporting non-significant findings (increase in PA), whilst two smaller studies with low attrition rates (<20%) yielded significant results. This phenomenon of participants stopping usage or being lost to follow-up has been recognised as a fundamental characteristic and challenge in the evaluation of eHealth applications (Eysenbach and Street, 2005).

2.7 Discussion

Each objective of the review is now discussed individually.

2.7.1 Objective 1 – To determine whether engagement with PA is changed with a digital intervention

A significant improvement in levels of PA were seen in seven of the twelve included studies in this review, providing evidence that people diagnosed with OA can successfully increase their levels of PA (for up to one year post-intervention) using digital self-management interventions. Furthermore, studies that reported non-significant improvements did note a trend towards increased participation. Heterogeneity was present in both study design and study populations, making it difficult for any comparisons to be made across the whole sample. In particular, the studies evaluating the chronic disease self-management programme were heterogeneous for disease, age, education and symptom distribution (Lorig *et al*, 2006b).

A number of studies reported changes in other areas of self-management. Lorig *et al* (2008) demonstrated significant improvements in arthritis self-efficacy (participants' confidence to manage their arthritis) as well as four out of six health indicators measured (health distress, activity limitation, self-reported global health, and pain) even though changes in health behaviours (including PA) were non-significant. Trudeau *et al* (2015)

also reported significant improvements in arthritis self-efficacy and in particular self-efficacy to manage arthritis pain, but not in the self-management behaviour variables measured including PA. Arthritis Self-Efficacy is recognised as a primary goal of self-management education programmes (Lorig *et al.*, 2008b), however, these results suggest that mechanisms other than self-efficacy (to manage arthritis) might also play an important role in changing behaviours such as PA.

2.7.2 Objective 2 – Outcome measures used to measure PA

Adequately measuring PA is important when evaluating interventions that aim to increase levels of PA (van Poppel *et al.*, 2010). Few studies used wearable activity monitors to measure objective PA. Fully validated self-report measures were used, however, they differed in the information they gathered, scoring different activities and lengths of activity in different ways. This heterogeneity amongst the outcome measures made it difficult for comparisons to be made.

Previous systematic reviews evaluating the effectiveness of digital interventions in non-OA specific populations have also reported heterogeneity of outcome measures (Bossen *et al*., 2014; Davies *et al.*, 2012; Foster *et al*., 2013). Subjective measurements tend to overestimate true levels of PA, increasing the variance in outcome measures (Bossen et al., 2014).

It is important to follow up-to-date guidelines on the most accepted and valid measure of PA so that results are transparent and comparable. It is also important to recognise that self-monitoring of behaviour was a commonly used BCT across interventions. Adequate methods of monitoring one's behaviour, whether subjective or objective, might support sustained behaviour change, and future research should further explore optimum monitoring methods.

2.7.3 Objective 3 – BCTs used to facilitate engagement with PA

This review found that a diverse range of BCTs were used within interventions. Coding of the various elements of each intervention against the behaviour change taxonomy

(Michie *et al.*, 2013) was carried out, but this task was difficult due to a lack of detailed reporting on how various elements were attempting behaviour change. Despite this, it was clear that more focus was placed on certain sections of the taxonomy than others. Negative BCTs such as punishments and removal of rewards were not used in any interventions, and none used material rewards or material incentives. This is in line with a social cognitive approach of improving one's self-efficacy, adopted by six of the interventions. All interventions used some form of goal setting, action planning, and provided some form of feedback and ways of monitoring the behaviour. Some of the interventions also used self-belief techniques such as self-talk and valued self-identity. Once again, this appears to be in line with attempting to increase self-efficacy for PA.

Complex behaviour change interventions are often not well described, and when they are, the terminology used is inconsistent (Michie *et al.*, 2013). It is vital to document and evaluate how individual components work, are used by participants, and how this influences the outcome and effectiveness of an intervention (Aalbers, Baars and Rikkert, 2011). Until such reports become widespread it will remain difficult to link specific components of an intervention to a specific effect (Aalbers, Baars and Rikkert, 2011).

Other systematic reviews have provided some evidence for which psychological techniques might be most effective for changing PA (healthy adults, and overweight adults) (Olander *et al*, 2013; Williams and French, 2011). One meta-analysis found how 'action planning', 'provide instruction' and 'reinforcing effort towards behaviour' were associated with higher levels of both self-efficacy and PA. 'Relapse prevention' and 'setting graded tasks' were associated with lower self-efficacy and PA levels in healthy adults (Williams and French, 2011). Another review conducted a similar evaluation but in an obese adult population. This found over 20 BCTs to be associated with positive changes in PA, with interventions containing 'teach to use prompts/cues', 'prompt practice' or 'prompt rewards contingent on effort or progress towards behaviour' found to have the largest effect for PA. A meta-analysis carried out by Webb et al (2010) of digital health behaviour interventions found that interventions that incorporated more BCTs tended to have larger effect sizes.

More recently, Lorig *et al* (2014) carried out a further analysis of the Internet Chronic Disease Self-Management Programme by evaluating the components of action planning within the programme and resulting behaviour change and health outcomes. They found that successful completion of action plans was associated with improved health behaviours (including aerobic exercise) and self-efficacy measures (Lorig *et al*, 2014a).

2.7.4 Objective 4 – Uptake and usage of digital interventions

A significant finding from this review was the wide variety of methods employed to report uptake and usage of digital interventions, making it difficult for any comparisons to be made. It is essential that we learn more about the dose-effect relationship (i.e. the effect of intervention exposure on intervention effectiveness), by recording number of logins, log-in frequency over time, length of logins, and number of pages visited to calculate how intervention exposure might influence any results (Aalbers, Baars and Rikkert, 2011).

Bossen *et al* (2013) reported that a lack of personal guidance, insufficient motivation, presence of physical problems, and low mood were all reasons for non-usage. Absence of human involvement was viewed as a disadvantage, having a negative impact on participation rates. Trust in the programme, functionality of the intervention, and commitment to the research team were all positively associated with usage (Bossen *et al.*, 2013a). A study evaluating the determinants of adherence to the E-exercise intervention (Kloek *et al,* 2018) reported issues such as internet skills, self-discipline, usability, flexibility, and acceptable required time, were all factors affecting adherence (De Vries *et al.*, 2017).

These findings highlight the importance of addressing issues such as motivation, commitment, time constraints, and usability/flexibility when developing digital interventions. It is important to recognise the impact that such issues might have on uptake and usage of an intervention.

2.8 Limitations of the review

There were limitations to this review including heterogeneity across the population groups, study designs and intervention designs. The populations varied across the twelve included studies, with a minority focusing solely on patients with OA.

The content of the interventions was diverse, and it was often unclear how interventions had used specific behaviour change techniques. This made it impossible for any meta-analysis to be carried out. Overall, the risk of bias differed across the included studies, with details such as blinding and allocation concealment often being judged of high risk.

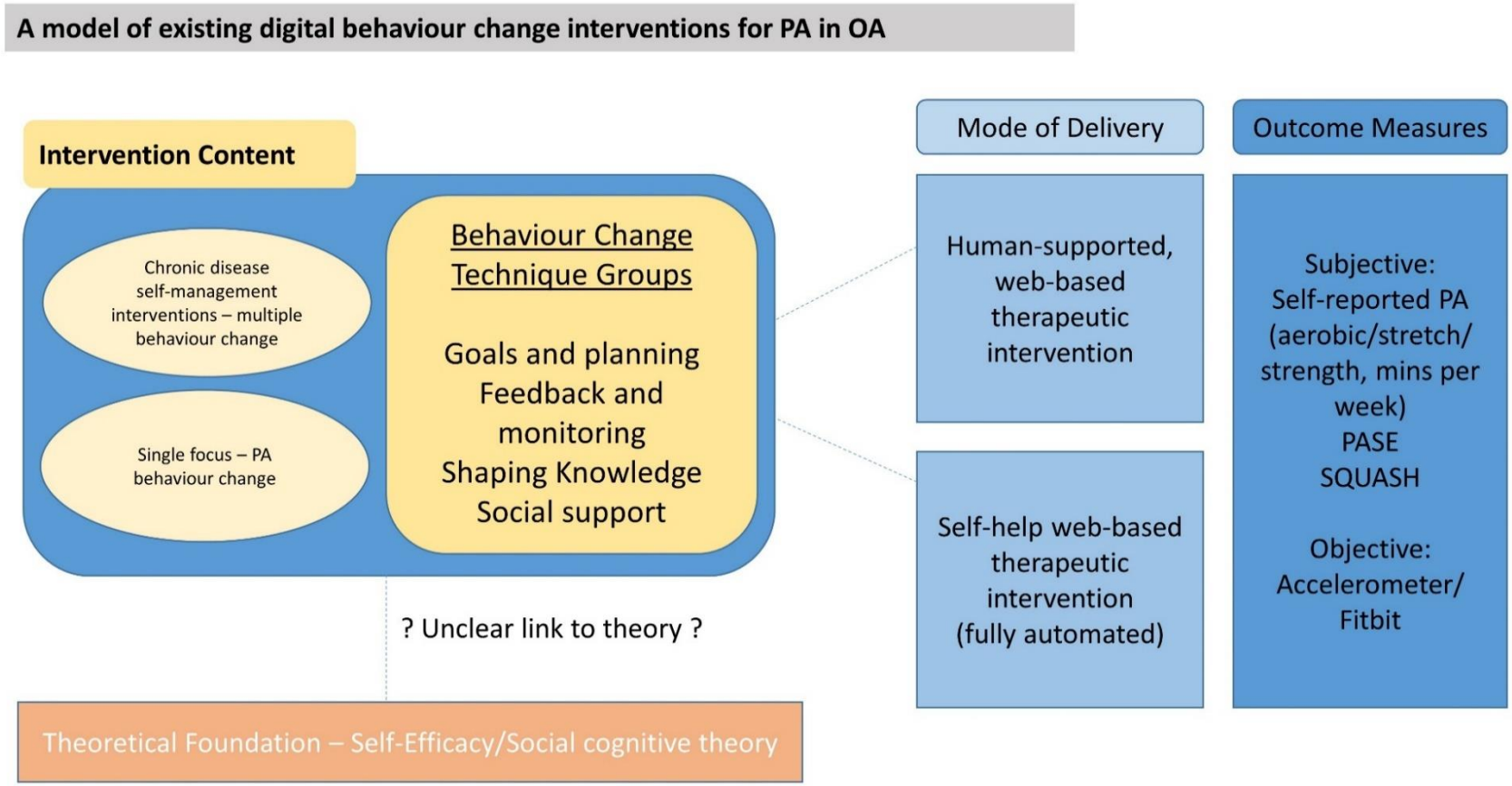
This was due to the inherent nature of exercise interventions, which make these issues particularly challenging (Hurley *et al*, 2018).

Finally, a number of the studies evaluated a multi-component intervention, that is, an intervention aimed at general self-management of OA (including PA levels as well as other health behaviours, pain management, medication management etc). Similar to conclusions in similar reviews, this makes it hard to determine whether the PA components were the actual determinants of any successful PA behaviour change (Bossen *et al.*, 2014).

2.9 Summary of findings and implications for future study design

Figure 2-5 below provides an overview of the current landscape of existing DBCIs in this field, highlighting the key findings from the review.

Figure 2-5: A model of existing digital behaviour change interventions for physical activity in OA



Results of this review showed that digital interventions can have a positive effect on levels of PA in this population, for up to 12 months post-intervention. Key findings from this review show that interventions with a focused primary aim, which do not try to change multiple behaviours simultaneously, resulted in more effective clinical outcomes, for this population. Importantly, a focus on realistic, graded, and autonomous goals that can be easily integrated into everyday life seemed to produce stronger outcomes. Both interventions with, and without human support were associated with improved outcomes, making it difficult to judge which is optimal.

In-depth development and evaluation (with potential end-users) prior to full trial, was seen as necessary, and recognised as a strong point for any intervention. Optimal intervention dosage needs further exploration, as it remains unclear how use of an intervention is associated with long-term engagement with PA. Future exploration of intervention burden, optimal frequency of prompts and moderator interaction would provide new evidence in this area. Future interventions should clearly document which theories and BCTs were used during the development stage, and use accepted taxonomies to record this. Up-to-date guidelines on the most accepted and valid measure of PA adherence should be used, and the uptake and usage of interventions reported in detail.

Information from this review guided future aspects of this thesis by:

- Ensuring the BCTs used within the intervention would be clearly identified. All BCTs were directly coded against the taxonomy used to code interventions within this review (Michie *et al.*, 2013) (Chapter 5).
- Clearly stating how any psychological theory (e.g. self-determination theory/self-efficacy) informed specific parts of the intervention content. This was done in detail during the developmental phase (Chapter 5).

The next chapter investigates the determinants of PA in this population in more detail, guided by the findings of this review. The concept of self-efficacy and other motivational constructs proposed to affect PA behaviours are explored in this population, using a cross-sectional survey to gather data from a sample of people with OA.

Chapter 3: What beliefs, motives, and gains are associated with physical activity in people with osteoarthritis?

3.1 Overview

The previous chapter systematically explored evidence of digital interventions for people with osteoarthritis (OA), and found that half (n=6) of interventions focused on improving levels of self-efficacy for physical activity (PA). Further exploration of the relationship between theoretical constructs such as self-efficacy and autonomous motivation in this population could help to guide future intervention development, by highlighting the potential impact that these constructs have on both changing and maintaining PA behaviours.

This chapter builds on the last, by exploring in more detail the motivations, beliefs, gains, and levels of self-efficacy for PA in a group of people with OA. Findings from this chapter are taken forward to future chapters of this thesis, to inform the development of a digital health intervention to motivate people with OA to become and stay active.

3.2 Rationale

Motivation and Self-Efficacy for exercise, are both considered to be key, yet unique factors in understanding behaviour change and sustained participation in PA (Peeters, Brown and Burton, 2014; Slovinec D'Ange*lo et al*, 2014; Teixeira *et al*, 2012).

The previous chapter reported that a number of existing digital interventions were based on self-efficacy. Whilst most studies produced small, yet positive improvements in levels of PA, they also reported high levels of attrition, suggesting that self-efficacy might not be the only construct affecting levels of PA in this population.

The extent to which the construct 'self-efficacy' might overlap with other elements of motivation, has been debated (Rodgers *et al*, 2014; Senecal, Nouwen and White, 2000; Slovinec D'Angelo *et al*, 2014). The importance of distinguishing between different concepts is recognised, for both theoretical and practical purposes. Clearly distinguishable variables can contribute to a greater understanding of human behaviour

(Rodgers and Sullivan, 2001). A greater understanding of the effect that constructs such as self-efficacy and autonomous motivation have on levels of PA in this population, can assist with the identification of key constructs to utilise within a behaviour change intervention.

This study adds to both self-efficacy and motivation literature in this field, by carrying out an in-depth quantitative analysis, using validated questionnaires that have been specifically designed to measure the impact of these psychological constructs on levels of PA.

Autonomous motivation and self-efficacy are now discussed in more detail, before the aims and objectives of this study are described.

3.2.1 Motivation

Motivation represents one's will or determination to act, and is defined as 'the psychological energy that initiates and continuously directs behaviour' (Slovinec D'Ange*lo et al*, 2014, p1345). Previous research has recognised that motivation can act as a facilitator for PA in people with OA (Brittain *et al.*, 2011; Holden *et al.*, 2012; Petursdottir, Arnadottir and Halldorsdottir, 2010).

Motivation is most comprehensively defined by self-determination theory (SDT) (Deci and Ryan, 2000), a broad theory of human motivation which delineates motives according to the degree to which they are non-self-determined versus self-determined (Slovinec D'Angelo *et al.*, 2014), and this theory has been used frequently in PA research (Teixeira *et al.*, 2012).

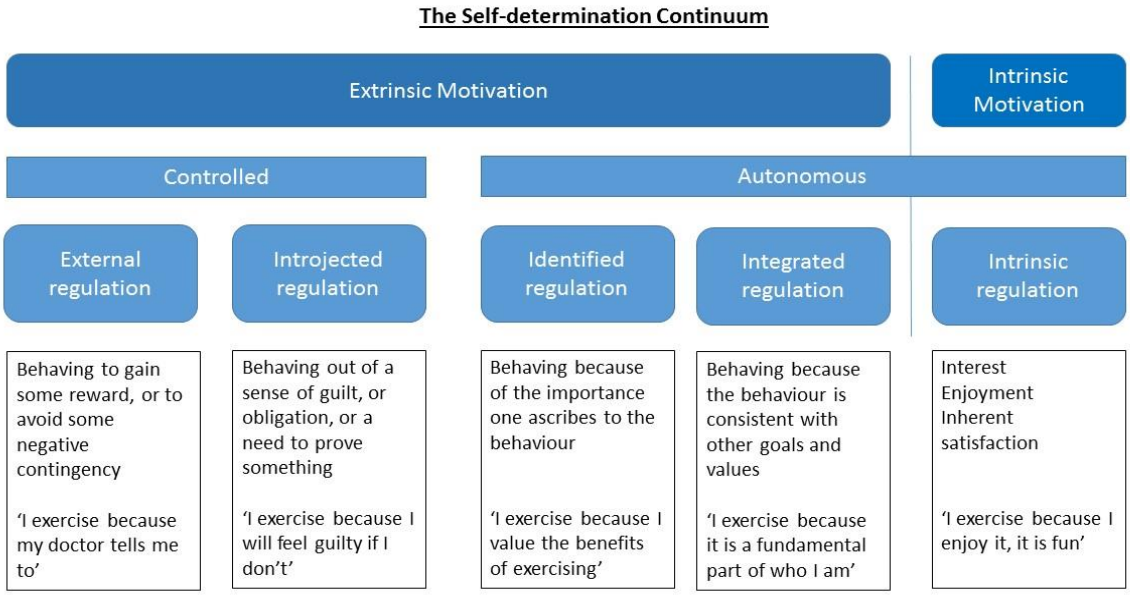
SDT maintains that three innate psychological needs when satisfied yield enhanced motivation:

- Autonomy: Being fully engaged and feeling in control of one's actions
- Relatedness: Being connected and valued by others
- Competence: Having a mastery over one's actions, being competent.

(Deci and Ryan, 2000)

SDT theorises that by using behaviour change techniques that satisfy all three of these needs, motivation will be sustained over a longer period. The continuum of motivation is used to describe how an individual is motivated, ranging from extrinsic (controlled), to intrinsic (autonomous) as shown in figure 3-1 below. Intrinsic motivation can be described as doing an activity just because it is fun, or to learn new skills. In contrast, extrinsic motivation refers to doing an activity to achieve a desirable outcome such as weight loss, or to avoid disapproval by others (Teixeira *et al.*, 2012).

Figure 3-1: The self-determination continuum showing types of motivation with their regulatory styles.



(Adapted from: (Ryan and Deci, 2000; Ng et al*, 2012; Patrick and Williams, 2012, open access)*

Importantly, intrinsic motivation (autonomous regulation) has been found to be associated with an increased likelihood of exercise (Ingledew, Markland and Strömmer, 2013), and as being predictive of long-term exercise maintenance (Teixei*ra et al*, 2012). A comprehensive review of 66 empirical studies, examined the relationship between SDT-constructs and PA behaviour outcomes, and found a positive relationship between more autonomous forms of motivation and level of activity. More specifically, the review reported a trend towards identified regulation predicting initial/short-term

adoption of PA more strongly than intrinsic motivation, and intrinsic motivation being more predictive of long-term exercise adherence (Teixeira *et al.*, 2012).

These findings support the argument for interventions to generate more intrinsic forms of motivation for a behaviour, thus creating more autonomous forms of motivation, so that engagement with the intended behaviour is sustained over time.

3.2.2 Self-Efficacy

The psychological variable of self-efficacy (SE) was first proposed by Albert Bandura in 1977, who described it as a construct denoting one's belief in his or her ability to successfully organise and implement a specific task, such as PA. Bandura (1977) proposed that SE beliefs, which can be strengthened, potentially explained the discrepancy between having knowledge about a skill and the actual performance of this skill. This supports the view that SE beliefs are predictive of motivation levels, thought patterns, emotional reactions, and attitudes that can mediate the willingness to participate in health-promoting behaviours (Bandura, 1977).

Research has established the importance of SE in the self-management of chronic conditions (Dobkin *et al.*, 2005; Slovinec D'Angelo *et al.*, 2014), and effect on levels of PA in healthy adults (Williams and French, 2011) and older adults (McAuley, Lox and Duncan, 1993). The effect that SE might have on levels of PA specifically in people with OA has also been examined (Hammer *et al.*, 2015; Gecht *et al.*, 1996; Gyurcsik, Estabrooks and Frahm-Templar, 2003; Marks and Allegrante, 2005; Marks, 2014; Peeters, Brown and Burton, 2014).

Gecht *et al.*, (1996) studied the influence of beliefs on exercise participation among people with arthritis and demonstrated that the stronger one's belief in the benefits of exercise and the higher one's SE for exercise, the greater the frequency and intensity of exercise participation (Gecht *et al.*, 1996). This was supported by research from Gyurcsik et al (1993) who found a positive relationship between higher levels of self-efficacy and attendance at an aquatic exercise class for people with arthritis.

3.3 Aim

The aim of this study was to explore what different beliefs, motives, and gains were associated with PA engagement in a group of people with OA.

3.3.1 Objectives

The research objectives were:

1) To determine which participation motives were present for PA in a group of people with OA.
2) To determine which participation gains were present for PA in a group of people with OA.
3) To assess the level of exercise self-efficacy in a group of people with OA.

3.4 Design and Methods

Much consideration was given to the most appropriate method to meet the aim and objectives of the study. Previous research has used qualitative methods (such as focus groups and interviews) to investigate the various determinants of PA in this population (Holden *et al.*, 2012; Hurley *et al.*, 2010; Petursdottir, Arnadottir and Halldorsdottir, 2010), with numerous determinants reported to affect behaviour and motivation, often within small sample populations.

The aim of this study was to investigate the specific role that different motivations and beliefs might have on PA participation, and to further compare currently active participants with those who did not participate in PA.

Therefore, this study adopted a cross-sectional survey research design, utilising a one-point-in-time questionnaire to gather information. Advantages of survey research include the ability to reach a large group of participants, producing a large amount of data in a short amount of time, and at low cost (Kelley *et al.*, 2003). This enables researchers to set a finite time-span for a project, which can assist with project planning. Other methods such as focus groups and interviews, whilst being able to collect more in-depth information, are more costly, time-consuming, and typically involve much smaller groups of participants (Kelley *et al*, 2003).

3.4.1 Questionnaire Development

Several different questionnaires that assess levels of motivation for PA were considered for use in the study. The sections below describe measures used in previous research investigating motivations and SE for PA and provide a rationale for why the final measures for motivation and self-efficacy were selected.

3.4.1.1 Motivation for physical activity measures

A variety of different scales have been used in previous research investigating the effect of motivation on levels of PA.

Teixeira et al (2012) reviewed the literature that has explored exercise motivation from a SDT perspective. They found that the Motivation for Physical Activity Measure (MPAM-R), and the Exercise Motivations Inventory (EMI-2) have both been used to assess exercise motives in a variety of populations (See Appendix B1 and B2 respectively). Table 3.1 below provides more detail of these questionnaires, including a critique of their appropriateness for use in this study.

Table 3.1: Overview of questionnaires used to assess motives for physical activity

Measure	Description	Critique	Populations
EMI-2 - Exercise Motivations Inventory (Markland and Ingledew, 1997)	Examines issues such as: • Influence of motives on exercise participation, • How affective responses to exercising may be influenced by reasons for exercising • How involvement in PA might have a reciprocal influence on participation motives • Groups questions into sub-categories (appearance/weight management, enjoyment/revitalisation, social engagement, health/fitness)	(+ve) Comprehensive assessment of factors affecting participation motives for PA. (+ve) Applicable to both exercisers, and non-exercisers.	Students (mean age 19.5yrs) Office workers (mean age 40yrs) Employees (mean age 40yrs) (Teixeira *et al.*, 2012)
MPAM-R - Motivation for Physical Activity Measure - Revised (Frederick, & Ryan, 1993)	Assesses the strength of five motives for participating in physical activities such as weight lifting, aerobics, or various team sports. • Fitness – being physically active out of the desire to healthy, and to be strong and energetic • Appearance – to look better, to achieve or maintain a desired weight • Competence/challenge – to meet a challenge, to acquire new skills • Social – to be with friends and meet new people • Enjoyment – being active just because it's fun, makes you happy, is interesting, stimulating	(+ve) Comprehensive assessment of factors affecting participation motives for PA. (-ve) Sport focused – asks about primary sport carried out. Less appropriate for non-exercisers?	Healthy adults (mean age 39yrs) College students (mean age 22yrs) Chinese adults (30-59 years) (Teixeira *et al.*, 2012)

Both questionnaires were considered to carry out a comprehensive analysis of the motives affecting PA. However, for the purposes of this study, it was felt that the EMI-2 was more appropriate, primarily because the questionnaire could be completed if the participant was not currently active. Due to the nature of the population being studied, it was expected that a proportion of the sample in this study would be currently inactive. The EMI-2 would enable information to be gathered from the whole sample. There was also more of a general focus on PA, and less 'sport-focused', when compared to the MPAM-R. Therefore, the EMI-2 (combined into a recently updated version – see details below) was adopted for use in this study.

Exercise Motivations Inventory (EMI-2) / Exercise Motives and Gains Inventory (EMGI)

A recent development of the EMI-2 is the Exercise Motives and Gains Inventory (EMGI) (See Appendix B3) which incorporates the role of perceived exercise gains (what people feel they get from exercise), as well as the role of exercise participation motives (what an individual aims to attain or avoid through participating in a certain behaviour) (Strömmer, Ingledew and Markland, 2015). The authors argue that previous PA motive research has overlooked the possible role of gains, and hence the possible role of motive fulfilment (when people get what they want) in PA participation (Ingledew, Markland and Strömmer, 2013). The effect that gaining more than originally expected from PA has yet to be explored in this population.

The questions attempt to gain insight into which types of motives are present by using questions such as, 'personally, I exercise (or might exercise) to stay slim, … to avoid ill-health, …. because I enjoy the feeling of exerting myself. Answers are given using a 5-point Likert scale (ranging from 0 = not at all true for me, to 4 = very true for me). Fifty-one questions in total are grouped into 14 sub-scales, which can be further aggregated into 'higher-orders' as shown below.

- Appearance/weight management (appearance, weight management)
- Social Engagement (affiliation, challenge, competition, social recognition)
- Enjoyment/revitalisation (enjoyment, revitalisation, stress management)
- Negative Health (Health pressures, ill-health avoidance)

- Health / Fitness (positive health, strength/endurance, nimbleness)

The appearance and weight management grouping features questions related to looking younger, looking more attractive, staying slim, and helping to control weight. Social engagement refers to spending time with friends, developing personal goals, trying to win in physical activities, and comparing one's abilities to others. Enjoyment and revitalisation refers to enjoyment of the experience of exercising, feeling good, and helping to reduce tension. Negative health questions focus on doing exercise following advice from a doctor and preventing health problems. Finally, health/fitness questions refer to maintaining good health, building up strength, and maintaining flexibility.

Motive scores ranged from 0-4, with the following description given on the questionnaire:

0 = Not at all true for me

2 = Somewhat true for me

4 = Very true for me

(Strömmer, Ingledew and Markland, 2015)

This novel approach of focusing on the impact of both exercise motives and exercise gains (the EMGI) has yet to be evaluated in people with OA.

Psychometric properties – Validity can be defined as 'the degree to which scores on an appropriately administered instrument support inferences about variation in the characteristic that the instrument was developed to measure' (Cizek, 2012 p35). Confirmatory factor analysis is an important component within a broad class of methods called structural equation modelling. It assesses how well measured variables reflect certain latent variables, i.e. how well does a questionnaire capture what it intends to measure (Thompson, 2004).

Confirmatory factor analysis of the EMGI indicated that the 14 subscales have good discriminant validity and reliability, with items reflecting their intended constructs (Strömmer, Ingledew and Markland, 2015). Cronbach's alpha coefficients were above 0.70 for all categories, except for the health pressures motive (0.54), health pressures

gain (0.68), and revitalisation motive (0.68) (score closer to 1 = best fit). The correlations of motive scales with corresponding gain scales were all significant and positive, and were notably high for enjoyment (0.83), competition (0.84), and stress management (0.86) (Strömmer, Ingledew and Markland, 2015).

It is important to note that these results were from a population of young, healthy adults. One of the lowest scoring subscales was the health pressures motive scale (0.54). Whilst such areas might not apply to healthy young adults, it could apply to other samples (Strömmer, Ingledew and Markland, 2015). Equally, the competition motive and gain scales, were the highest scoring (0.94 and 0.95 respectively), another area which might not be so applicable in different populations.

3.4.1.2 Self-efficacy Measures

The attributes of self-efficacy (in the arthritis population) have been assessed most consistently by an instrument developed by Lorig *et al*. (1989) (see Appendix B4) that focuses on pain self-efficacy, self-management, and functional self-efficacy (Bossen *et al.*, 2013b; Dobkin *et al.*, 2005; Marks, 2014). Self-efficacy for exercise, task self-efficacy, coping self-efficacy, scheduling self- efficacy, and mobility-related self-efficacy, are among other domains that have also been examined (Marks, 2014).

Despite being a preferred measure in this population, the Arthritis Self-Efficacy Scale (Appendix B4) fails to clearly focus on specific behaviour change such as PA but is more generic covering all areas of arthritis self-management, including pain, function, and other symptoms related to OA. Certain questions are also very joint specific (asking, for example about how certain activities affect joints in the hand, which may not be applicable to all people with OA).

Exercise Self-Efficacy Scale (ESE)

After a comparison of measures used to assess SE in this population, it was felt that the ESE questionnaire (See Appendix B5) most accurately measures the specific aspects of SE

that might affect whether or not a person with arthritis participates in PA, over the long-term.

Gecht (1996) developed and used the Exercise Self-efficacy Scale (ESE), which proposes that the likelihood of engaging in health-related behaviour (specifically exercise or PA within the arthritis population) is dependent upon the perceived benefits of the behaviour, the perceived barriers to the behaviour, and the perceived threat posed by not engaging in the behaviour (Glanz and Bishop, 2010). The ESE examines the following concepts: beliefs about one's ability to exercise (self-efficacy for exercise), barriers to exercise, benefits of exercise, and the impact of exercise on arthritis.

Dobkin (2005) used both the arthritis self-efficacy scale (Lorig 1989), and the ESE (Gecht, 1996), and compared these measures to levels of PA in people with fibromyalgia. They found a trend between beliefs about exercise, and actual levels of PA, and a negative association between barriers to exercise and levels of PA. Hurley *et al* (2012) used the ESE to assess changes in self-efficacy and beliefs over a period of 30 months, following a rehabilitation programme for chronic knee pain (which integrated patient education, self-management strategies, and exercise). An increase in self-efficacy for exercise was seen immediately following the intervention (significant difference between intervention and control groups), and these changes were maintained at 18 months.

The ESE is a 20-point questionnaire, divided into four sub-categories:

- Beliefs about one's ability to exercise (self-efficacy for exercise)
- Barriers to exercise
- Benefits of exercise
- Impact of exercise on arthritis.

Answers are given on a five-point Likert scale (1-5, ranging from strongly agree, to strongly disagree). Some questions are reverse scored (See Appendix B6 for ESE scoring key), and an average mean score can be taken of the whole scale, or individual sub-categories.

Psychometric Properties – The internal validity of this questionnaire has been evaluated. Alpha coefficient scores for the four sub-scales were: self-efficacy for exercise 0.73; barriers to exercise 0.80; impact of exercise on arthritis 0.89; and benefits of exercise 0.90 (Gech*t et al*, 1996).

3.4.1.3 Definition of Physical Activity and Exercise

Both the EMGI and ESE questionnaires use the terms 'physical activity' and 'exercise' interchangeably. For clarity, the following definition was provided at the start of the participants' questionnaire (Box 3-1 below). This definition is based on one used in the UK Department of Health policy 'Start active, Stay active – A report on PA for health' (Department of Health, 2011). It was easy to understand, whilst also providing helpful, real-life examples.

Box 3-1: Definitions of physical activity and exercise used in the questionnaire

What is physical activity? - For the purposes of this questionnaire, we use the following definition to cover both terms 'physical activity' and 'exercise':

Physical activity includes all forms of activity, such as everyday walking or cycling to get from A to B, work-related activity, active recreational activities (such as going to the gym), dancing, gardening or playing active games, as well as organised and competitive sport.

Examples: Swimming, brisk walking, range of motion exercises, exercise classes, cycling, dancing, tai chi, or gardening.

Note: This can include any exercises you may have been given to do by a healthcare professional.

(Department of Health, 2011)

3.4.1.4 Level of Physical Activity

A key aim of the study was to assess how motivation and levels of self-efficacy differed in groups reporting different levels of current PA. Therefore, it was important that data were gathered on participants' level of PA. The following questions (see Box 3-2) were used to gather information about each participant's current level of PA, and history of PA.

Box 3-2: Levels of Physical Activity

If you **DO NOT** currently participate in physical activity, please answer the following question:

How long has it been since you did ***regular*** physical activity or exercise? (please circle)

a) Less than 6 months
b) More than 6 months but less than 1 year
c) More than 1 year but less than 2 years
d) More than 2 years but less than 5 years
e) More than 5 years but less than 10 years
f) More than 10 years
g) I have never been regularly physically active

If you **DO** currently participate in physical activity, answer the following questions:

1) How many days per week are you physically active? (circle/days) 1 2 3 4 5 6 7
2) Approximately how long each day (minutes)? _____ mins
3) How long have you been physically active at this level? (please circle)
   a) Less than 6 months
   b) More than 6 months but less than 1 year
   c) More than 1 year but less than 2 years
   d) More than 2 years but less than 5 years
   e) More than 5 years but less than 10 years
   f) More than 10 years
4) What activities do you do? (please circle all that apply)
   a) Walking
   b) Swimming
   c) Cycling
   d) Gym
   e) Exercise classes
   f) Dancing
   g) Gardening
   h) Tai Chi
   i) Exercises from a healthcare professional
   j) Other (please state)
   _____

Various cut-points were considered for analysing the PA levels of the sample. The policy guidelines of 150 minutes per week of moderate intensity activity are the same for adults (18-64) and older adults (≥65) (Public Health England, 2014). Recent commentary has argued that a focus on this recommendation may mean that the benefits of smaller amounts of activity are overlooked (de Souto Barreto, 2015; Powell, Paluch & Blair, 2011; Sparling *et al*, 2015). Furthermore, guidance from the UK's Chief Medical Officer states, "the majority of UK older adults have low levels of activity, and so it is important to emphasise that those who are currently inactive can achieve some health benefits from increasing their activity, even if it is below the recommendation". In such cases, a gradual increase in the frequency, duration and intensity of activity to achieve the target is recommended (Department of Health, Physical Activity, 2011, p38).

Because of this, days per week when physically active, rather than total minutes per week, were used to categorise the group as follows:

- Non-actives (no PA at present)
- Low actives (carry out PA between 1-3 days per week)
- High actives (carry out PA on 4 of more days per week)

3.4.1.5 Demographic Data

Demographic information collected included: gender, date of birth, postcode, marital status, level of education, and co-morbidities.

3.4.1.6 Severity of OA

Participants were also asked to rate the perceived severity of their OA using a visual analogue scale (VAS). This was to establish a picture of the range of perceived severity within the sample.

The VAS is a widely used measurement instrument, which measures a characteristic or attitude believed to range across a continuum of values. It is commonly used to measure pain, or other variables that cannot be easily measured (Crichton, 2001). Other measures of disease severity were considered, such as the Western Ontario and McMaster Universities Arthritis Index (WOMAC (hip or knee)) or the Knee Injury and Osteoarthritis

Outcome Score (KOOS), which have been used in previous OA research (Bossen *et al*, 2014; Damush *et al*, 2005; Hurley *et al*, 2010; Kapstad *et al*, 2008; Kloek *et al*, 2014; Li *et al*, 2013; Veenhof *et al*, 2006). These questionnaires would take longer to complete than the VAS, and eligibility criteria for this study included people with OA in any joint, therefore a joint-specific questionnaire would not have been suitable. Severity of disease was not an outcome in this study, therefore, a simple measure was deemed adequate, to describe the population sample.

3.4.1.7 Patient Insight Partner Involvement

A patient insight partner (JA) was recruited to give advice regarding the design of the questionnaire. Insight from an expert patient was very helpful, specifically in gaining a greater understanding of the interpretation of the questions, and the general flow of the questionnaire. The patient insight partner trialled the questionnaire on a number of occasions (along with other team members). Comments were made on ease of use, duration of completion, flow of the questionnaire, and timings to complete. Some minor adjustments were made prior to widespread distribution. These consisted mainly of changes in wording on the participant information sheet, for example, about how long the questionnaire would take to complete. Some of the questions in the EMGI were also described as being repetitive; however, no changes could be made, as this would have invalidated the questionnaire.

3.4.2 Sample Population

Participants were recruited to complete the survey via two routes: postal and online. These methods were chosen for several reasons. Access was available to a group of participants who had previously taken part in a study within the Centre for Health and Clinical Research at the University of the West of England (UWE). This group had consented to be contacted in the future, about any new research projects. There were 200 participants in this group, all from the South West region of England. To increase the number of participants in the study, and to widen geographical spread, the questionnaire was also advertised online, via national arthritis charities and online arthritis groups (see Table 3.2 below).

3.4.2.1 Postal recruitment:

The questionnaire pack was posted to 200 participants who met the study inclusion and exclusion criteria, had previously taken part in a research study within the Centre for Health and Clinical Research at UWE, and had consented to be contacted about any future projects.

The pack included:

- Invitation Letter (Appendix B7)
- Participant Information Sheet (Appendix B8)
- Study Questionnaire – (Appendix B9)
- Pre-paid envelope (for return of questionnaire)

The Invitation Letter and Participant Information Sheet provided information about the study including; the purpose of the study, why the participants were invited to take part, what the study involved, and what would happen with the results.

The anticipated return rate was 40-50%, as guided by accepted response rate trends for postal questionnaires (Baruch and Holtom, 2008).

3.4.2.2 Online Recruitment:

Ethical approval was also granted to distribute the questionnaire via an online advert (Appendix B10) to several charities and arthritis associations (See Table 3.2 below). The online advert led directly to an online version of the questionnaire (a replica of the postal version).

Table 3.2: Distribution of questionnaire

Organisation	**Details of support**
Arthritis Action	Shared online and with all members
Arthritis Care	Shared link to questionnaire on Facebook (FB) page
Arthritis Care Wales	Shared link to questionnaire on Facebook (FB) page
Arthritis Digest online	Shared on FB and twitter feed
Arthritis Research UK (via Professor Nicola Walsh)	Advertised in Arthritis Today issue
Bournemouth University (via Dr Sarah Muir)	Shared on twitter feed and sent to research participant pool
CHCR UWE twitter account	Shared on twitter feed
University of the Third Age	Placed in monthly newsletter
University of the Third Age (Bournemouth group)	Monthly email sent out to group

Qualtrics online software (Qualtrics, 2016) was used to design and disseminate the questionnaire, and there was also an option for participants to request a paper copy, if they preferred this method of completing the questionnaire.

3.4.3 Sample Size

Due to the nature of the recruitment methods described above, a pragmatic approach was taken with regards to sample size, as the reach of the questionnaire was unclear. Therefore, an approximate sample size was not suggested, but rather a period for which the online questionnaire would remain live and accessible (5 months).

3.4.3.1 Inclusion Criteria

Participants who had previously taken part in a research study in the Centre of Health and Clinical Research led by Professor Nicola Walsh; Facilitating Activity and Self-management in Arthritis (FASA Study - ISRCTN66190737) were invited to take part. All participants from the FASA study had a clinical or radiographic diagnosis of OA/degenerative joint pain, and were aged 50 or over.

For online recruitment, the following inclusion criteria applied:

Inclusion criteria: Adults (≥18 yrs.) with a diagnosis of OA

All participants had to meet the inclusion criteria to be eligible to take part. The online version of the questionnaire included a question prior to consent as follows:

Do you have a diagnosis of osteoarthritis? YES / NO.

For those who selected 'NO' an automated message appeared explaining that they were not eligible to enter the study.

Previous research has recognised the potential benefits of self-reporting OA, particularly in large-scale population studies. It can be quicker, cheaper, and does not require a radiological or GP confirmation (March *et al.*, 1998). Parsons et al (2015) recently investigated the agreement between radiographic, clinical, and self-reported diagnoses of OA, and found modest agreement (72% of study participants with a self-reported diagnosis of OA, were also found to have a radiographic diagnosis of OA) between the different methods of reporting (Parsons *et al*, 2015). Another study aimed to determine whether a self-completed postal questionnaire could detect OA in the community, and found that nearly all self-reported diagnoses of OA could be confirmed following clinical examination (March *et al.*, 1998).

3.4.3.2 Informed consent

Informed consent was collected using a number of statements (see pages 1 and 2 of study questionnaire, Appendix B9). These included confirmations that the participant had read and understood the information sheet and understanding that involvement in the study was voluntary. Standard paragraphs including details about the 1998 Data Protection Act,

and details about how information would be used and stored by the university, were provided.

Participants were asked to initial a box next to each of these statements to confirm that they were willing to take part in the study.

3.4.3.3 Ethical Considerations

Ethical approval from the Faculty Research Ethics Committee at the University of the West of England was granted in August 2015 (UWE REC REF No: HAS/15/06/184). Two methods of recruitment (postal questionnaires and online questionnaires) were then carried out simultaneously.

No patient identifiable data were used. A unique reference number was allocated to each completed questionnaire received by the research team, and then used throughout the project. All electronic data were stored on encrypted laptops/computers and all data in paper format were always locked in secure filing cabinets.

3.4.4 Data Analysis Plan and Storage

Both data sets (online and postal) were combined and imported into excel. Data were cleaned and checked for duplication. Any duplicates were removed. Questions were scored in the same way for both data sets (including any reverse scoring etc.). Scoring keys are provided in Appendix B6 (ESE scoring key) and Appendix B11 (EMGI scoring key).

Participants who returned postal questionnaires with missing data were contacted (if they had completed the optional contact details section at the end of the questionnaire). Where contact could not be made, missing data was coded as 999. The online questionnaire was designed so that all questions required a score, before proceeding to the next page, therefore no missing data was present in the online sample.

Means and standard deviations (SD) were used to describe the data from the EMGI and ESE questionnaires, in line with previous papers that have used these questionnaires (Dacey, Baltzell & Zaichkowsky, 2008; Hurley *et al*, 2010; Silva *et al*, 2010). Graphs were also used to show the spread of reported scores for different categories of the

questionnaires. Descriptive statistics and frequency distributions were used to describe the results for this sample, guided by the objectives of the study.

Inferential statistics were used to explore the differences between groups within the sample. ANOVA (Analysis of variance) tests were used to look for differences between the means of the different PA sub-groups (non-actives, low actives, high actives) (variation between conditions). ANOVA tests measure the variation between (more than two) groups, when the independent variables are categorical rather than continuous (Miles and Shevlin, 2005).

3.5 Results

The sample of 262 (mostly female) participants had a mean age of 64 years and had been diagnosed with OA for approximately 11 years (most commonly knee or hip OA). Most were physically active on four or more days per week, and they carried out a range of activities, most often walking and gardening. Postal code data collected as part of the demographic information revealed that the sample came widely from across the UK, and Republic of Ireland.

Questionnaire distribution and completion took place between August 2015 and January 2016. Both methods of recruitment (postal and online) returned good response rates. The postal survey response rate was 50% (n=100), and online recruitment added another 162 completed questionnaires to the sample, resulting in a total sample of 262.

Appendix B12 provides further details of the completion rates for each section of the questionnaire. Various sections of the questionnaire were only applicable if the participant was currently physically active or had been physically active in the last 12 months, therefore, some participants were not required to complete all sections.

3.5.1 Data Preparation

All data were examined (using IBM SPSS version 22) using descriptive statistics to check that continuous variables were within an expected range, means and SDs were plausible,

and that all discrete variables were within range. (Tabachnick & Fidell, 2014). Distribution of data was also check for normality, prior to any analyses being carried out.

3.5.2 Demographics

Table 3.3 below provides details of the demographics of the sample. 80% of the sample were female. The mean age was 64 years (SD = 11 years). Most of the sample were married or had a partner (68%). The most common co-morbidities reported were hypertension and diabetes (See Appendix B13 for co-morbidities).

Table 3.3: Sample characteristics of participants

Number in sample		N = 262
Sex	Female	209 (80%)
	Male	53 (20%)
Age (years)	Mean (SD)	64 (11)
	Minimum	33
	Maximum	92
Marital Status	Single	26 (9.9%)
	Married/partner	177 (67.6%)
	Divorced/separated	28 (10.7%)
	Widowed	30 (11.5%)
	Other	1 (0.4%)
Highest level of education	GCSEs or equivalent	48 (18.3%)
	College diploma or equiv.	61 (23.3%)
	University degree or equiv.	68 (26.0%)
	Post-graduate qualification	57 (21.8%)
	None	26 (9.9%)
	Missing	2 (0.8%)
Co-morbidities	Hypertension	56
	Diabetes	21
	Mental Health Condition	17
	Heart disease	16
	Lung disease	8
	Other	72 (Appendix B13)
	Osteoarthritis Symptoms	
Duration of OA (years)	Mean (SD)	11 (10)
	Minimum	1
	Maximum	61
Joints affected by OA (n=164 online participants only)	Knee	117
	Hip	84
	Spine	65
	Hand	72
	Other	58
VAS (OA severity) (0-100)	Mean (SD)	49 (23)
	Minimum	0
	Maximum	100

*VAS – Visual Analogue Scale, (SD) – Standard Deviation

3.5.3 Duration of OA

Participants were asked how long they had been diagnosed with OA. The mean duration since diagnosis was 11 years, with a standard deviation of 10 years (Table 3.3 above).

3.5.4 Joints affected by OA

Participants who completed the questionnaire online (n=164) were asked which joints were affected by OA. This question was not in the paper version of the questionnaire, but the online version was updated to enable this information to be gathered. Knee and hip joints were most commonly reported as being affected. Other joints affected included ankles, elbows, feet, shoulders, and wrists (Table 3.3).

3.5.5 Severity of Osteoarthritis

Participants perceived severity of their OA was reported as a mean score of 49, with a standard deviation of 23 (possible score 0-100).

3.5.6 Physical Activity History

Table 3.4 below shows how levels of PA were reported across the sample.

Table 3.4: Physical Activity History

Sample (n=262)	Currently active	199
	Currently not active	51
	Missing	12
Currently not active (n=51)		
Time since last active	<6 months	7
	6-12 months	8
	1-2 years	7
	2-5 years	10
	5-10 years	5
	>10 years	6
	Never	8
Currently active (n=199)		
Days per week when active (n=199)	Mean (SD)	5 (2)
	Low active (1-3 days)	38 (19%)
	High active (4-7 days)	161 (81%)
Minutes per day (n = 193)	Mean (SD)	70 (60)
	Minimum	10
	Maximum	420
Time active at this level	<6 months	11
	6-12 months	15
	1-2 years	13
	2-5 years	33
	5-10 years	35
	>10 years	92
Activities	Walking	178
	Gardening	122
	Swimming	58
	Exercises from a healthcare professional	50
	Cycling	42
	Exercise classes	37
	Gym	25
	Dancing	15
	Tai Chi	4

3.5.7 Motives for Physical Activity

Table 3.5 shows the means and standard deviations (SD) for the whole sample. The sample was split into those who were currently not active, those who reported being active for at least 1-3 days per week (low active), and those who reported being active between 4-7 days per week (high active). The reasoning behind dividing the sample in this way was reported earlier in section 3.4.1.4 of this chapter).

The general trend was an increase in mean motive score, as reported level of PA increased. Results of the inferential tests are reported below in section 3.5.7.2.

Table 3.5: Descriptive and inferential statistics for the sub-categories of the EMGI - Motives (mean (SD))

(n=244 complete data sets)	Non Active (n=52)	Low Active (n=38)	High Active (n=154)	ANOVA (F)	P value
Appearance/Weight Management	1.28 (0.75)	1.39 (0.74)	1.65 (0.68)	6.25	0.002*
Social Engagement	1.59 (0.78)	1.81 (0.67)	2.01 (0.60)	8.38	0.000*
Enjoyment/Revitalisation	1.48 (0.88)	1.89 (0.79)	2.05 (0.78)	11.19	0.000*
Negative Health	0.99 (0.79)	1.25 (0.75)	1.61 (0.93)	10.60	0.000*
Health/Fitness	1.53 (1.00)	2.04 (0.95)	2.22 (0.89)	10.85	0.000*

df = 2, *sig.

3.5.7.1 Motives vs. Level of physical activity

Figures 3-2 to 3-4 show the motive scores for each of the three groups (non-active, low active, and high active), for the enjoyment/revitalisation, negative health, and health/fitness sub-categories.

Figure 3-2 (below) shows a difference in the spread of motive scores between the highly active group, and the non-active group. Those who were active had higher motive scores for this category (scoring two or three). Those who were not active were more likely to score one or two.

Figure 3-2: Enjoyment/Revitalisation Motive (EMGI)

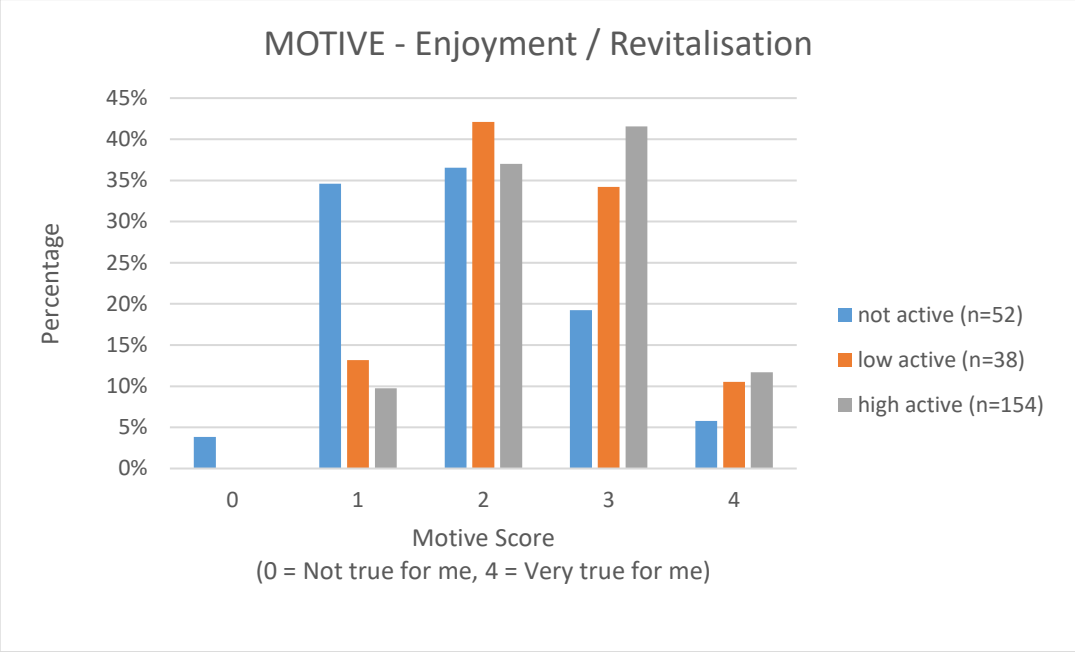


Figure 3-3 (below) shows how those who were not active had a lower motive score for this category, negative health (i.e. importance of avoiding negative health). Those who were low active, or high active, tended to score higher for this motive.

Figure 3-3: Negative Health Motive (EMGI)

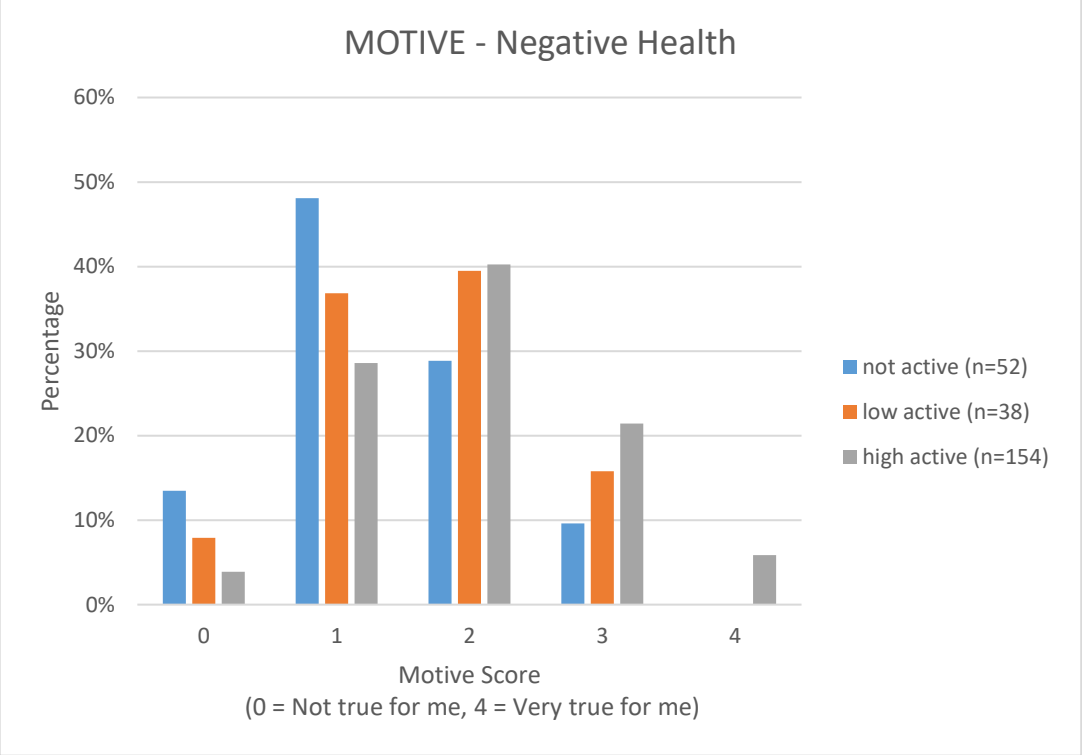
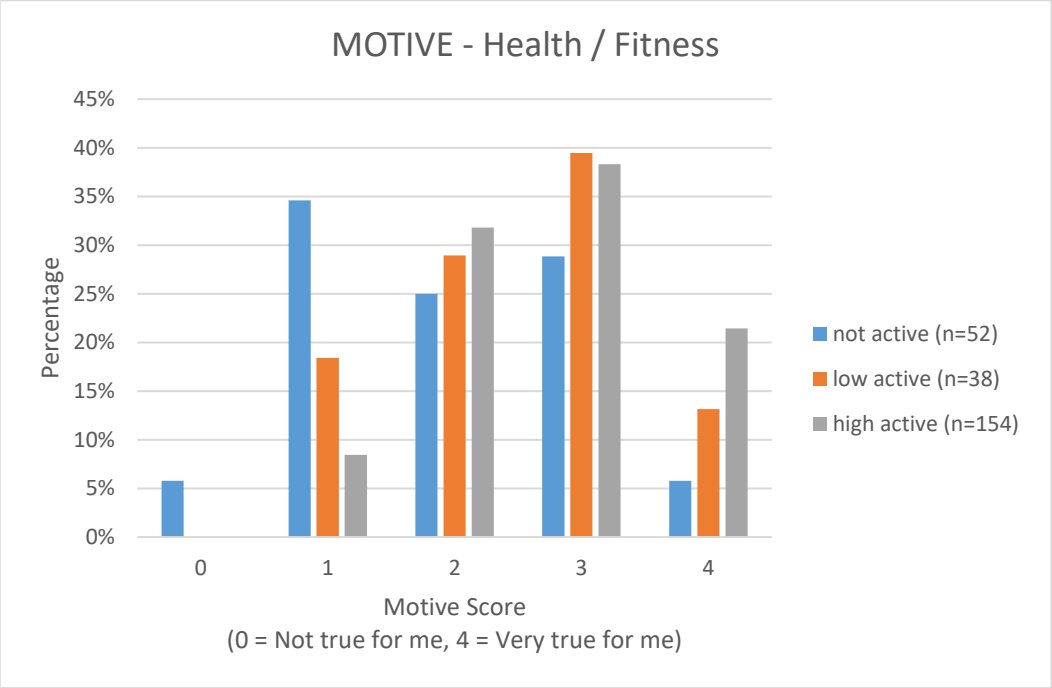


Figure 3-4 (below) shows how those who were not active had lower motive scores for health/fitness. Those who were low active, or high active, had higher motive scores for this category.

Figure 3-4: Health/Fitness Motive (EMGI)



Graphs (5 and 6) for the Appearance/Weight management motive, and Social Engagement motive, can be found in Appendix B14).

3.5.7.2 Inferential analysis of Motives vs. Level of physical activity

Data were checked for normality assumptions, kurtosis/skewness was found to be within limits. Therefore, one-way analysis of variance (ANOVA) tests were used.

Results (see Table 3.5) showed a statistically significant difference between sub-groups, for all categories of the EMGI. Tukey post-hoc tests revealed significant differences between the sub-groups 'non-active' and 'high active' for all categories of the EMGI questionnaire. Significant differences were also seen between the 'non-actives' and 'low actives' in two categories; Enjoyment, and Health Fitness.

3.5.8 Motives vs. Gains

The second part of the Exercise Motivations and Gains Inventory (EMGI) asked participants who had been physically active over the last 12 months, about any gains they might have experienced associated with PA. Questions were scored 0-4 (0 = not at all true for me, 4 = very true for me) (Strömmer, Ingledew and Markland, 2015).

Table 3.6 below compares the mean motive score with mean gain score for those who reported being active over the last 12 months. An increase in mean score was seen (between motive and gain) in the social engagement, and enjoyment/revitalisation sub-groups. Conversely, mean scores were lower for gains in appearance/weight management, negative health, and health/fitness.

Data were checked for normality assumptions, kurtosis/skewness was found to be within limits. Therefore, Independent samples t-tests were performed to explore the difference in mean scores between motives and gains of each sub-group of the EMGI questionnaire (Table 3.6). Gain scores were significantly higher than motive scores for social engagement and enjoyment/revitalisation sub-groups. Conversely, gain scores for negative health and fitness were significantly lower than motive scores.

Table 3.6: Motive scores and Gains scores associated with each sub-group of the EMGI.

	Motives (n=196)	**Gains (n=211)**	**T test**	**P value**
Appearance/Weight Management	1.87 (1.05)	1.72 (1.07)	1.46	0.15
Social Engagement	1.08 (0.81)	1.25 (0.91)	-1.95	0.05*
Enjoyment/Revitalisation	2.07 (1.05)	2.30 (1.06)	-2.19	0.03*
Negative Health	2.32 (0.77)	1.99 (0.83)	4.15	0.00*
Health Fitness	3.02 (0.81)	2.68 (0.93)	3.82	0.00*

***sig**

Figures 3-5 to 3-9 below show the spread of results for motives and gains (for those who reported being physically active over the last 12 months).

Figure 3-5: Motives and Gains scores for Appearance/Weight Management

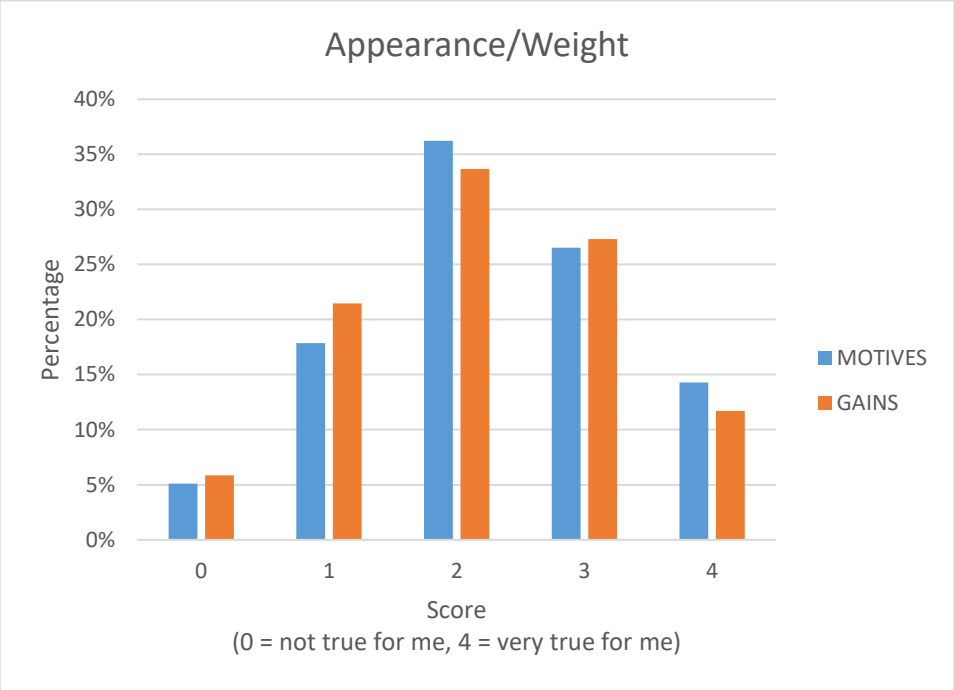


Figure 3-6: Motives and Gains scores for Social Engagement

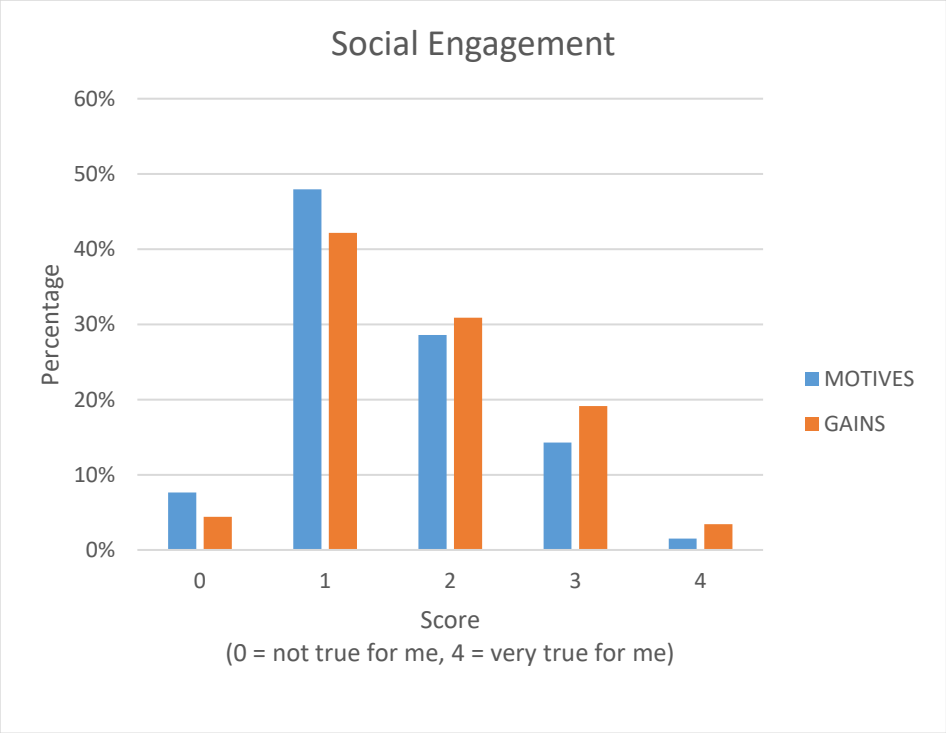


Figure 3-7: Motives and Gains scores for Enjoyment/Revitalisation

Figure 3-7 shows that gain scores for enjoyment/revitalisation tended to be higher than the corresponding motive scores.

Figure 3-8: Motives and Gains scores for Negative Health

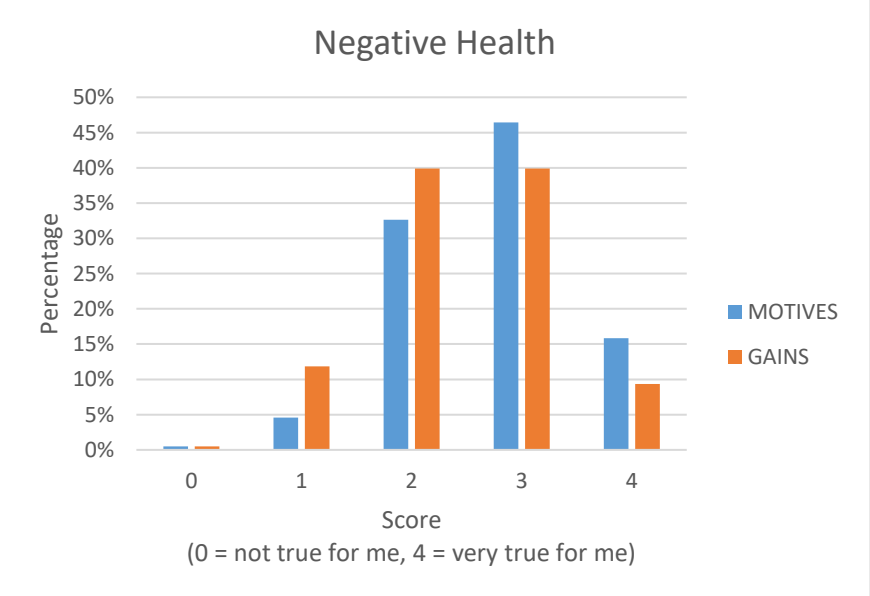


Figure 3-9: Motives and Gains scores for Health/Fitness

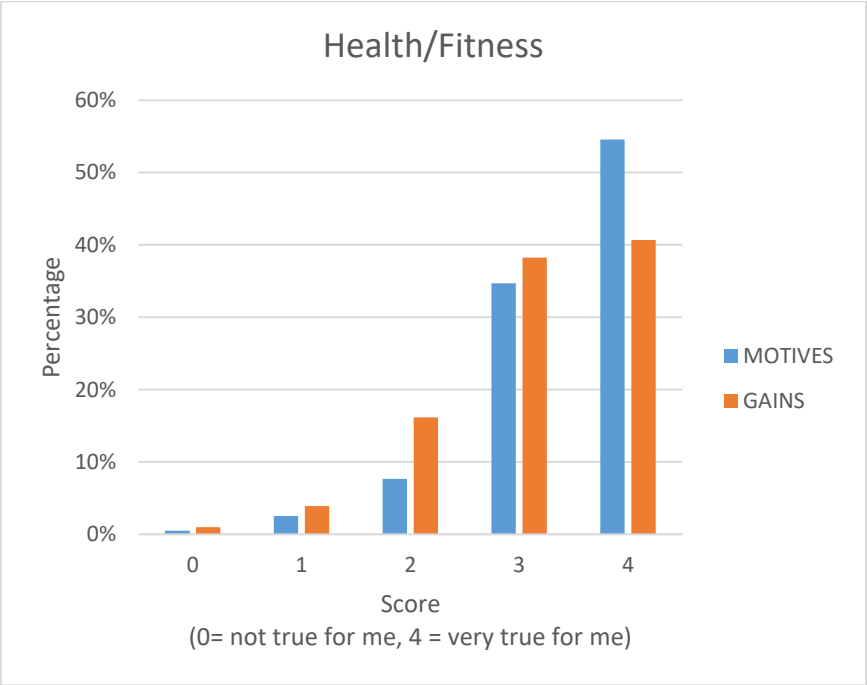
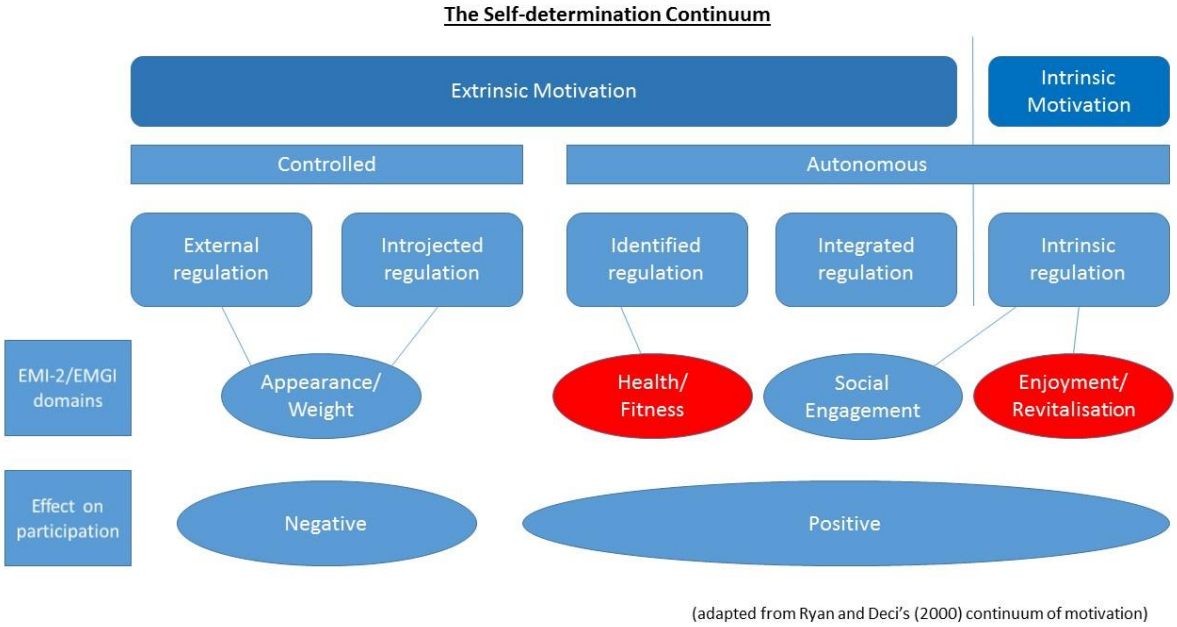


Figure 3-10 below highlights the domains of the EMGI that appear to have the greatest effect on PA and exercise in this sample of people with OA. The highlighted domains (in red) show the categories with the greatest difference in mean scores, between active and non-active people in this sample.

Figure 3-10: Domains of the EMI-2/EMGI which appeared to have the greatest effect on levels of activity in this sample



3.5.9 Exercise Self-Efficacy

Participants completed the 20-point questionnaire Exercise Self-Efficacy Scale (ESE) developed by Gecht (1996). Sub-categories included:

- Beliefs about one's ability to exercise (self-efficacy for exercise)
- Barriers to exercise
- Benefits of exercise
- Impact of exercise on arthritis.

Answers were given on a five-point Likert scale (1-5, ranging from strongly agree, to strongly disagree).

3.5.9.1 Exercise Self-efficacy vs. Level of Physical Activity

Mean (SD) scores for each sub-category of the ESE were calculated for each PA group (non-actives, low actives, high actives) (see Table 3.7 below).

Table 3.7: Means (SD) for sub-categories of the exercise self-efficacy scale (ESE)

	Non Active (n=51)	**Low Active (n= 38)**	**High Active (n=161)**	**ANOVA (F)**	**P value**
SE for exercise	3.01 (0.90)	3.87 (0.88)	4.08 (0.88)	28.41	0.00*
Barriers to exercise	3.41 (1.03)	4.04 (0.71)	4.07 (0.91)	10.53	0.00*
Benefits of exercise	3.64 (0.85)	3.86 (0.54)	3.92 (0.77)	2.65	0.07
Impact of exercise on arthritis	3.50 (0.67)	3.93 (0.46)	4.06 (0.58)	17.84	0.00*

Mean (SD), *sig. at p<0.05

Figures 3-11 to 3-14 show the frequency of scores for each sub-category of the ESE, in the non-active, low active, and high active groups.

Figure 3-11 shows that those participants who reported being most active, tended to report a higher self-efficacy for exercise.

Figure 3-11: Frequency of scores for Self-Efficacy for Exercise

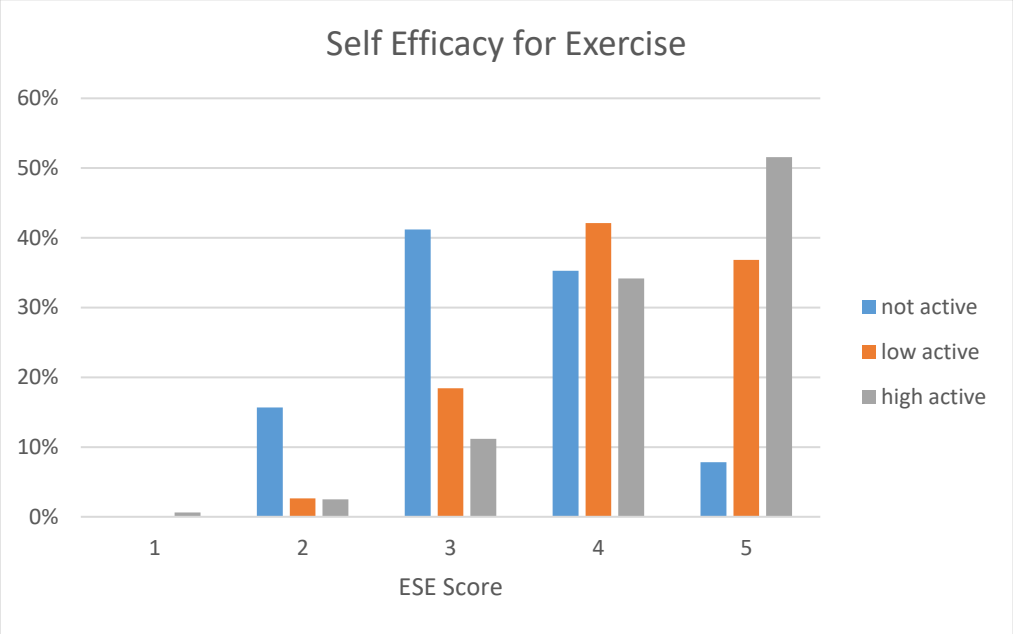
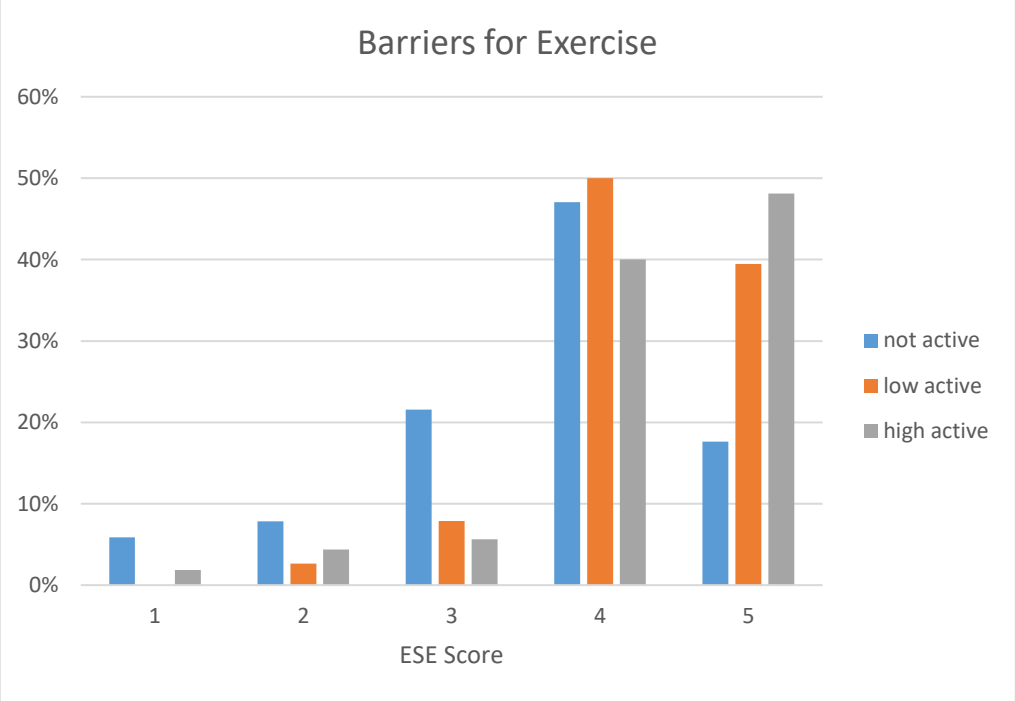


Figure 3-12 shows that those who reported being the most active reported a higher score for the Barriers to Exercise category.

Figure 3-12: Frequency of scores for Barriers to Exercise



Figures 3-13 and 3-14 also show that those participants who reported being most active, tended to score higher for both the benefits of exercise, and the impact of exercise on arthritis categories.

Figure 3-13: Frequency of scores for Benefits of Exercise

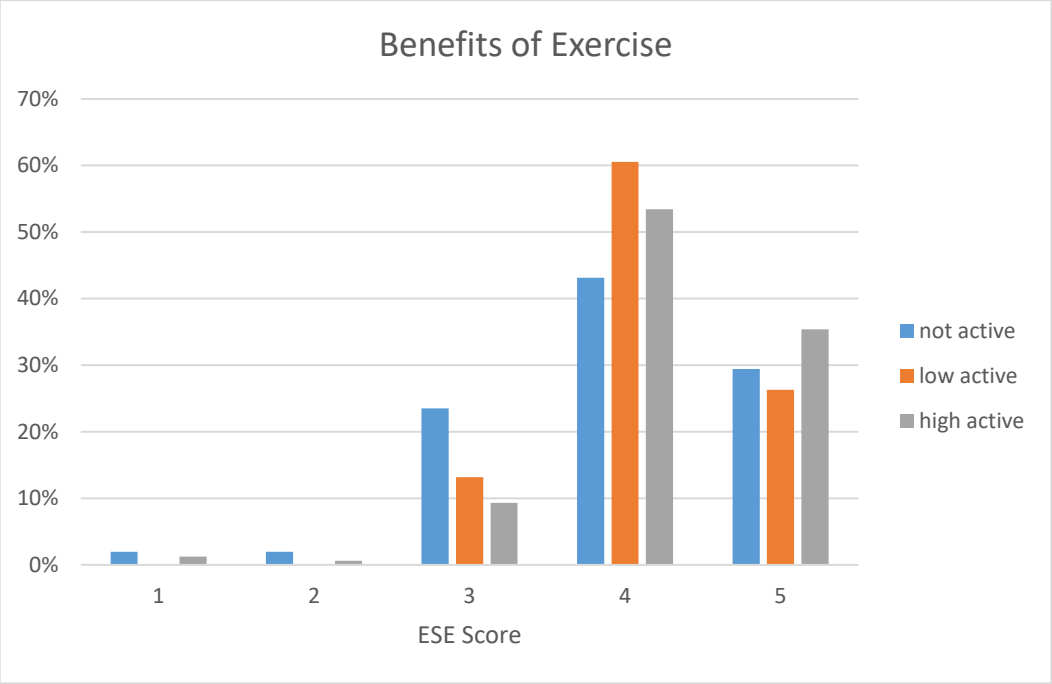
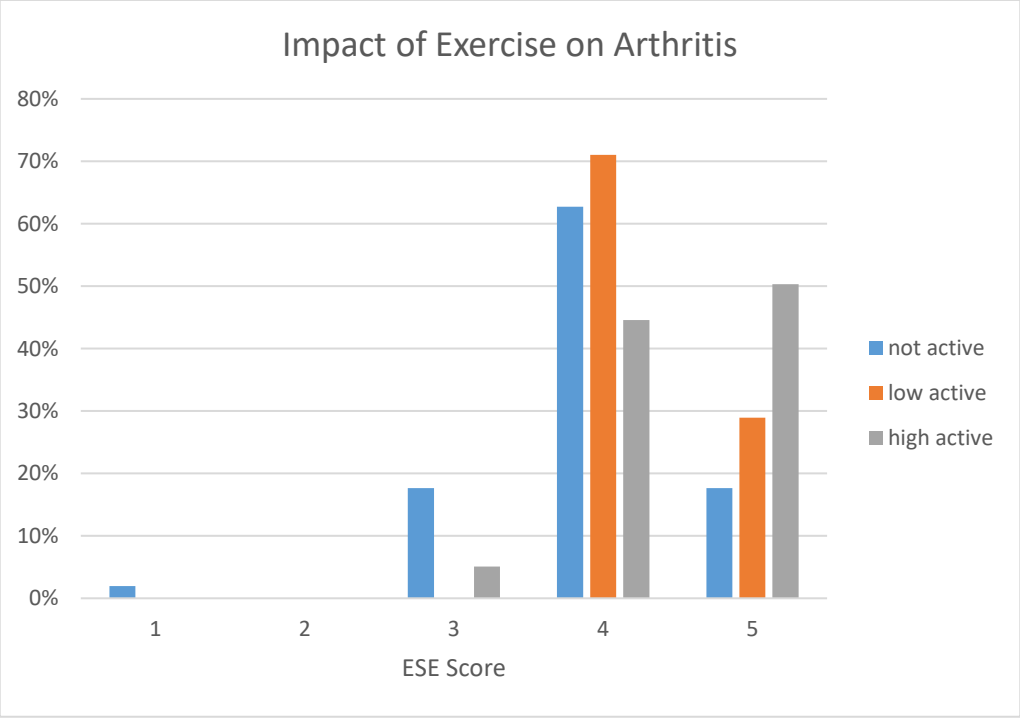


Figure 3-14: Frequency of scores for Impact of Exercise on Arthritis



3.5.9.2 Inferential analysis of Exercise Self-efficacy vs. Level of physical activity

Data were checked for normality assumptions, and kurtosis/skewness was found to be within limits. Therefore, a one-way analysis of variance (ANOVA) test was conducted, which showed a significant difference between groups (See Table 3.7 above). Tukey post-hoc tests revealed statistically significant differences between the sub-groups 'non-actives' and 'high actives', and 'low-actives and 'high-actives' for 'Self-efficacy for exercise', 'Barriers to exercise', and 'Impact of exercise on arthritis'. Differences between sub-groups for 'Benefits of exercise' were not significant (See Table 3.8).

3.5.10 Summary of Results

Participants who reported being most active (active on 4 or more days per week), reported higher motive scores for all five categories of the EMGI. The greatest differences were seen between the non-actives and the high actives, with ANOVA tests reporting significant differences across all sub-categories of the EMGI between these two groups. Significant differences were also seen between the non-actives and low actives, for enjoyment/revitalisation health and fitness categories. Differences between the low active and high active groups were not significant (See Table 3.8 below).

A comparison of motives and gains, for those who reported being active in the last 12 months, revealed that participants reported a higher gain score for social engagement, and enjoyment/revitalisation, when compared to motive scores.

Self-efficacy scores were higher for participants who reported being the most active. Scores for all four sub-categories of the ESE scale were scored higher by those who were active on four or more days per week. ANOVA tests revealed significant differences between sub-groups for all categories of the ESE questionnaire, except 'Benefits of exercise' (See Table 3.8 below).

Table 3.8 below provides an overview of the significant differences between groups revealed by the ANOVA tests.

Table 3.8: Overview of significant findings across sub-groups of physical activity level (ANOVA tests)

		Non Active vs. Low Active	Non-Active vs. High-active	Low-Active vs High-active
ESE Questionnaire	Self-efficacy for exercise			
	Barriers to exercise			
	Benefits of exercise			
	Impact of exercise on PA			
EMGI Questionnaire	Appearance/Weight			
	Social Engagement			
	Enjoyment/Revitalisation			
	Negative Health			
	Health and Fitness			

3.6 Discussion

The total sample of 262 participants were mostly female, with a mean age of 64 years, and most commonly reported having either knee and/or hip OA. These figures are in line with the OA population data for the UK, which reports that: more women are affected than men; over a third of people over 45 years of age have sought treatment for OA; and most are affected by knee or hip OA (Arthritis Research UK, 2013).

The following discussion covers the following areas:

- Motives for PA in this sample
- A comparison of motives and gains in this sample
- The effect of self-efficacy and exercise beliefs on PA participation
- Implications for content development of a behaviour change intervention

3.6.1 Motives for Physical Activity

3.6.1.1 Appearance / Weight Management Motive

Participants who reported being most physically active, reported higher scores more frequently for this motive (mean = 1.65), when compared to those reporting lower levels of activity (mean = 1.39), or no activity (mean = 1.28). Significant differences were seen between the non-active group and the high-active group. These results suggest that appearance and weight management is considered more important to those who carry out higher levels of PA.

This result is in contrast to previous literature, with this motive being associated with both external regulation (behaving to gain some reward, or to avoid some negative contingency), and introjected regulation (behaving out of a sense of guilt, or obligation). These regulatory styles are considered to have a negative effect on participation (Ingledew and Markland, 2008; Ingledew, Markland and Ferguson, 2009). It is important to note, however, that population groups in these previous studies were office workers with a mean age of 40 (Ingledew and Markland, 2008), and young adults (Ingledew, Markland and Ferguson, 2009).

The results of this current study appear to be more in line with a study by Dacey *et al* (2008), who also examined motives of PA in older adults (age 50-79, mean = 63.8). They

found that the appearance motive differentiated between inactive and long-term maintainers of PA, but the importance of this motive decreased with age. Despite this finding, the authors advised that a sole focus on appearance and weight management in this population would be unlikely to affect behaviour change (Dacey, Baltzell and Zaichkowsky, 2008). This could be an indication of the importance placed on other, more intrinsically regulated motives, which are commonly regarded as having more influence over behaviour change. When appearance and weight management are considered alongside the other sub-categories of the EMGI, it perhaps becomes clearer that this is not a key motivator for PA in this sample.

3.6.1.2 Social Engagement Motive

This motive has been associated with intrinsic regulation, and therefore intrinsic motivation, in office workers (Ingledew and Markland, 2008) and young adults (Ingledew, Markland and Ferguson, 2009). In the current study, those who reported being most active had a significantly higher score (mean = 1.64), with those who were not active scoring lower (mean = 1.32) (p=0.00). This result mirrors that of previous research with older adults (Dacey, Baltzell and Zaichkowsky, 2008).

These findings are also in line with other OA literature (Dacey, Baltzell and Zaichkowsky, 2008; Damush *et al.*, 2005), where the impact of social support has been recognised as an important motivating factor. Damush *et al* (2005) found that social support from friends, relatives and physicians was rated as a significant motivator to join and continue to exercise (in those with knee pain). Evidence has found that being married or having a partner or exercise partner who provides support, is more likely to be associated with PA (Damush *et al.*, 2005; Holden *et al.*, 2012; Stubbs, Hurley and Smith, 2015).

Equally, the loss of social support has been reported as having negative consequences on PA participation, such as when an exercise buddy gets sick and can no longer participate (Holden *et al.*, 2012).

It is clear from the results of this study and previous OA literature, that social engagement is an important factor for PA participation, and it is important to consider how this motive can be incorporated into behaviour change interventions.

3.6.1.3 Enjoyment / Revitalisation Motive

Enjoyment and revitalisation have been highly correlated with intrinsic motivation (Ingledew and Markland, 2008). In this sample, those who reported being more physically active were likely to score higher in this domain. Significant differences in mean scores were seen between those who were non-active and high-active, and between those who were non-active and low-active.

This is in line with previous research (in older adults and young adults) which links this motive to intrinsic motivation, and to increased participation in PA and exercise (Dacey, Baltzell and Zaichkowsky, 2008; Maltby, 2001; Ryan *et al.*, 1997).

Previous OA research has also recognised the importance of enjoyment. Petursdottir *et al* (2010) investigated facilitators and barriers to exercise in people with OA. 'Motivation by enjoyment' was reported to be a key facilitator in this phenomenological study, suggesting that consideration be given to how enjoyment can be increased when planning interventions (Petursdottir, Arnadottir and Halldorsdottir, 2010). Holden *et al* (2012) further support this finding, but also recognise it as a barrier, highlighting the importance of the correct choice of PA for each individual (Holden *et al.*, 2012).

3.6.1.4 Negative Health and Health/Fitness Motives

In previous research these motives (previously grouped as one higher domain in the EMI-2) have consistently been associated with increased identified regulation (behaving because of the importance one ascribes to the behaviour), and therefore increased participation in PA (Ingledew and Markland, 2008; Ingledew, Markland and Strömmer, 2013).

OA research has also described a link between motivation for health/fitness and increased levels of exercise. Petursdottir *et al* (2010) refer to this motive as 'motivation by results' – 'I exercise because it's good for me, not because I like it'. This is also suggestive of identified regulation (behaving because of the importance once ascribes to the behaviour).

In the current study, the more active participants reported a higher mean score in both domains. Those who were not active or less active, reported lower mean scores in both

domains. In this sample, these motives appear to be associated with increased participation in PA and exercise.

In overview, the greatest differences in mean scores between the non-active and active groups were in the enjoyment/revitalisation and health/fitness/negative health motives. All of these motives fit with autonomous forms of motivation. This result concurs with SDT, which theorises that autonomous types of motivation are linked with increased participation in PA and exercise (Ingledew, Markland and Strömmer, 2013; Teixeira *et al.*, 2012).

These results provide us with useful information about the specific elements of motivation that might be most likely to affect levels of participation in PA in people with OA.

3.6.2 A comparison of Motives and Gains

An increased mean score for gains when compared to the corresponding motive suggests that participants might gain more from PA than they originally expected. This is an important implication when considering specific content for behaviour change interventions (i.e. success stories about unexpected gains, from active people). Enhancing positive outcome expectations might motivate those with OA to maintain their PA participation, therefore it could be worthwhile educating participants about potential positive outcomes early in an intervention (Damus*h et al*, 2005).

In this sample, people with OA who were physically active felt they gained more than their original motives, in terms of both social engagement and enjoyment/revitalisation. According to SDT, these two domains are important for fostering autonomous and more intrinsically focused motivation. Appearance/weight management, negative health, and health/fitness, all had lower mean scores for gains than for motives, suggesting that in this sample not all motives were met with positive outcomes. As negative health and health/fitness are associated with autonomous motivation (Ingledew and Markland, 2008; Ingledew, Markland and Strömmer, 2013; Petursdottir, Arnadottir and

Halldorsdottir, 2010), further research might focus on the reasons why motives were not met with equal or more positive gains in these categories within this population.

Learning more about this apparent mismatch between motives and gains might help our understanding of why people with OA might discontinue an activity and become inactive.

3.6.3 Exercise Self-Efficacy (ESE) and physical activity participation

In line with previous research in people with arthritis (Gech*t et al*, 1996), in this sample those who were most active (active on 4 or more days per week) believed in the positive benefits of exercise, had higher self-efficacy for exercise, that is, felt more confident about their ability to exercise. They also believed more strongly in the positive impact that exercise could have on their OA.

The greatest difference in mean scores between the non-actives and high actives was in the self-efficacy for exercise sub-group, suggesting the most active in the sample had the greatest confidence about their ability to exercise.

OA research further supports these findings. Petursdottir *et al* (2010) reported how believing in exercise as part of OA treatment was a facilitator. Other studies have described how having positive expectations about the benefits of exercise influences exercise motivation and therefore participation (Damush *et al.*, 2005), and equally that uncertainty about the benefits of exercise is linked with a lack of activity (Holden *et al.*, 2012).

3.6.4 Implications for content development of a behaviour change intervention

The results from this study have produced new knowledge about which motives, gains and levels of self-efficacy are present in a group of people with OA. They have also allowed for a comparison of those who reported being currently inactive, with those who were physically active on most days of each week. This has provided us with information about which specific motives, gains and elements of self-efficacy for exercise, might be most useful to focus on when developing the content of a behaviour change intervention.

Specifically, the results suggest that a future behaviour change intervention might focus on the following content:

- Enjoyment of PA, and feelings of revitalisation
- Health and fitness benefits of PA
- Positive elements of social engagement (Gain)
- Self-efficacy for PA
- Information about the barriers to PA, and how to overcome them
- Positive impact that PA can have on OA symptoms

3.7 Strengths and Limitations

This study has been able to assess motives, gains and levels of SE in a sample of 262 people with OA. Two aspects of the study distinguish it from previous motivation and SE research in this population.

This is the first time that the EMGI questionnaire has been used in this population. This has enabled an in-depth analysis of different elements of motivation (specifically participation motives linked to a self-determination continuum), which can be used to assess how autonomously motivated participants were towards PA. It was also able to assess gains from PA for the first time. What's more, the design of the study allowed for a comparison of non-active and active participants. This provided more evidence about the differences within the sample.

Secondly, the analysis of SE included a comprehensive assessment of the sub-categories of the ESE scale. Once again non-active and active participants were compared, producing

new evidence about specific elements of SE, and how these might affect levels of PA in this population.

Limitations of the study include the self-reporting nature of PA levels, as well as the fact that data were collected at just one point in time. Self-report instruments are one of the most widely used type of PA measure (Sallis and Saelens, 2000). The benefits of self-report measures include their ability to collect data from many people at low cost (Sallis and Saelens, 2000), but the validity of such measures has been brought into question. Prince et al (2008) examined the extent of agreement between subjectively (i.e. self-report), and objectively (i.e. accelerometer) assessed PA in adults. They found only a low-to-moderate correlation between the two methods, revealing a need for more valid, accurate and reliable measures (Prince *et al.*, 2008).

3.8 Conclusions

The central role that attitudes and beliefs play in determining health-related behaviour, including PA and exercise, has been highlighted in previous research (Holden *et al*, 2012; Hurley *et al*, 2010), and results from this study provide further evidence to support this. By looking at differences between those who reported being currently active, and those who were not currently active, a greater understanding about the effect that different motives, gains and levels of SE might have on levels of PA was gained.

This is the first time that the EMGI questionnaire has been used in this population. This study is unique in providing us with information about what motives for, and gains from, PA are present in a group of people with OA.

Results from the exercise self-efficacy scale (ESE) are in line with previous research carried out in this population (Gecht *et al.*, 1996; Hurley *et al.*, 2012). An in-depth analysis of the sub-categories of the scale has enabled us to learn more about the impact that different elements of self-efficacy might have on levels of PA.

Whilst this sample has provided us with new data, it is unable to tell us more about how motivation or levels of SE might change over time. Learning more about the relationship between these constructs and level of PA over a period of time, could help us to design

interventions which are more effective at helping people with OA maintain engagement with PA, over the long-term.

Previous research has debated the importance of autonomous motivation, and levels of SE on both the initiation and maintenance of PA. Slovinec D'Angelo *et al* (2014) found that both autonomous motivation and SE were important determinants of short-term exercise behaviour (6 months), however, reported that only autonomous motivation remained a significant predictor of long-term exercise behaviour (Slovinec D'Angel*o et al*, 2014). Another study has argued that, in the health domain we are often interested in producing only the behavioural outcome, regardless of the quality of the motivation underpinning those behaviours (Rodgers *et al.*, 2014). This study suggested that whilst increasing SE is probably enough to produce behavioural attempts (or initiation) of a behaviour, other constructs of motivation (i.e. elements of SDT) might help us to understand why people who have high task SE for a behaviour, do not necessarily engage in that behaviour, over the long-term (Rodgers *et al.*, 2014).

It seemed a natural next step, to explore the effect of SE on levels of PA in this population, over a period of time. An evaluation of the sub-categories of the ESE, at several time points, in a group of people with OA, could tell us more about any differences between the initiation stages of PA, and the maintenance of PA.

The next chapter describes how this issue was examined in more detail. Data from a group of people with OA was compared, including levels of SE, and levels of PA, over a period of 7.5 months.

Chapter 4: The Relationship between Self-Efficacy and Physical Activity Maintenance in People with Osteoarthritis

4.1 Overview

The previous chapter explored levels of motivation and self-efficacy for exercise at one point in time, in a group of people with osteoarthritis (OA) via a cross-sectional survey. It provided information about the relationship between self-efficacy (SE) and levels of physical activity (PA). The results indicated that people who were active were more likely to have higher SE, compared to those who were inactive.

This chapter investigated how levels of SE and levels of PA changed over time in this population. This was done by analysing the total score and sub-categories of the Exercise Self Efficacy questionnaire (ESE) (Gecht et al., 1996), and self-reported levels of PA over a period of 7.5 months. The relationship between the two variables was explored to learn more about how they might interact over time.

4.2 Rationale

As described in the previous chapter, SE is the extent to which a person believes they are capable of carrying out a certain behaviour**.** First described in 1977 by Albert Bandura, research has established its importance both in the overall self-management of chronic conditions (such as OA), as well as changing behaviours such as PA (Brittain *et al.*, 2011; Dobkin *et al.*, 2005; Gecht *et al.*, 1996; Hammer *et al.*, 2015; McAuley, Lox and Duncan, 1993; Peeters, Brown and Burton, 2014; Slovinec D'Angelo *et al.*, 2014; Williams and French, 2011).

4.2.1 Self-Efficacy and Physical Activity

The information gathered in chapter 3 showed a significant, positive relationship between SE and PA in people with OA. Those who reported being most active had significantly higher levels of SE, compared to those who were not active. This is in line with previous

research which has described an increase in levels of SE in arthritis populations, following various behaviour change and self-management interventions (Goeppinger *et al*>, 2009; Hughes>*et al*>, 2006; Hurley>*et al*>, 2007; Lorig>*et al*>, 2008b, 2008a, 2013a; Trudeau>*et al*>, 2015).

The majority of these studies used the Arthritis Self-Efficacy Scale (ASES) (Lorig *et al.*, 1989), an instrument developed to measure all areas of arthritis self-management. However, Hurley *et al* (2007), used the Exercise Self-Exercise Scale (ESE) developed by Gecht et al (1996), a scale purposely developed to measure SE for exercise, in people with arthritis. This scale could be more useful than a broader questionnaire such as the ASES, when trying to learn more about the specific relationship between self-efficacy and levels of PA in this population.

4.2.2 Self-Efficacy and Physical Activity Maintenance

Factors contributing to PA maintenance, particularly after behaviour change interventions, have received little attention (Knittle *et al.*, 2016).

Fjeldsoe *et al* (2011) carried out a literature review of maintenance of behaviour change following PA and dietary interventions. Of the 157 trials initially considered for review, only 55 (35%) included a post-intervention follow-up of three months or longer. The team noted that more studies are needed which evaluate strategies targeting the maintenance of behaviour change, and also that explore the determinants of behaviour change initiation and maintenance (Fjeldsoe *et al.*, 2011).

A small number of studies have focused specifically on the relationship between self-efficacy and PA maintenance in populations with chronic conditions, including arthritis (Dobki*n et al*, 2005; Hammer *et al*, 2015; Knittle *et al*, 2016) and older adults (McAuley, Lox and Duncan, 1993; Stralen *et al*, 2010), with varying results.

Dobkin *et al* (2005) followed up people with Fibromyalgia for 3 months after an intervention, and found marginally non-significant (P = 0.08) effects of increasing beliefs in the benefits of exercise (at follow-up). They also found that greater increases in perceived barriers during treatment predicted a significant decrease in post-treatment

levels of PA (P = 0.04). They used two commonly used SE measures, the ESE (appendix B5) and ASES (appendix B4); however, the period of follow-up was only three months.

Knittle et al (2016) carried out a process evaluation of a behaviour change intervention for people with Rheumatoid Arthritis. They found higher levels of PA and higher SE in the intervention group at follow-up (32 weeks post-intervention), however, not significantly greater than increases also seen in the control group. The measure of self-efficacy used was not specific to arthritis, but a measure developed by Bandura (1996) to assess the extent to which individuals perceived they would be physically active in a number of different situations (Appendix C1).

A further study by Hammer et al (2015) was the only one identified which focused specifically on OA, examining a small sample of people (n= 52) with hip OA. They explored the relationship between levels of SE and PA eight months after an intervention, and found that those who had maintained their level of PA had a significantly higher level of SE. Despite these results, the authors suggest that the measure used in this study (the ASES developed by Lorig *et al*, 1989) might not be the best for examining SE related to PA. PA maintenance was also defined by asking just one self-report question: Have you been more or less active over the last 12 months? This was recognised by the authors as a potential inaccurate measure of PA maintenance. This study provides an example of the importance of a clear (and justifiable) method of defining PA maintenance.

Conversely, one other study, which investigated the relationship between SE and maintenance of PA 9 months after a 5-month structured exercise programme for older people (aged 45-65yrs) found SE to be the only significant unique predictor of PA maintenance. The measure used was very specific to the intervention, such as SE for bicycling, SE for walking, and SE for sit-ups. Limitations included a small sample size (n=44), with the authors suggesting that similar results need to be reproduced in larger samples (McAuley, Lox and Duncan, 1993).

Overall, previous studies have produced conflicting results about the relationship between self-efficacy and PA maintenance in this area. Some studies have reported statistically significant relationships (Hammer *et al.*, 2015; McAuley, Lox and Duncan,

1993), however, limitations such as small sample sizes and the use of self-efficacy scales not related to both PA and arthritis specific populations have been acknowledged.

Learning more about the relationship between SE and PA maintenance over time in this population, by using an exercise self-efficacy scale developed specifically for people with arthritis, in a larger sample, could provide more directed and accurate information, about how these two variables might interact with each other.

4.2.3 Current Gap in Knowledge

Evidence from a number of RCTs aimed at people with arthritis has shown that levels of SE improve following behaviour change interventions. However, the majority of these studies have measured self-efficacy for general self-management of the condition, rather than self-efficacy related specifically to PA. The relationship between level of PA and self-efficacy over time has been less frequently investigated.

A majority of studies have focused on the initiation of PA, following up any post-intervention effects over a short period of time. A small number of studies have focused more on the specific relationship between self-efficacy and PA maintenance. These have produced conflicting evidence about the relationship between these two variables, they have been limited by small sample sizes and by the use of SE scales not specific to PA and exercise. Only one study (Dobkin *et al.*, 2005) has been identified which used the ESE to examine the relationship between SE and PA maintenance, although the population under investigation were people with a diagnosis of fibromyalgia, and not arthritis.

4.3 Aim and Objectives

4.3.1 Aim

To explore how levels of SE and maintenance of PA change over time in a group of people with OA.

4.3.2 Objectives

1) To explore the differences in self-efficacy score (ESE), between those who maintain a moderate level of PA over time and those who do not.
2) To explore the differences in sub-categories of self-efficacy (ESE) score, between those who maintain a moderate level of PA over time, and those who do not.

4.4 Design and Methods

Consideration was given to the most appropriate method to meet the aims and objectives of the study. The area of investigation here was centred on assessing changes in scores over time, and looking at differences between groups with different levels of PA. This has been done previously in several different ways. Literature which has measured 'PA maintenance' was explored, and how this was measured differed greatly between studies. These are described in table 4.1 below.

4.4.1 Sample Population

This study used data previously collected in a cluster randomised controlled trial (cRCT) - Facilitating Activity and Self-Management in Arthritis (FASA) (Walsh *et al.*, 2013). Further details about the FASA study can be found in Box 4-1 below. Secondary analysis of the FASA data was conducted for this current study, utilising the ESE and PA data.

B*ox 4-1: Details of the FASA Study*

The FASA study examined whether an exercise and self-management intervention delivered to groups of patients with chronic knee, hip or lower back pain could improve function at six months post-completion of the intervention. Secondary outcomes included an analysis of self-efficacy, using the self-efficacy and exercise health beliefs questionnaire(ESE) (Gecht *et al.*, 1996). Levels of self-reported physical activity were also collected.

Participants were recruited into the cRCT via GP surgeries from 2012-2014. Individuals allocated to the intervention group attended 12 (twice weekly) group sessions, each lasting 60 minutes, and included group discussions and problem solving sessions regarding issues of self-management. After each discussion, participants took part in supervised strengthening, aerobic, and co-ordination activities. They also completed an action plan about physical activities they wanted to achieve, and this was reviewed each week. Individuals allocated to the control arm were permitted to continue any current pharmacological or non-pharmacological strategies (Wals*h et al*, 2013).

The primary outcome measure was the Dysfunction Index of the Short Musculoskeletal Functional Assessment (SMFA). A number of other outcome measures were also used, including the self-efficacy and exercise health beliefs questionnaire (ESE). Data collected using this measure is of particular interest for this study, as these data allow for further analysis to be carried out, using the sub-categories of this measure.

4.4.1.1 Inclusion/Exclusion Criteria

Inclusion criteria included:

- Aged 50 years and over
- A clinical or radiographic diagnosis of degenerative hip, knee, or lower back pain of at least six months duration.

Exclusion criteria included:

- Physiotherapy in the preceding six months
- Lower limb arthroplasty
- Unstable medical or psychiatric conditions
- Non-English speaking

Self-efficacy data were collected using the ESE measure, at baseline, 6 weeks, and 7.5 months (6 months post-intervention). PA data were collected at baseline and 7.5 months. Complete data (i.e. including 7.5 months) was available for 270 participants.

4.4.2 Outcome Measures

The outcome measures used to collect levels of self-efficacy and PA in this sample are reported separately below.

4.4.2.1 Self-Efficacy

The exercise self-efficacy scale (ESE) (Gecht *et al.*, 1996) was used to collect data on levels of self-efficacy. The ESE questionnaire is made up of four sections; self-efficacy for exercise, barriers to exercise, benefits of exercise, and the impact of exercise on arthritis. It provides an overall picture about a person's opinions and beliefs about exercise and arthritis. When separated out, however, it can also provide information about how these specific beliefs and opinions differ between activity groups. A comparison of sub-group

responses from non-active and active participants, for example, could provide new knowledge to shape future interventions.

Sub-categories of the ESE questionnaire:

Self-efficacy for exercise (4 questions) – asks about how confident the respondent feels about being able to do exercise, using questions such as 'if I want to exercise, I know I can do it', 'I'm not sure if I could exercise regularly, even if I wanted to'.

Barriers to exercise (3 questions) – this section finds out more about people's opinions of potential barriers to exercise, with questions such as 'exercise is boring', 'exercise is a waste of time'.

Benefits of exercise (5 questions) – this section asks about people's opinions of the potential barriers of exercise, with questions such as 'exercise can help lift one's spirit', 'exercise gives a person more energy'.

Impact of exercise (8 questions) – This section explores respondent's opinions about their views on the potential impact that exercise might have on their OA, both positive and negative. Questions include: 'exercise is dangerous for people with arthritis', 'people with arthritis who exercise are healthier'.

4.4.2.2 Physical Activity Outcome Measure

To measure levels of PA, participants were asked 'What is your estimated weekly activity level (in minutes)'. This question was collected face-to-face by the assessing physiotherapist, who carried out the assessments at baseline and 7.5 months.

4.4.2.3 Definition of physical activity maintenance

To establish how PA maintenance has been previously measured, studies specifically examining PA maintenance in people with arthritis, or older adults, were examined. Table 4.1 below provides an overview of the different definitions.

Table 4.1: Measurement of Physical Activity Maintenance

Author	Aim	Definition of PA maintenance
Hammer et al (2015)	To explore SE in relation to post-intervention PA maintenance in patients with hip OA maintenance.	'Maintainers' = i.e. participants who at 12-month follow-up self-reported to be *more* physically active compared to baseline. 'Non-maintainers' = i.e. participants who at 12-month follow-up reported to be *less* physically active compared to baseline. *Note: Data for participants who at 12-month follow-up reported to be equally physically active compared to baseline were not reported*
Peeters et al (2014)	To identify psychosocial factors associated with increased PA in mid-age adults with arthritis who did not meet recommended PA levels (at baseline)	Increased PA was defined as an increase of ≥200 MET* min/week (equivalent to 1 h of walking or at least moderate intensity activity) over a two-year period (baseline subtracted from follow-up).
McAuley et al (1993)	Primary objective concerned whether increases in physical efficacy and psychological change brought about by a structured walking programme were maintained at follow-up. Second objective examined the role of self-efficacy in the maintenance of exercise behaviour over 9 months.	Exercise adherence was treated as a dichotomous variable and assessed by asking subjects whether they had/had not continued to exercise at the frequency, intensity, and duration prescribed at the end of the programme.

*MET – Metabolic Equivalent

These studies showed that a variety of methods have been used to establish levels of PA maintenance. The general pattern appeared to be an assessment of the difference between levels of PA (self-reported or otherwise) reported at baseline, and the same measure at follow-up.

To encapsulate all possible outcomes of the PA data within this study, it was decided that the whole sample would be divided up into four sub-groups, as shown in Table 4.2 below. This would capture those who were not active at either time-point (non-actives), those who were active at baseline, but reported a drop in activity over the 7.5 months (non-maintainers), those who increased activity between the two time-points (improvers), and those who were doing adequate amounts of PA, at both time points (Maintainers).

Table 4.2: Measure of Physical Activity Maintenance

	7.5 months	
Baseline	Inadequate PA (<120MINS)	Adequate PA (≥120mins)
Inadequate PA (<120mins)	Non – Active (NA)	Improvers (IMS)
Adequate PA (≥120mins)	Non-Maintainer (NM)	Maintainers (MA)

NA – Non-active at baseline, non-active at follow-up (non-actives)

NM – Adequate at baseline, not adequate at follow-up (non-maintainer)

IMS – Inadequate at baseline, adequate at follow-up (improvers)

MA – Adequate at baseline, adequate at follow-up (maintainers)

Various cut-points were considered when defining an 'adequate level of PA'. Recent commentary has argued that the benefits of smaller amounts of PA have been overlooked (de Souto Barreto, 2015; Powell, Paluch & Blair, 2011; Sparling *et al*, 2015). The UK's Chief Medical Officer states, "The majority of UK older adults have low levels of activity, and so it is important to emphasise that those who are currently inactive can achieve some health benefits from increasing their activity, even if it is below the recommendation". (Department of Health, Physical Activity, 2011, p38).

It was felt that using the policy guidelines of 150 minutes per week (Public Health England, 2014) could potentially label those doing a beneficial level of PA as 'inadequate'. It was decided therefore, that the cut-off point should be reduced from 150 minutes, to 120 minutes.

4.4.3 Data Analysis Plan

4.4.3.1 Statistical analysis

Descriptive statistics were used to describe the sample included in the analysis. Data from baseline and 7.5 months were included in the analysis, incomplete data sets were discarded. One-way analysis of variance (ANOVA) tests were used to explore any statistically significant differences between the sub-groups.

4.4.4 Ethical considerations and data storage

All data were anonymised using unique ID numbers. No personal information about any of the participants was accessed. All data were electronic and were stored on encrypted laptops/computers. No identifiable data was used in any published materials, posters, conferences, or at any time during the dissemination of the results. Back-up copies of electronic data were made regularly onto the main shared drive of the University computer system. Ethical approval was provided for secondary data analysis.

4.5 Results

4.5.1 Demographics

Table 4.3 provides details of the breakdown of demographics. The majority of the sample were female (65%), had a mean age of 67 years, were White (96.8%), and married (67.7%).

Table 4.3: Demographics of sample (n=248)

N = 248		
Gender (n, %)	Female	161, (65%)
	Male	87 (35%)
Age	mean (SD)	67 (7.9)
	minimum	50
	maximum	88
Ethnicity (n, %)	White	241 (96.8%)
	Black Caribbean	3 (1.2%)
	Black African	2 (0.8%)
	Indian	2 (0.8%)
Marital Status (n, %)	Married	168 (67.7%)
	Widowed	34 (13.7%)
	Divorced	20 (8.1%)
	Single	15 (6%)
	Cohabiting	10 (4%)
	Separated	1 (0.4%)

4.5.2 Data preparation

All data was examined (using IBM SPSS, version 22) using descriptive statistics to check that continuous variables were within an expected range, means and SDs were plausible, and that all discrete variables were within range. (Tabachnick and Fidell, 2014). Potential errors were checked in the original questionnaire data sets. Distributions of data within each sub-group is reported separately below (Sections 4.5.2.6 and 4.5.2.7).

4.5.2.1 Missing Data

Missing data is one of the most prevalent problems in data analysis (Tabachnick and Fidell, 2014) and can be characterised in several ways, including:

- Missing completely at random (MCAR)
- Missing at random – or ignorable nonresponse (MAR)
- Missing not at random – non-ignorable (MNAR)

(Tabachnick and Fidell, 2014)

There are various procedures for handling missing values. If there are only a few missing data, and they seem to be a random subsample of the whole sample, deletion is a good option (Tabachnick and Fidell, 2014). It is also possible to assess missing data using SPSS. A statistically significant result of the MCAR test (Little's MCAR) would suggest that the data is not missing completely at random (MCAR).

MCAR tests run using IBM SPSS for all variables in this dataset, revealed a non-significant result of 1.00, therefore missing data within the dataset was considered to be missing completely at random (MCAR). For this reason, missing data was not included in any analyses.

4.5.2.2 Missing Data – Level of Physical Activity

Missing data for PA level (collected at baseline and 7.5months) were coded 999. Cases that had missing data at either of these time points were not included in the analysis, as an overall 'PA difference' score was unable to be calculated.

4.5.2.3 Missing Data – ESE Scores

Missing data within the ESE questionnaire data was also coded 999. The 'exclude cases pairwise' option within SPSS was used during data analysis. This excludes cases only if they are missing data required for a specific analysis, so they will be included in those analyses where they have complete data (Pallant, 2013). This resulted in different sample sizes for each of the sub-groups of the ESE (reported below in table 4.4 below).

Other options for dealing with missing data within IBM SPSS include the 'exclude cases listwise' option in SPSS, or the 'replace with mean' option. The 'exclude cases listwise' option, only includes cases if they have full data on all of the variables. This option can severely, and unnecessarily, reduce the size of the overall sample (Pallant, 2013). Replacing a missing value with the mean option, calculates the mean for the variable, and replaces each missing value with this figure. This can severely distort the results and therefore is not recommended, especially if there are a number of missing data in a dataset (Pallant, 2013). Table 4.4 illustrates how the sample sizes of each ESE sub-category varied across PA groups.

Table 4.4: Number of cases with complete data for each sub-category of the ESE, at baseline and 7.5 months.

	Non Actives	Non Maintainers	Improvers	Maintainers
ESE SE	25	26	23	160
ESE Barriers	28	26	24	167
ESE Benefits	26	23	21	155
ESE Impact	26	24	22	152
ESE Total	23	23	20	145

4.5.2.4 PA Difference

Change in PA over time was measured by calculating the difference between reported weekly exercise (in minutes) recorded at baseline, and at 7.5 months. This figure was coded as 'PA Difference'. This score could only be calculated for those with complete PA data at both time points. Any participants with missing data at either time point were removed from the analysis.

4.5.2.5 ESE Difference

Change in ESE total score over time, and change in sub-category scores over time, were measured in the same way. The score for each sub-category reported at baseline was subtracted from the matching score reported at 7.5 months to calculate any change in ESE over time.

4.5.2.6 Distribution of Data and Outliers (PA Difference) / Assessing Normality

Distribution of PA data was checked for normality using SPSS. Figures 4-1 and 4-2 show a boxplot and histogram of the data, revealing that a number of extreme outliers were identified by the SPSS software.

Deciding whether a data point is an outlier and deciding what action to take is much more of an art than a refined science (Tabachnick and Fidell, 2014). Original data were checked for errors, and all data was correctly imputed, therefore the identified outliers were considered to be true outliers. Some statistics writers suggest removing all (true) extreme outliers from a data file (Pallant, 2013). SPSS automatically provides a trimmed mean value, which is an updated mean value, following the removal of the top and bottom 5% of the data sample. A large difference between the mean value of the whole sample (untrimmed) and trimmed sample was found (whole sample = 20.01, and trimmed sample = 3.50).

Figure 4-1: A box-plot showing the distribution of PA difference scores in the whole sample (n=276)

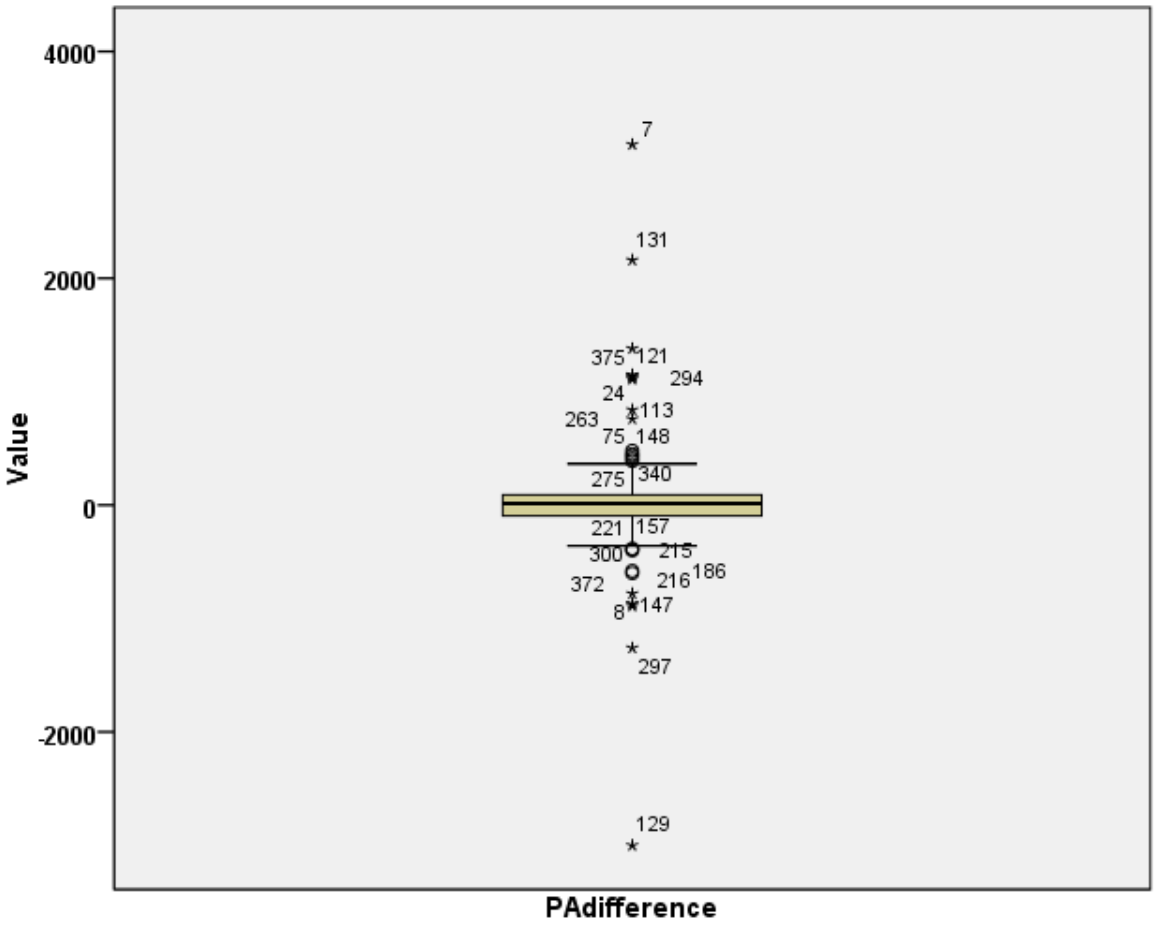
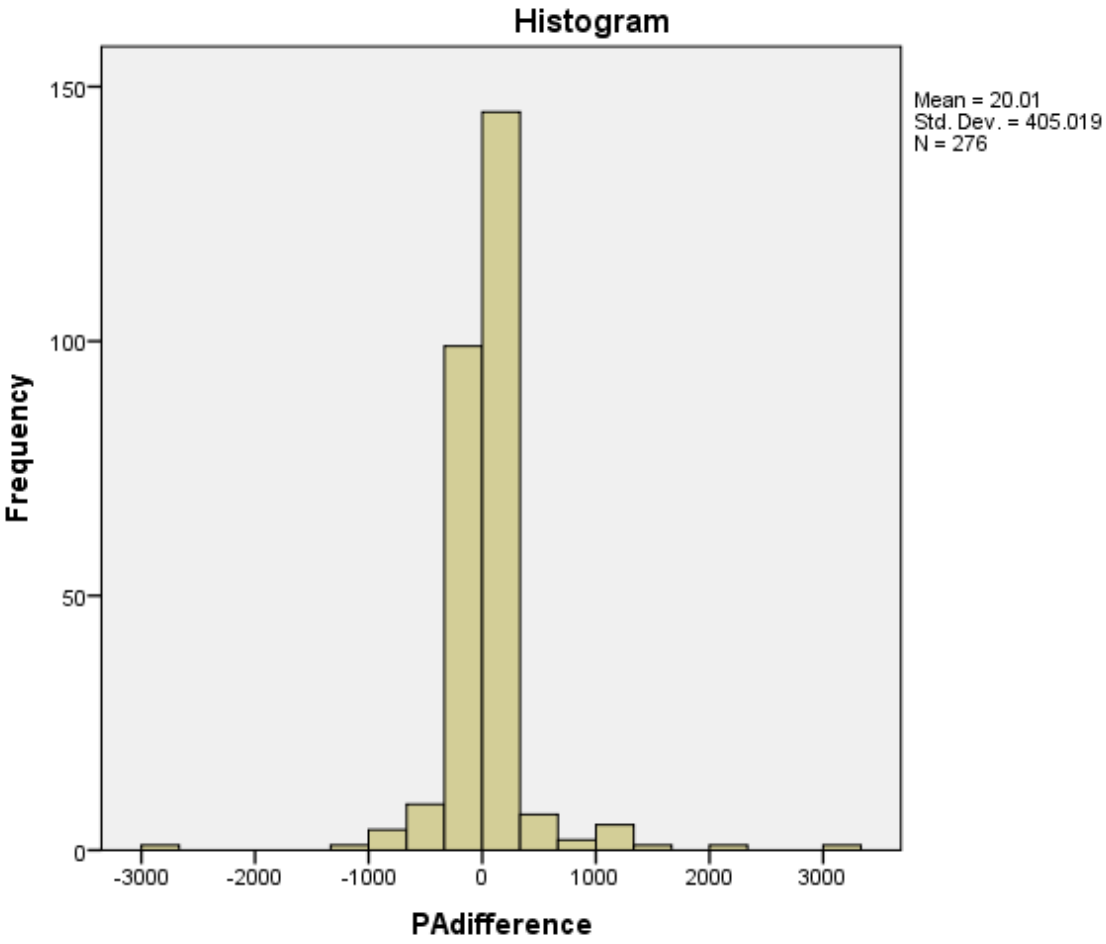
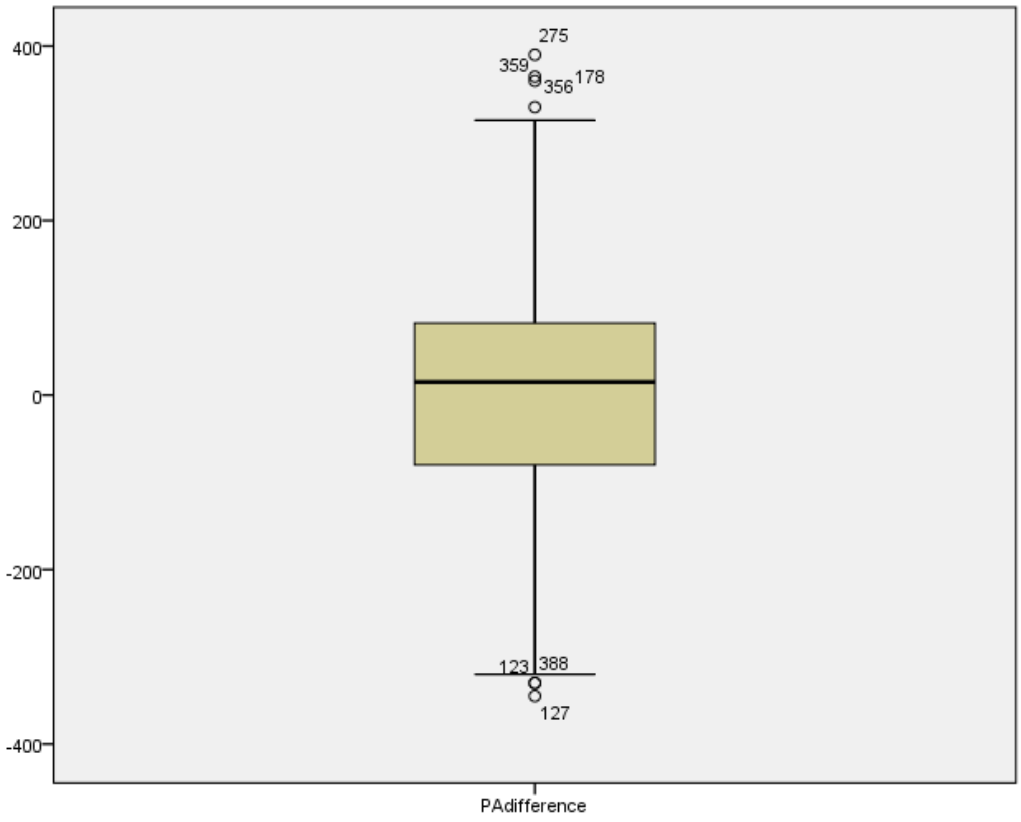


Figure 4-2: A histogram showing the distribution of PA difference scores in the whole sample (n=276)



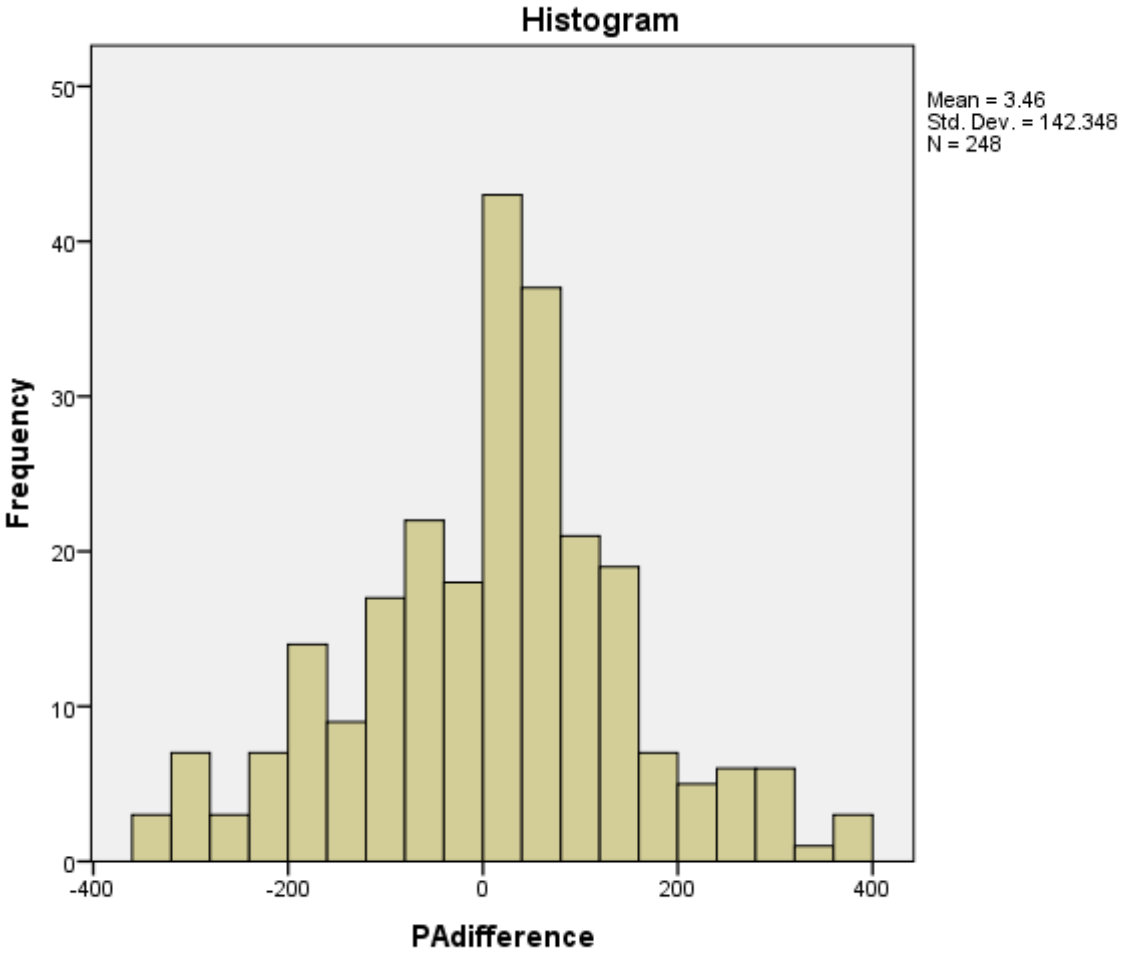
Following accepted methods of removing identified outliers (Pallant, 2013), the top and bottom 5% of the sample were removed from the analysis. This resulted in 28 sets of data being removed, with an updated total sample of 248. Following this procedure, the updated mean (3.46) and trimmed mean (3.32) were found to be much closer together. A Box-plot (see Figure 4-3) for this updated sample (n=248) shows a reduced number of outliers.

Figure 4-3: Updated box-plot following removal of outliers (for PA difference score of updated sample, n=248)



The statistical tests used in this study, relied on an assumption that the distribution of scores on the dependant variable (in this instance, PA difference) was normal (Pallant, 2013). Tabachnick and Fidell (2013) recommend inspecting the shape of the distribution of a data set, using a histogram. Following removal of the outliers, an updated histogram (see Figure 4-4 below) showed a normal distribution of the data.

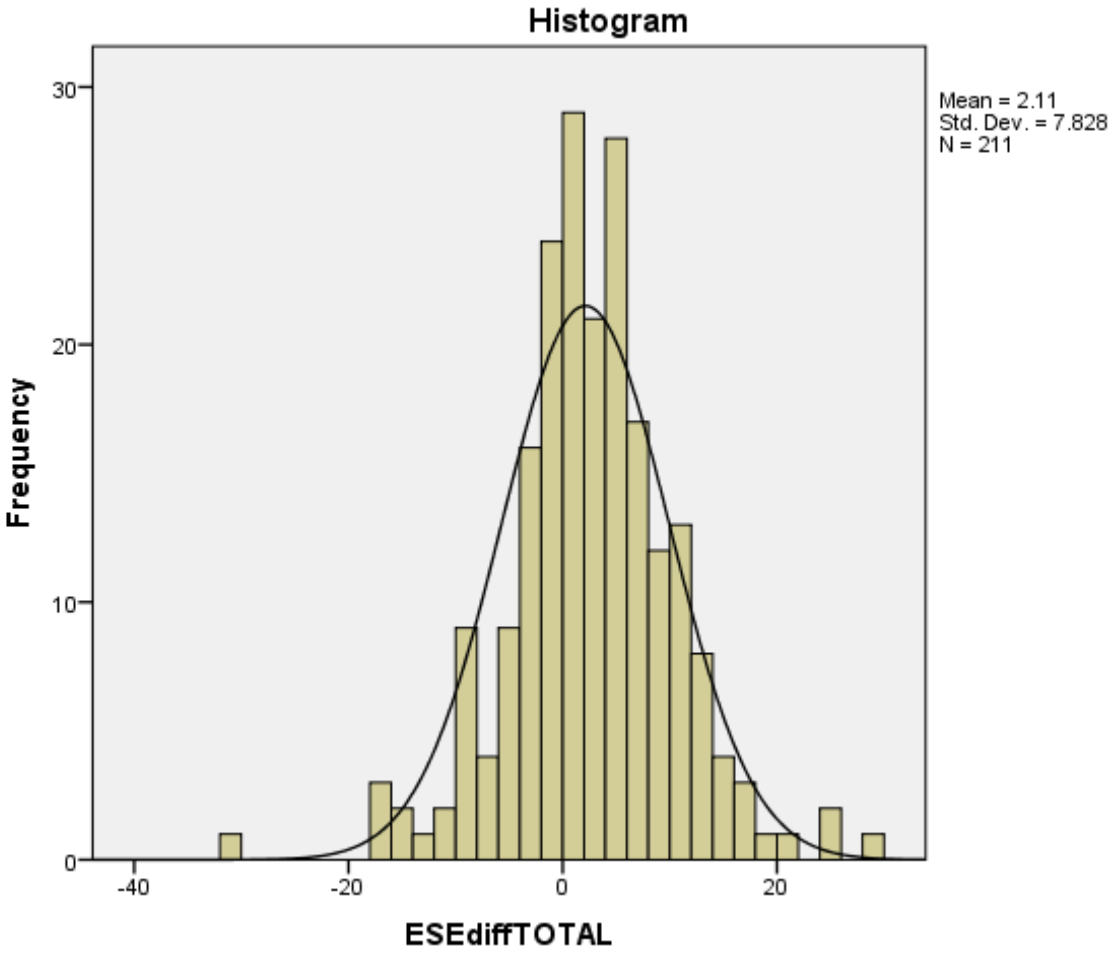
Figure 4-4: Updated histogram showing the distribution of PA difference scores in the whole sample (n=248)



4.5.2.7 Distribution of Data and Outliers (ESE Difference) / Assessing Normality

Frequency distribution of the ESE data was also checked, and all data were found to follow a normal distribution. No extreme outliers were identified. A histogram for the total ESE change scores for the wholes sample are shown in figure 4-5. Visual inspection of the histogram showed that data were distributed normally, with no extreme outliers identified, therefore means (SD) were used when describing the results.

Figure 4-5: A histogram showing the distribution of ESE difference scores in the whole sample (n=211)



4.5.3 Changes in ESE scores and PA levels over time

ESE change scores were calculated for each of the four PA sub-groups, as described earlier in table 4.2. Sample size for each ESE sub-group was also described earlier in table 4.4.

Figures 4-6 and 4-7 below show how levels of PA and levels of self-efficacy (total ESE score) changed over time, within each of the four sub-groups.

Figure 4-6 shows a clear drop in level of PA for the 'non-maintainers', almost mirroring the increase in PA seen in the 'improvers' group. The 'non-actives' and 'maintainers' remained more constant over time, with very small increases in PA reported.

Figure 4-6: Change in level of physical activity over time

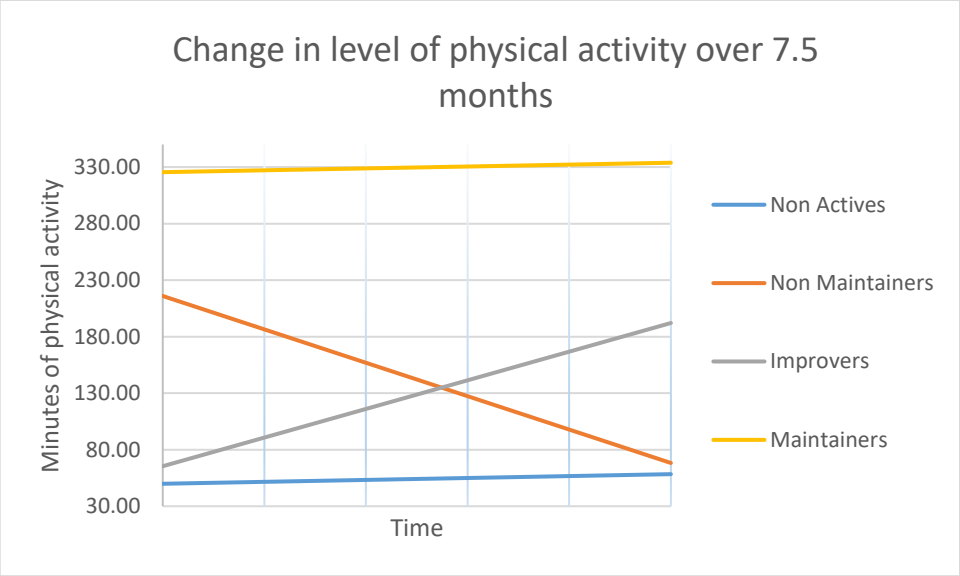
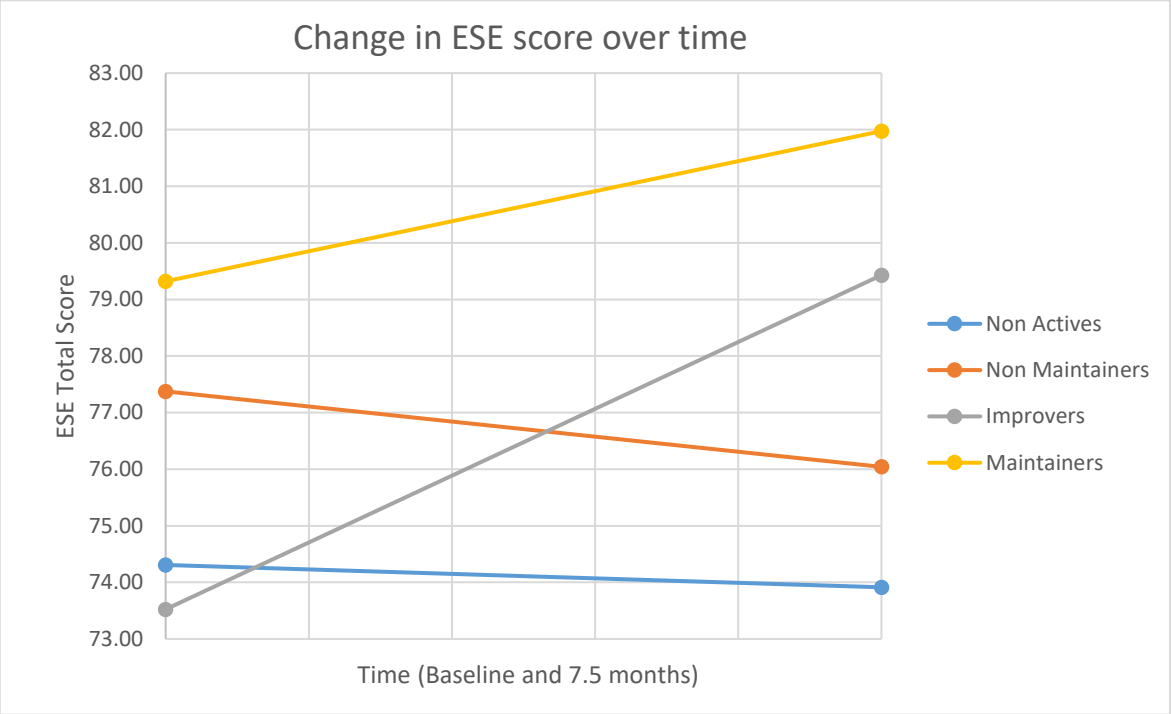


Figure 4-7 shows a slight fall in SE for both the non-actives and non-maintainers. The improvers reported a sharp increase in SE over the 7.5 months, and the maintainers also reported an increase in SE over time.

Figure 4-7: Change in total ESE score over time



4.5.4 Difference between PA groups over time

Table 4.5 below shows how scores within each of the ESE sub-groups changed over time. A pattern emerges, where the non-active (NA), and non-maintainers (NM) had a reduction in scores in most categories. Conversely, the improvers (IMS) and maintainers (MA) reported an increase in ESE scores across all sub-groups; most significantly, the improvers (IMS) reported a large increase in total ESE score of 5.7.

Table 4.5: Mean difference scores for each sub-category of the ESE.

	Non-actives	Non-maintainers	Improvers	Maintainers	Anova (F)	P value
ESE SE	0.00 (2.43)	-0.12 (3.42)	1.61 (3.67)	0.66 (3.04)	1.62	0.185
ESE Barriers	-0.14 (1.78)	-0.19 (2.55)	0.33 (2.46)	0.36 (1.70)	1.06	0.366
ESE Benefits	-0.65 (2.31)	-0.35 (1.92)	1.81 (4.27)	0.48 (3.08)	3.05	0.030*
ESE Impact	-0.46 (2.72)	-0.37 (3.79)	1.50 (3.86)	1.02 (3.46)	2.55	0.057
ESE Total	-1.09 (5.31)	-1.57 (7.13)	5.70 (9.57)	2.71 (7.70)	4.92	0.003*

Mean (SD), *sig.

One-way analysis of variance (ANOVA) tests revealed a significant difference between groups in the ESE Benefits sub-category, and the ESE total score. Tukey post-hoc tests revealed that the significant difference seen in the ESE Benefits sub-category was between the non-actives, and the improvers (p=0.032).

The significant difference in the ESE total score was between the non-actives and improvers (p=0.02), and the non-maintainers and the improvers (p=0.01).

4.6 Discussion

To the author's knowledge, this is the first time that the ESE questionnaire has been used to explore how levels of self-efficacy change over time, in a sample of people with OA.

Mean scores for ESE sub-groups were reduced in those who were not active or did not maintain an adequate level of PA over time. Mean ESE scores were higher for those who did more PA, or maintained an adequate level of PA. Of particular interest were those who increased their level of PA to 120 minutes or more between baseline and 7.5 months (the 'improvers'), who reported the greatest increase in scores across all sub-groups of the ESE questionnaire.

The analysis of the ESE sub-categories shows in more detail what changes occurred between the different PA groups over a period of time. Analysis of the sub-groups of the ESE questionnaire highlighted how differences were seen between those who were not active and those who improved, specifically with regard to their beliefs about the benefits of exercise ($p=0.032$). The total ESE score was also significantly different between the non-maintainers and the improvers, which shows that ESE scores did differ according to level of PA.

These important findings can inform future interventions, in particular the importance of highlighting the potential benefits of PA for OA, in order to motivate people with OA to be more active.

4.7 Strengths and Limitations

A particular strength of the study was the ability to evaluate changes in two variables over time; this allowed us to learn about the potential relationship between self-efficacy and PA maintenance. Another strength was the further analysis of the sub-categories of the ESE scale. As well as considering the broader picture of the total self-efficacy score, we were also able to explore any differences between PA group in relation to the sub-categories, such as benefits of PA or barriers to PA.

However, this study was not without limitations. The sample was mostly made up of white, married participants; a more balanced sample, representing a variety of ethnic groups and marital status, would have provided a more accurate representation of the OA population.

Sample size of the different PA groups was also imbalanced. The majority of the sample fit into the 'Maintainers' group, that is, they reported sufficient levels of PA both at baseline and at 7.5 months. Future research might consider how best to recruit those who are less active. Notably, the non-active group, though small in numbers (n=23) reported the lowest SE scores and these even declined slightly over the 7.5 month period. Arguably, this particular group is where future research should place its focus, to further explore how to engage those who might benefit the most from becoming active.

Another limitation was the self-reporting nature of PA. As previously highlighted in chapter 3, self-report instruments are one of the most widely used type of PA measure (Sallis and Saelens, 2000). The benefits of self-report measures include their ability to collect data from many people at low cost (Sallis and Saelens, 2000). However, the validity of such measures has been brought into question.

Within this study, a number of extreme outliers were identified in the PA data. Checking back to the raw data revealed a wide variation in how people reported their PA, suggesting that definitions used to quantify PA might not have been sufficient. Future research should include accepted objective measures of PA, in an attempt to capture data that are more accurate.

The statistical analysis carried out within the study, like similar studies exploring SE and PA (Hammer *et al.*, 2015) cannot tell us whether there is a causal relationship between SE and PA. We do not know if an increase in SE led to increased, or maintained PA levels, or if engagement in and maintenance of PA itself led to an increase in SE. This means that results from this study are not transferable to the OA population, and future studies, with larger sample size would be beneficial, to learn more about the relationship between SE and PA over time.

Due to time restrictions of the thesis, we were unable to gather data that compared levels of autonomous motivation and levels of PA over time. Future research could explore this relationship in more detail.

4.8 Conclusion

This chapter adds to the previous study by adding knowledge about the potential differences seen in levels of self-efficacy over time, in a sample of people with OA. The results provide further insight into the potential relationship between self-efficacy and engagement in PA, by showing patterns in different physical activity sub-groups. In particular, a difference was seen between those who increased their level of PA over time, and those whose level of PA decreased. Within each of these groups, self-efficacy scores also increased and decreased in line with the level of PA.

To the author's knowledge, this is the first time that longitudinal data of exercise self-efficacy and level of PA have been compared in a sample of people with OA. These findings contribute to our understanding of the impact that self-efficacy might have on the long-term maintenance of PA in this population, though future research could explore this relationship further by gathering data from larger samples.

Findings from this chapter (and chapter 3) are now utilised within the intervention mapping approach adopted in the next chapter, to guide the development of the theoretical underpinnings for the digital intervention. The next chapter will describe in more detail how the identified theoretical determinants were linked to the practical elements of the prototype website.

Chapter 5: Building the Theoretical Foundations of a Complex Digital Health Intervention

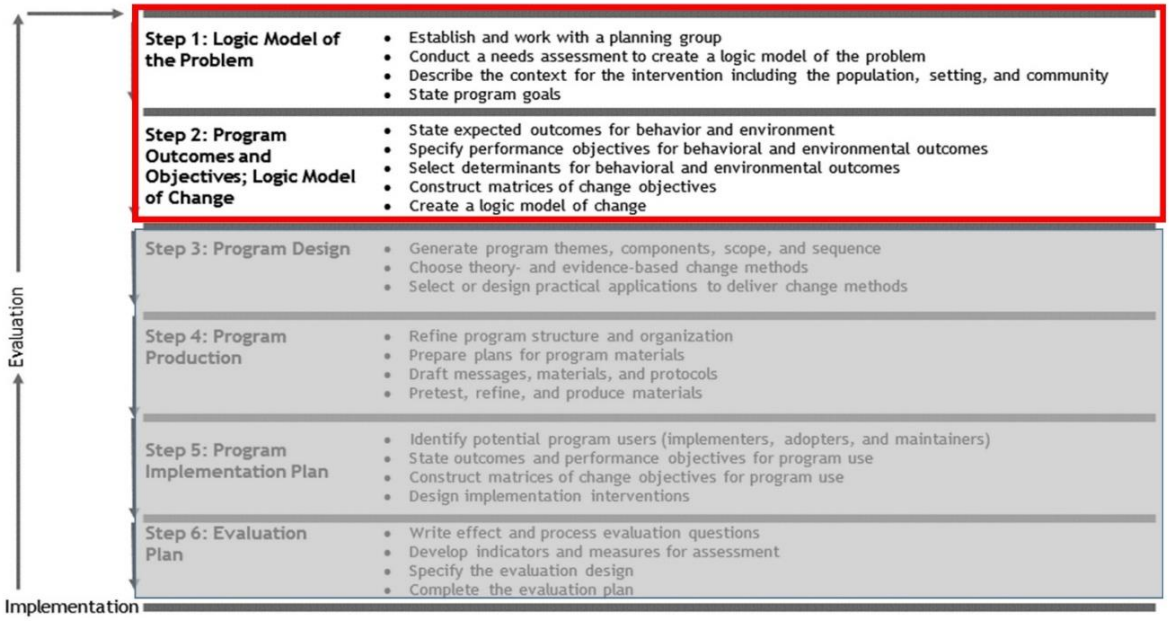
5.1 Overview

Previous chapters (Chapters 2-4) of this thesis focused on assessing the effectiveness of existing digital interventions, as well as identifying the theoretical determinants affecting motivation for PA in a population with OA.

This chapter illustrates how the findings from chapters 2-4 were used to guide the development of a digital health intervention (prototype website). More specifically it uses the Intervention Mapping (IM) approach (described in more detail in section 5.2.3 of this chapter) to document how theoretical constructs were linked to practical elements of the intervention.

The focus of this chapter was solely on the early work carried out to develop the intervention. This exercise was undertaken to build a clear, logical and strong foundation to the intervention, which is not only guided by but also grounded in theory. Steps 1 and 2 of the IM approach are covered here (Illustrated in figure 5-1 below). Step 1 involved describing the problem that the intervention focuses on, and Step 2 involved stating the aims and objectives of the intervention, and identifying which aspects of behaviour the intervention attempts to change.

Figure 5-1: Steps 1 and 2 of the Intervention Mapping Approach *(with permission from John Wiley & Sons (Jossey-Bass))*



(Bartholomew et al, 2016)

5.2 Rationale

Guidelines for the development of DBCIs suggest that the fundamental concept behind development is that the process should be flexible, ongoing and workable (West and Michie, 2016). Too strong a focus on the main evaluation of a complex intervention, at the expense of adequate development and piloting work, might result in weaker interventions, meaning they are less likely to be effective for the target population (Craig *et al.*, 2008).

5.2.1 Complex Intervention Development – National Guidelines

Complex behaviour change interventions are often not well described, and when they are, the terminology used is inconsistent (Michie *et al.*, 2013). It is vital to document and evaluate how individual components work, are used by participants, and how this influences the outcome and effectiveness of an intervention (Aalbers, Baars and Rikkert, 2011).

An intervention that is described as 'complex' often contains several interacting components, however, it may also be described this way due to the range of possible outcomes, or variability within the target population (Craig *et al.*, 2008). Within this thesis, evidence gathered in earlier chapters suggested that an intervention, which attempts to change just one behaviour, rather than multiple behaviours simultaneously, might produce stronger outcomes (Chapter 2). The intervention developed within this thesis focuses wholly on increasing and maintaining levels of PA in a population with OA. It recognises the importance of motivation in this group and therefore becomes complex due to the various constructs of motivation that it will attempt to address simultaneously.

West & Michie (2016) usefully illustrate how guidance from the UK's Medical Research Council (MRC) for developing and evaluating complex interventions can be adapted to guide the development of digital interventions. The MRC proposes a cycle of development which involves: establishing a theoretical underpinning; undertaking appropriate development and piloting; and later a full scale evaluation and implementation (West and Michie, 2016). This chapter focuses on the development phase of this cycle, as it uses information gathered in previous chapters about existing interventions, and identification of theoretical constructs, to development the content of a prototype intervention by modelling processes and intended outcomes.

5.2.2 Why is it important to document how interventions have been developed?

Recent recommendations from an international workshop on how to create, evaluate, and implement effective digital interventions for health (Michie *et al.*, 2017) highlight the importance of detailed development, advising:

- **Advancing models and theories**
  - Specify the circumstances in which a proposed mechanism of action of a digital behaviour change intervention (DBCI) will produce a targeted effect.
- **Understanding and promoting engagement**
  - Specify and establish empirically what constitutes "effective engagement" for each DBCI, that is, sufficient engagement to achieve the intended outcomes.
  - Develop DBCIs with a person-centered and iterative approach, using mixed methods to progressively refine the DBCI to meet user requirements.

This guidance is in line with findings from the review of existing digital interventions (Chapter 2), which highlighted the lack of a clear link between theory and practical materials used within existing interventions, as well as the difficulty in establishing and measuring 'effective engagement' with an intervention. The development work presented in this chapter follows these guidelines, by clearly linking constructs from motivational theory to practical materials used within the intervention.

5.2.3 Why Intervention Mapping? A comparison with other intervention development methods

A number of different methods were considered when deciding how to document the development of the intervention. Published development papers were reviewed to explore which development methods were currently being used, and why they had been chosen.

5.2.3.1 The Behaviour Change Wheel and COM-B Framework

The behaviour change wheel (BCW) (Michie, van Stralen and West, 2011) is a three-layered model for designing behaviour change interventions and is becoming increasingly used to guide intervention development. It is used in conjunction with the COM-B framework (Abraham and Michie, 2008), a theoretical framework which attempts to incorporate all of the key components (capability, opportunity, and motivation) considered to affect behaviour.

The focus within this thesis is on factors affecting motivation for sustained engagement with PA. This made it difficult to adopt this method of development, as it requires that all elements of the COM-B framework are identified, and is less useful if other theoretical determinants (outside of the COM-B framework) are chosen to guide development. For this reason, the BCW and COM-B framework were not adopted for use within this thesis.

5.2.3.2 Person-Based Approach

This approach, described by Yardley *et al* (2015), consists of two key elements:

1) A developmental process involving qualitative research with a wide range of people from the target user populations carried out at every stage; 2) The identification of 'guiding principles' that can inform development by highlighting the distinctive ways that the intervention will address key context-specific behavioural issues (Yardley *et al.*, 2015).

This approach is complementary to the chosen method used for developing the intervention within this thesis (Intervention Mapping, section 5.2.3.4 below). The key

focus of involving potential users at every stage of the project is invaluable and crucial in the early development stages, where user involvement has the chance to shape what the intervention might look like, and how it will be used.

Though not the primary method used, features of this approach were adopted to aid the development of the intervention. This was achieved by the involvement of patient insight partners throughout the entire design and production phase (this chapter, and chapter 6), as well as the involvement of potential users during pre-testing (chapter 7) , which helped to gain a greater understanding of the perspectives of the potential users of the intervention (Yardley *et al.*, 2015).

5.2.3.3 Digital Intervention Models

A number of models and roadmaps were consulted to explore how useful it would be to translate intervention components to a digital setting.

A number of models were identified that have been used in published literature describing digital intervention development. These include: the Behavioural Intervention Technology Model (BIT Model) (Mohr *et al.*, 2014), the Centre for eHealth Research and Disease Management (CeHRes) Roadmap for the development of eHealth technologies (Gemert-pijnen *et al.*, 2011), and the IDEAS (Integrate, Design, Assess, and Share) Framework (Mummah *et al*, 2016a).

The BIT model defines both the conceptual and technological architecture of a digital intervention. Both the BIT model and IM are considered complementary, each with their own qualities. For example, the BIT model is deemed useful in step 4 of IM, where the components, or the 'what' of the intervention are identified (Crutzen, 2014). The BIT model provides tools that are very useful and specific to the context of digital interventions (i.e., the BIT-Tech aspect of the model) (Crutzen, 2014).

The CeHRes Roadmap proposes that a fresh way of thinking is required about how technology can be used to innovate health care, and provides new concepts and instruments to develop and implement technologies in practice. Like the BIT model, its key working principles echo those from both IM, and the person-centred approach,

describing how development should be participatory, and be carried out in continuous evaluation cycles (Gemert-pijn*en et al.*, 2011).

Lastly, the IDEAS framework is a similar step-by-step process (like IM) which integrates behavioural theory, design thinking, user-centred design, rigorous evaluation, and dissemination to guide the development of effective digital interventions.

For the purposes of this project, the decision was made to use the IM approach alone initially, rather than integrating it with a more digitally focused model (at this stage). It was felt that the link between content and theory, and involvement of users to identify and pre-test materials should be the focus. Future steps involving more thorough feasibility testing within a digital setting, might benefit from the incorporation of digital intervention development guidance, and this issue will be revisited at a later stage.

5.2.3.4 Intervention Mapping (IM)

Intervention mapping (IM) is an approach which provides a framework for effective decision making throughout the planning, implementation, and evaluation stages of intervention development (Bartholomew *et al.*, 2011). It is a logical step-by-step procedure, which helps researchers to gather their thoughts as they move from theory and evidence, to practice, whilst providing tools to clearly describe the process (Brendryen *et al.*, 2013).

This approach provides detailed guidance on how to document the link between: a preliminary needs assessment; identification of the determinants of the behaviour; and perhaps most importantly the use of matrices of change, which show how each specific part of the intervention is linked back to its corresponding determinant of the behaviour.

IM provides a logical process for intervention development that fulfils the MRC framework criteria and has previously been used to develop health behaviour change interventions in similar settings (Direito *et al.*, 2018; Hurley *et al.*, 2016; Muir *et al.*, 2017).

It was felt that this method provided the most comprehensive guide to map the identified theoretical constructs to the content of the intervention, therefore it was chosen for use in this project.

5.3 Methods and Results

For ease of reporting, the methods and results within this chapter are combined, and this section is reported in two sections, following the IM approach: Step 1 – Logic model of the problem; and Step 2 – Logic model of change.

5.3.1 Planning Group

Prior to the initiation of any development processes, it was important to identify the planning team. In addition to the PhD supervisory team (SM, CM, NW), two patient insight partners were recruited into the team, specifically to assist with developing and producing the prototype digital intervention.

Establishing an appropriate planning group, and including potential programme users during the planning process was considered essential for the resulting programme's effectiveness (Bartholome*w et al*, 2016). It is important to recognise that potential answers for every question come from several types of information: theoretical and empirical evidence, practice, and lived experience (Bartholome*w et al*, 2016).

Short biographies are described below in boxes 5-1 and 5-2 to provide an overview of each patient partners' journey with OA.

Box 5-1: Patient Insight Partner Biography (JB, Female, Age 74)

Living with Osteoarthritis

I have a history of arthritis in my family, and have been affected by it myself over the last 10 - 15 years. Initially I developed neck pain after years of being a teacher, which I remained doing up to the age of 70. For many years, I was a carer for my mother, and then my husband. I didn't have any time to think about myself.

My hips and knees also became a problem, and I eventually had a total knee replacement in 2016, which reduced the level of pain, but I still suffer from lots of stiffness and a lack of balance. Arthritis has affected my life, reducing the amount of things that I am able to do. I have to climb the stairs slowly, I've reduced the size of my allotment, and use the fork as a walking stick!

Overall, despite seeing improvements in pain after the total knee replacement, arthritis continues to affect my everyday life. I'm working at being more active, but my other knee is now also becoming a problem.

Box 5-2: Patient Insight Partner Biography (DJ, Male, Age 75)

My experience of living with OA.

I was in my 40s when I was first told about arthritis. I was feeling very stiff, so checked it out with my GP and after some tests, I found out about my developing condition. My GP was very good, he explained what it would mean for the future. Eventually my GP referred me to a consultant, who advised me to keep active, and that this would help with my mobility. I am now 75 so have lived with osteoarthritis for nearly 40 years.

So what does a typical day look like? First thing in the morning I am very stiff, so I try to do some light stretching exercises, followed by a hot mug of coffee, and two painkillers. I increase my dose of painkillers according to my level of pain. Some days I don't feel like moving much, so I treat myself to a lazy day. Weather plays a bit part in how I plan my day, it's important to keep myself warm, if I get cold I go so stiff and it gets painful. On these days, I have to double my painkillers.

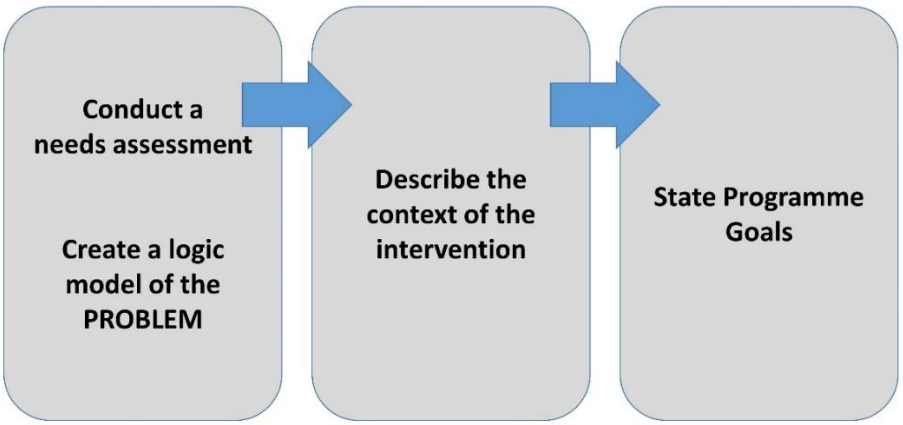
Osteoarthritis is not for the faint-hearted, every day I plan my activity based on my energy levels, pacing myself is important. I do have a little chuckle to myself when I hear other people, much younger, complaining about their aches and pains!

My motto: Be brave, be bold, and put yourself out there.

5.3.2 Step 1 – Logic Model of the Problem

The purpose of this first step in IM was to: conduct a needs assessment to inform the creation of a logic model of the problem (in this case, physical inactivity within the OA population); describe the context of the intervention; and to state the programme (intervention) goals. Tasks within this step are illustrated in figure 5-2 below.

Figure 5-2: Step 1 of the Intervention Mapping Approach



Primary data gathered in earlier chapters (Chapters 2-4) formed the needs assessment described here, so this step illustrates how previous findings were used to guide the development of the intervention. The methods and results of each sub-task are reported together within each of the four sections: 1) Needs Assessment; 2) Logic Model of the Problem; 2) Context of the Intervention; 3) Programme Goal.

5.3.2.1 Needs Assessment – Determinants of Behaviour

A needs assessment should present a full description of the problem in as much detail as can be ascertained within the boundaries of the project. Even though planners may need to narrow their focus during intervention planning, they should begin by analysing the problem and its multiple causes as widely as possible (Bartholomew *et al.*, 2016).

Within this thesis, data gathered during an initial exploration of the determinants of PA behaviours were described in chapter 1, and primary data was produced in chapters 3-4. This information was combined to provide insight into the problem of physical inactivity within this population, from a motivational perspective. Findings are summarised in Box 5-3 below:

Box 5-3: Needs Assessment

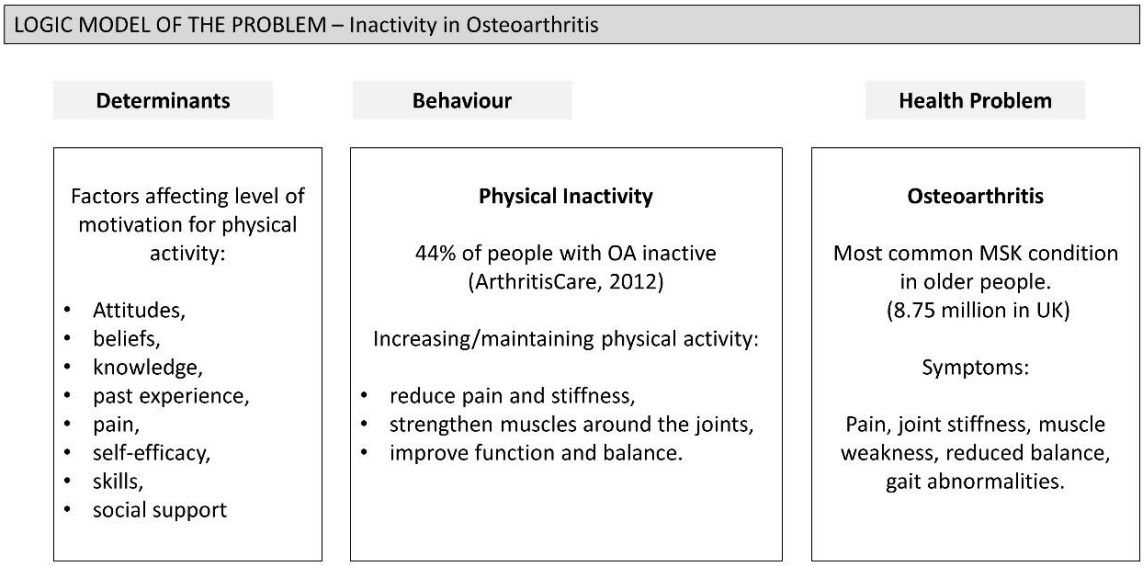
Chapter	**Key findings in relation to the problem of physical inactivity within the OA population**
1	• Clinical Guidelines for self-management of OA reviewed. • PA guidelines reviewed. • Determinants of PA within OA explored. • Psychological theories of behaviour change reviewed.
2	• Identification and review of effectiveness of existing digital interventions. • Behaviour change techniques and theory used within existing digital interventions evaluated.
3/4	• Low self-efficacy associated with lower levels of PA. • Non-autonomous forms of motivation associated with lower levels of PA. • Higher self-efficacy associated with higher levels of PA. • Autonomous motivation associated with higher levels of PA.

The findings described in box 5-3 were used to develop a logic model of the problem shown below in figure 5-3. This model describes all of the identified determinants of the behaviour, the behaviour that the intervention will focus on changing (physical inactivity), and the health outcomes of this behaviour (improving symptoms of OA).

5.3.2.2 Logic Model of the Problem

A logic model of the problem (figure 5-3) is a model of the factors that cause or influence the health problem that will be the focus of the intervention (Bartholomew *et al.*, 2016). Within this thesis, the behaviour identified as being a problem was physical inactivity within the OA population. (This was the first of two logic models created during the IM process. A logic model of change (Step 2) was also created to describe the determinants of the behaviour that the intervention aims to change, this is described and illustrated in Section 5.3.3.4).

Figure 5-3: Logic Model of the Problem



5.3.2.3 Context of the Intervention – Digital Technology

Within the context of this thesis and intervention development process, a digital behaviour change intervention 'DBCI' refers to an intervention that uses digital technologies to promote and maintain health, through primary or secondary prevention and management of health problems (Yardley *et al.*, 2016).

DBCIs have the potential to overcome many of the barriers associated with traditional face-to-face programmes, by offering cost-effective and widely accessible information, which is convenient, anonymous, and can be tailored to the individual (Bossen *et al.*, 2014; Norman *et al.*, 2007; Vandelanotte *et al.*, 2007).

The systematic literature review in chapter 2 highlighted that existing digital interventions could successfully increase levels of PA in this population, but only for short periods of time, and highlighted the issue of non-usage or attrition. These findings support the need to further develop digital interventions where the focus is on establishing optimal motivation for sustained engagement with PA in this population.

5.3.2.4 Programme Goal

The programme goal was created after considering the key findings from the needs assessment and evaluation of the context of the intervention. The programme goal of this intervention was:

To provide tools (via a digital platform) which promote both autonomous forms of motivation and increase self-efficacy for physical activity, to facilitate sustained engagement in physical activity for people with OA.

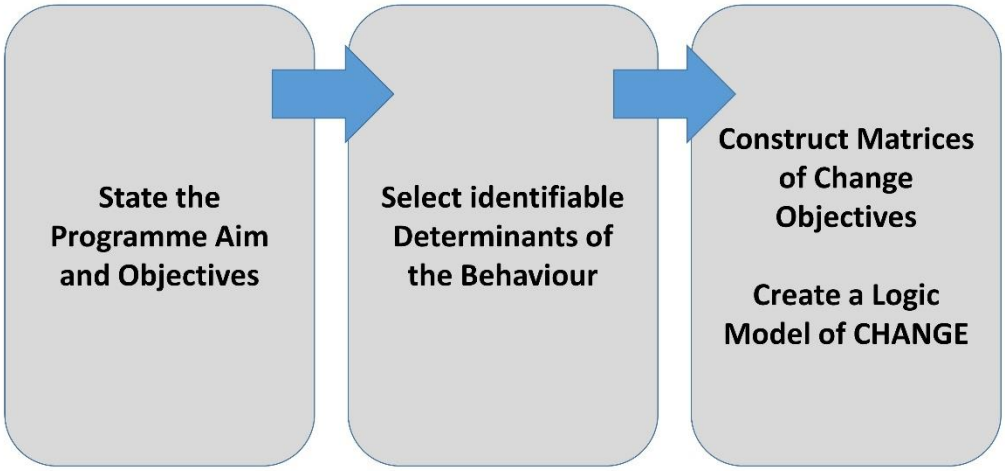
5.3.3 Step 2 – Programme Aim, Objectives, and Logic Model of Change

This step provided the foundation for the intervention by specifying who, what, and how change will occur as a result of the intervention (Bartholomew *et al.*, 2011).

Figure 5-4 below provides an overview of the tasks carried out during this step. In line with the previous section, methods and results are integrated and described in the

following sections: 1) Aims and objectives of the intervention; 2) Determinants of the behaviour; 3) Matrix of change objectives; 4) Logic model of change.

Figure 5-4: Step 2 of the Intervention Mapping Approach



5.3.3.1 Programme outcome (Aims and Objectives)

This sub-task involved referring back to the evaluation of existing interventions to identify what key areas the current intervention would focus on. Components of the effective interventions included in the SLR (Chapter 2, Table 2.8) were mapped to the behaviour change taxonomy, highlighting the main areas of focus. This exercise guided the formation of the overall aims for the intervention (Table 5.1 below).

Table 5.1 shows how the results of the needs assessment informed the development of the programme aims. Behaviour change techniques (BCTs) identified within the effective interventions reported in the systematic review (chapter 2) were grouped together (according to the BCT taxonomy V1). From this, three main areas were identified: knowledge and skills, action planning, and social support.

Table 5.1: Development of Programme Aims

BCT identified in Needs Assessment (coded to the Behaviour Change Technique Taxonomy v1 Michie et al (2013)).		**BCT grouping**	**Guidance for Programme Outcome (AIMS)**
1.1	Goal setting (behaviour)	GOALS AND PLANNING	ACTION PLAN
1.2	Problem solving		
1.4	Action planning		
1.5	Review behaviour (goals(s)		
1.6	Discrepancy between current behaviour and goal		
1.9	Commitment		
2.3	Self-monitoring of behaviour	MONITORING	ACTION PLAN
2.4	Self-monitoring of outcome(s) of behaviour		
2.7	Feedback on outcomes of behaviour(s)		
3.2	Social support (practical)	SOCIAL SUPPORT	SOCIAL SUPPORT
3.3	Social support (emotional)		
4.1	Instruction on how to perform the behaviour	KNOWLEDGE	KNOWLEDGE/ SKILLS
4.2	Information about antecedents		
5.1	Information about health consequences	NATURAL CONSEQUENCES	KNOWLEDGE/ SKILLS
6.1	Demonstration of the behaviour	COMPARISON OF BEHAVIOUR	KNOWLEDGE/ SKILLS
7.1	Prompts/cue	ASSOCIATIONS	ACTION PLAN
8.1	Behavioural practice / rehearsal	REPETITION	ACTION PLAN
8.3	Habit formation		
8.7	Graded tasks		
9.1	Credible source	COMPARISON OF OUTCOMES	KNOWLEDGE/ SKILLS
10.4	Social reward (includes positive reinforcement)	REWARD	SOCIAL SUPPORT
11.2	Reduce negative emotions (includes 'stress management')	REGULATION	ACTION PLAN
12.6	body changes (strength training/relaxation)	ANTECEDENTS	KNOWLEDGE/ SKILLS
13.2	framing/reframing	IDENTITY	KNOWLEDGE/ SKILLS
13.3	incompatible beliefs		

These areas were taken forward to produce the three main aims illustrated below (table 5.2). Information from the needs assessment was used to guide the formulation of objectives for each aim.

Table 5.2 below provides details of the three aims of the intervention, and related performance objectives (i.e. what the participants need to do to perform the health-related behaviour).

Table 5.2: Aims and objectives of the intervention

KNOWLEDGE/SKILLS To provide the user with sufficient knowledge about the benefits of PA for OA, and access to appropriate resources, enabling the user to develop sufficient skills to carry out their chosen PA.	PO 1.1: Understand, and accept the benefits of PA for OA. PO 1.2: Understand how to select, and safely perform their chosen type of activity. PO 1.3: Understand that normal physiological responses (such as pain) can be experienced, and how to respond.
ACTION PLANNING To provide the user with the appropriate tools to formulate and self-monitor SMART goals, including the ability to review and update them when necessary.	PO 2.1 Learn about, and set SMART (specific, measurable, achievable, realistic, timely) goals for PA, using pacing/graded tasks. PO 2.2 Learn about self-monitoring and updating goals. PO 2.3 Acknowledgement of past successes of PA. PO 2.4 Problem solving, and planning for challenging times, including recognition of how others have overcome barriers.
SUPPORT To enable the user to identify and develop supportive social links, providing a sustained supportive environment for maintaining PA.	PO 3.1: Accept the emotional and practical benefits of a social network of support (and plan for). PO 3.2: Identify new social network links – friends/family/active others with OA. PO 3.3: Accept that one's own behaviour can be an example for others to help them to be physically active.

5.3.3.2 Determinants of behaviour

The purpose of this task was to explore and identify the important and changeable determinants of PA. Exploration of the determinants of PA during the needs assessment (data gathered in chapters 3 and 4) showed that fostering both self-efficacy and autonomous forms of motivation might help people with OA to become and stay active.

Bandura (1997) proposed four strategies for increasing self-efficacy, namely: the facilitation of task mastery; exposure to direct or vicarious experiences of the intended behaviour; social or verbal encouragement and persuasion; and assistance with dealing with somatic or emotional responses (described in more detail in Box 5-4 below).

Deci and Ryan (2000) proposed three innate psychological needs: autonomy; relatedness; and competence, which when all satisfied yield enhanced motivation over a longer period of time (described in more detail in Box 5-4 below).

The strategies described in Box 5-4 were adopted as the determinants of behaviour (D1-D7) for the intervention.

Box 5-4: Determinants of Behaviour

- **D1: Self-Efficacy, mastery experiences (personal successes)**
  Derived from prior personal experiences with similar activities. Success through perseverant effort can enhance perceived SE, failure can undermine it.
- **D2: Self-efficacy, vicarious experiences (seeing others succeed)**
  Observation of other people similar to oneself engaging in similar activities. Watching other people succeed can raise the observers SE, and observing other people's failure can lower SE.
- **D3: Self-efficacy, Social persuasion (i.e. verbal encouragement)**
  Verbal persuasion of possessing the necessary skills to master a given activity can increase SE and thus cause a greater effort and perseverance.
- **D4: Self-efficacy, Somatic/emotional states (emotional support)**
  Physiological and emotional states elicited by a given activity. Interpreting the states negatively is likely to reduce perceived SE, while positive interpretation or attribution to situational factors can increase SE.
- **D5: Self-determination theory, Relatedness:**
  Being connected to others who are currently active, feeling valued by others.
- **D6: Self-determination theory, Autonomy**:
  Feeling a sense of ownership, and being able to make their own choices. Doing an activity/choosing an activity that the individual values. Being fully engaged and feeling in control of one's actions. Choice.
- **D7: Self-determination theory**, **Competence:**
  Feeling capable of carrying out the chosen activity. Having mastery over the activity.

5.3.3.3 Matrix of change objectives

The change objectives represent the pathways for the most immediate changes in the identified behaviour (Bartholomew *et al.*, 2011). Within this intervention, the change objectives were those pathways that worked directly on the motivational constructs identified earlier, to influence new health behaviours and actions (i.e. PA).

Three tables of change objectives were created (tables 5.4, 5.5, 5.6 below), with all of the determinants of behaviour listed horizontally as column headings, and with each programme objective listed vertically as row headings. Team members (NW, CM, AB, JB, DJ) were asked to consider which determinants they felt needed to be changed for each programme objective to be met. Each team member received a blank version of the matrices, and inserted an X in each box where they considered the determinant was necessary to affect the objective. An example of this is provided, in table 5.3 below.

Table 5.3: An example of a Change Objective

	Determinant of behaviour: Self-efficacy – vicarious experience (seeing others, like you, succeed)
Performance objective: Learn about, and set SMART goal for PA, using pacing/graded tasks.	Team vote = 5 (100%) Change objective written by AB: Individual understands that others have benefited from setting SMART goals/and using pacing/graded tasks.

Team votes were collated, and those with a majority vote (3 or more) were identified. Change objectives were then written by AB for all boxes with a majority vote. These are shown in tables 5.4, 5.5, and 5.6 below (empty boxes show where team votes did not reach majority; therefore, no change objective was created). AB explored different methods for enhancing the identified determinants, as reported in the SE and SDT literature. For example, Bandura (1997) and Strecher *et al*. (1986) suggest methods to

enhance SE should include: 1) identify and reinforce past and present successes, 2) direct patient to observe successful behaviour of others, 3) provide positive feedback, 4) try to ensure the patients interpret their feelings correctly. Marks et al (2014) reviewed the evidence relating to SE and arthritis treatment strategies and recommended several approaches for promoting arthritis self-efficacy, which also guided the development of the change objectives within this study. Literature reporting similar interventions (digital and non-digital) were also used to guide the development of the change objectives.

Table 5.4: Change Objectives for Knowledge and Skills

KNOWLEDGE/SKILLS - To provide the user with sufficient knowledge about the benefits of PA for OA, and access to appropriate resources, enabling the user to develop sufficient skills to carry out their chosen PA.							
Performance Objective	**DO1: Self-Efficacy, mastery experiences**	**DO2: Self-efficacy, vicarious experiences**	**DO3: Self-efficacy, Social persuasion**	**DO4: Self-efficacy, Somatic/ Emotional states**	**DO5: SDT, Relatedness**	**DO6: SDT, Autonomy**	**DO7: SDT, Competence**
PO 1.1: Understand, and accept the benefits of sustained engagement with PA for OA.	CO1.1.1: Individual to have access to sufficient information so that they are able to understand how PA can help OA.	CO1.1.2: Individual to understand how others (from a physiological perspective) have benefited from starting and continuing PA.	CO1.1.3 PROCESS Individual to receive persuasive prompts/ advice.	Co1.1.4 PROCESS -Messages to be focused on understanding of emotional states/Mood.	CO1.1.5: Individual to understand how others have benefited from continued PA	CO1.1.6: PROCESS - Individual to have choice about what information they receive– I.E. more/less.	CO1.1.7: Individual to have access to sufficient information so that they are able to understand how continued PA can help OA in the long term.
PO 1.2: Understand how to select, and safely perform their chosen type of activity.	CO1.2.1 Individual to have access to sufficient information so they can select appropriate activity, and carry it out safely.	CO1.2.2 Examples of how others chose safe over unsafe activities.				CO1.2.6 PROCESS – have choice for more/less information.	CO1.2.7 Individual to have access to sufficient information so they can select appropriate activity, and carry it out safely.
PO 1.3: Understand that normal physiological responses (e.g. pain) can be experienced, and how to respond.	CO1.3.1 Individual to reflect on previous/current experiences of physiological responses such as pain, and consider options for how to respond.	CO1.3.2 Individual to recognise that others with OA have experienced 'normal physiological responses' and how they have overcome barriers.		CO1.3.4 Individual to recognise that others can experience 'normal physiological responses' and how they have overcome such barriers.			CO1.3.7 Individual to understand what a 'normal physiological response' might feel like.

Table 5.5: Change Objectives for Action Planning

ACTION PLAN: To provide the user with the appropriate tools to formulate and self-monitor SMART goals, including the ability to review and update them when necessary.							
Performance Objective	**DO1: Self-Efficacy, mastery experiences**	**DO2: Self-efficacy, vicarious experiences**	**DO3: Self-efficacy, Social persuasion**	**DO4: Self-efficacy, Somatic/ Emotional states**	**DO5: SDT, Relatedness:**	**DO6: SDT, Autonomy:**	**DO7: SDT, Competence:**
PO 2.1 Learn about, and set SMART Goals for PA, using pacing/graded tasks.		C02.1.2 Individual understands that others have benefited from setting SMART goals/and using pacing/graded tasks.	CO2.1.3 Verbal encouragement about the benefits of setting GOALS.	CO2.1.4 Individual understands the benefits of using pacing and graded tasks.	CO2.1.5 SEE CO2.1.2.	CO2.1.6 Individual understand what a SMART goal is, and to choose own SMART goals. And choice to decide how many goals etc.	CO2.1.7 Individual confident to select appropriate goals/pacing/graded tasks for current level of PA.
PO 2.2 Learn about self-monitoring and updating goals.	CO2.2.1 Individual accepts the benefits of self-monitoring, and is confident to make a plan.	CO2.2.2 Examples of others who have set up goals. How and when, have self-monitored their behaviour.	CO2.2.3 Social encouragement from others, you can succeed at your goals – sharing of goals?	CO2.2.4 Understand the emotional benefits of self-monitoring your goals – stories?	CO2.2.5 (SEE CO2.2.2).	CO2.2.6 Individual chooses how they monitor PA, and how often they receive prompts.	CO2.2.7 (SEE CO2.2.1).
PO 2.3 Acknowledgement of past successes of PA.		CO2.3.2 Individual to recognise the benefits of others who have	CO2.3.3 Verbal encouragement about the benefits of	CO2.3.4 Individual to accept that exploring previous success can have a	CO2.3.5 (SEE CO2.3.2.	CO2.3.6 PROCESS - Individual to have a choice to record	CO2.3.7 Individual to explore and recognise the value of

		explored their previous successes.	exploring, and recording past success.	positive effect on emotional / somatic states.		previous successes/or not.	previous personal successes.
PO 2.4 Problem solving, and planning for challenging times, including recognition of how others have overcome barriers.	CO 2.4.1 Individual to explore (and record) previous (and current) barriers, and how they were (and might be) overcome.	CO2.4.2 Accept that others have successfully overcome barriers, and learn about how they have done this.	CO2.4.3 Advice from others, (verbal encouragement) about how others have successfully overcome barriers – tools and advice.	CO2.4.4 Individual to understand how to overcome emotional and somatic responses/barriers to PA (Mood etc).	CO2.4.5 Relate to others who have successfully overcome barriers.		CO2.5.7 Individual to understand, and accept that barriers to PA can be overcome.

Table 5.6: Change Objectives for Social Support

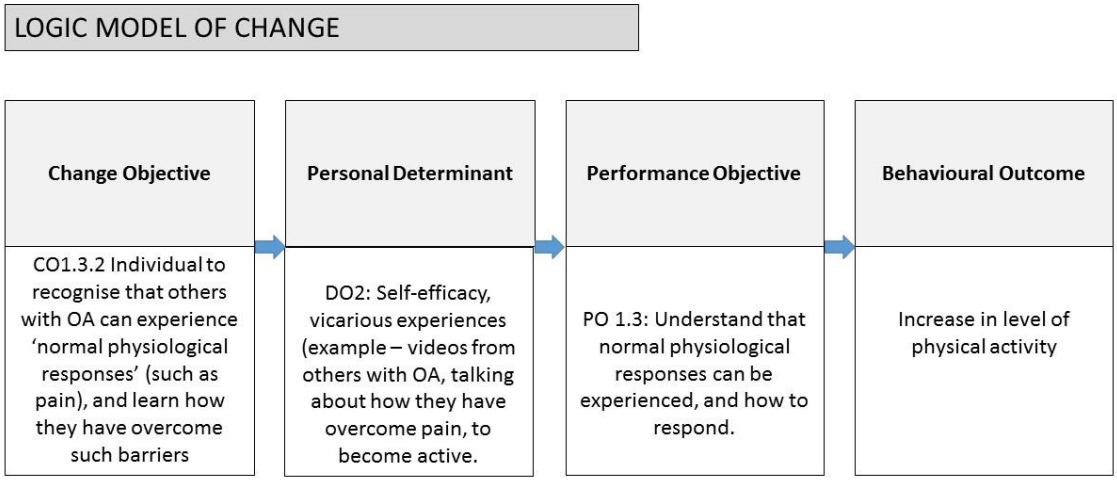
SUPPORT: AIM: To enable the user to identify and develop supportive social links, providing a sustained supportive environment for maintaining PA							
Performance Objectives	**DO1: Self-Efficacy, mastery experiences**	**DO2: Self-efficacy, vicarious experiences**	**DO3: Self-efficacy, Social persuasion**	**DO4: Self-efficacy, Somatic/ Emotional states**	**DO5: SDT, Relatedness:**	**DO6: SDT, Autonomy:**	**DO7: SDT, Competence:**
PO 3.1: Accept the emotional and practical benefits of a social network of support (and plan for).	CO3.1.1 Individual to plan for how social support might help with practical issues of PA		CO3.1.3 Individual to accept the benefits that emotional and practical support	CO3.1.4 Recognise the positive effects that a social network can have on emotional responses		CO3.1.6 PROCESS – Individual to make own plan about how a social network might support them	CO3.1.7 Individual to be accept the benefits of developing a social network
PO 3.2: Identify new social network links – friends/family/active others with OA	CO3.2.1 Individual to gain confidence identifying and contacting friends/family for support	CO3.2.2 Individual to learn how others have benefited from support from family and friends	CO3.2.3 Individual to accept the benefits of support from family and friends	CO3.2.4 Individual to accept the emotional benefits of support from family and friends	CO3.2.5 Individual to learn how others have identified, and started new activities with others with OA	CO3.2.6 Individual to identify/name those who can provide such support	CO3.2.7 Individual to gain confidence in identifying and contacting friends and family for support
PO 3.3: Accept that one's own behaviour can be an example for others to help them to be physically active	CO3.3.1 Individual to identify positive personal outcomes that could help others with OA to be active	CO3.3.2 Individual to learn about how shared experiences can help people with OA become active	CO3.3.3 Encouragement from others, to share success stories	CO3.3.4 Individual to accept the emotional benefits of helping others to be active.	CO3.3.5 Recognise that one's own behaviour can help others to succeed.	CO3.3.6 PROCESS – Option to share own personal experiences to help others	

5.3.3.4 Logic Model of Change

The final task within this step of IM was the creation of a logic model of change to illustrate the proposed relationships between theory- and evidence-based change methods; the determinants they are expected to influence, and the behavioural outcomes that will address the health problem (Bartholomew *et al.*, 2011).

Figure 5-5 shows the logic model of change. It includes an example of how an individual change objective is hypothesised to have an effect on a personal determinant, and how that is linked to a performance objective and resulting behavioural outcome.

Figure 5-5: Logic Model of Change



5.4 Discussion

The detailed nature of the IM approach meant that it was possible to document how determinants of PA, taken specifically from the constructs of motivational theory, were used in combination with findings from previous literature, to identify specific elements of behaviour that need to change in this population.

This approach enabled detailed reporting of a digital intervention, when compared to interventions that already exist. Importantly, a primary reason for developing the intervention in this way was to enable more rigorous future testing of effectiveness. The clear foundation of the intervention makes it easier to identify which aspects of the intervention might be the most useful to users, and which techniques appear to have the greatest effect at increasing and maintaining levels of PA. Such findings can then be linked back to the original determinants, providing new knowledge about whether certain constructs of motivation are more important than others.

5.5 Strengths and Limitations

The main strength that IM brings to intervention development is one of structure and clear reporting of the content of a digital behaviour change intervention. The results of this stage of development produced a clear foundation for the intervention, which could be used to guide the production of the prototype website.

One challenging area during the development process was the writing of the change objectives. The process of developing change objectives felt quite subjective, although it was guided by other published research that had adopted the IM approach. All publications appeared to develop the change objectives in different ways, depending on how theory was combined with knowledge about existing interventions and their proposed mechanisms of change.

5.6 Conclusion

This chapter described the first two steps of the IM approach for developing a digital behaviour change intervention. This useful exercise provided a foundation upon which the practical materials of the intervention could then be identified and created. While IM is a time-intensive collaborative process, the range of methods and resultant high level of transparency is invaluable, allowing replication by future complex intervention and trial developers (Hurley *et al.*, 2016).

The next chapter moves forward to the design and production of the digital intervention, demonstrating how the change objectives were transformed into practical elements of the prototype website.

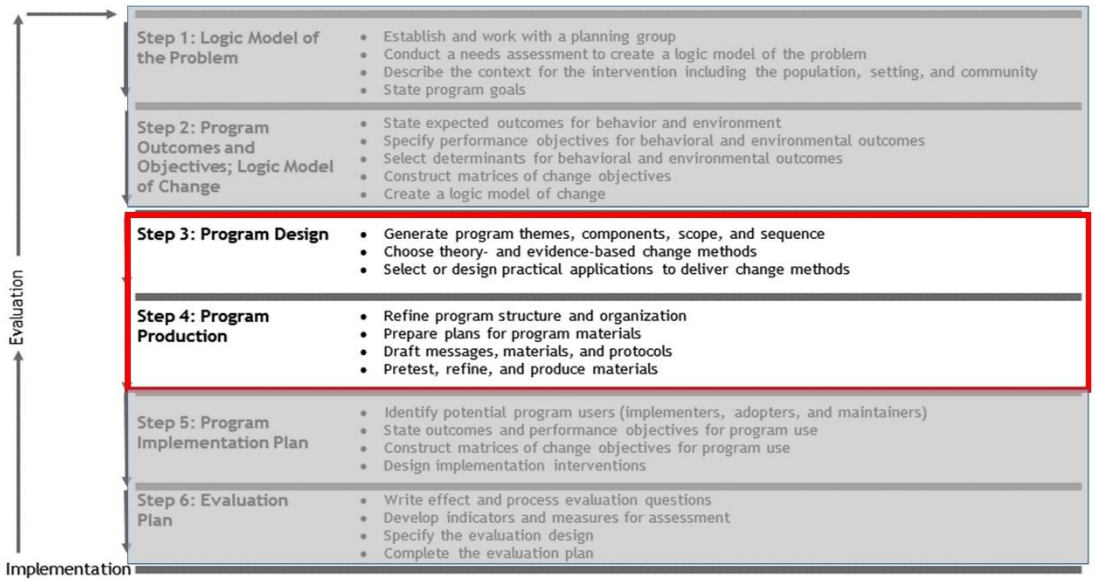
Chapter 6: Design and Production of a Prototype Website

6.1 Overview

The previous chapter described steps 1 and 2 of the intervention mapping (IM) approach, showing how the theoretical foundations of the intervention were identified, and linked to change objectives.

This chapter describes steps 3 and 4 of the IM approach (see Figure 6-1 below), which guide the design and production stages of the prototype website. In step 3, the logic model of change was used to conceptualise and design the intervention. In step 4, creative programme messages and materials were produced, based on the plan created in step 3. A challenge in this step is one of translation; designing the materials so that the BCTs and practical applications are effectively operationalised and the change objectives are accomplished (Bartholomew et al., 2016).

Figure 6-1: Steps 3 and 4 of the Intervention Mapping Approach (with permission from John Wiley & Sons (Jossey-Bass))



(Bartholomew et al, 2016)

6.2 Rationale

The intervention mapping approach provides in-depth guidance for the design and production stages of the intervention. The previous chapter (chapter 5) provided an in-depth rationale for using IM to guide the development of the prototype website.

6.3 Methods and Results

For ease of reporting, the methods and results within this chapter are combined, and this section is reported in two sections, following the IM approach: Step 3 – Programme design, and Step 4 – Programme Production.

6.3.1 Step 3 – Programme Design

In this step, planners work from the logic model of change (established in step 2) to begin to conceptualise and design the intervention (Bartholomew *et al.*, 2016). A range of methods were used to complete each sub-task, each is described separately below:

This step involved three sub-tasks:

- Generation of programme themes, components, scope, and sequence
- Identification and selection of theory and evidence-based change methods (Behaviour Change Techniques)
- Selection of practical applications to deliver chosen behaviour change techniques

6.3.1.1 Generate programme themes, components, scope, and sequence (Team consensus meeting)

The purpose of this step was to produce an initial plan that described the programme. This required that key programme themes and components should be identified, and scope and sequence explored. The scope is the breadth and amount of a programme (what's going to be included, and what's not), and sequence is the order in which each part of the programme will be delivered (Bartholomew *et al.*, 2016).

This generation of programme ideas was carried out by the planning group. The team included: the candidate (AB); members of the supervisory team (CM, NW); and two patient insight partners (JB, DJ). A full team consensus meeting was carried out which

focused on ideas for content of the intervention. The team worked through the aims and objectives of the intervention, discussing their ideas of what content might be included, and how it might be presented. An overview of the output from this meeting is described below, and in Table 6.1.

Bartholomew *et al* (2016) provide helpful guidance for participatory group work and processes for consensus within the IM approach to intervention development. A work group needs structure and guidance to produce the end products for each IM step; Consensus is the process of choice for most decisions made by health promotion planning teams. To work to consensus, group members need to listen; to seek differences of opinion, help each person clearly and fully present a position, critically consider all positions presented, tolerate and even encourage intellectual merit of someone else's argument, and focus on the goal of reaching the best possible decision (Johnson and Johnson 2012, cited in Bartholomew *et al*, 2016).

Guiding Principles / Key Themes

The team consensus meeting was held in January 2018. It provided an opportunity for the full team to discuss all ideas and possible content for the intervention. The team discussed at length their thoughts on the most useful materials to meet the aims and objectives of the intervention. Table 6.1 below describes the guiding principles, which were considered important and necessary to shape the development of the intervention. Table 6.2 summarises key points about the main sections of the website, and highlights where consensus was reached on the inclusion of practical materials. It also describes areas where it was considered important to further explore during prototype testing with users, for example, optimal methods for developing social support, and preferred referral pathways.

Table 6.1: Guiding Principles developed during Team Consensus Meeting

Subject	Overview
Simple, and easy to use	Consensus from team that information on the website should be simple, straightforward, and that the website should be easy to use. Animations could be really useful, making it more accessible. Try not to use external links. Have clear navigation i.e. NEXT and BACK buttons. Information must be accurate, well-informed – people hold onto these messages, they can have significant impact.
Familiarity	Important that website familiar, not too different from other common websites. Patient insight partner (PIP) quote: 'It's about having continuity, with an element of change'.
Stories from others	Recognition of the value of stories from others (relatedness and vicarious experience). PIP: 'I need inspiration' Currently available online videos may be too broad? Explore this further with users when testing.
Enjoyment/ Living Life – Despite OA	Team consensus that there should be a clear message up front that the focus of the website will be: • How to use PA to help me to live well. • Engaging with, and enjoying life – and how PA can help you to do this. • Less emphasis on 'I'm doing this BECAUSE of my OA' and more focus on 'I'm going to do…..despite my OA.' • Focus on ENJOYMENT 'I want to be happy, so what do I need to do to achieve that?'
Learning when in Pain LESS IS MORE	Valuable insight from PIPs about the difficulty of absorbing information, when in pain. PIP quote: 'A painful condition can undermine your ability to want to learn, because your focus is simply on trying to get through the day, because you've got this pain'. Awareness that people with OA might find it quite uncomfortable to sit for long periods of time.

Table 6.2: Key Points raised about potential content for the intervention

Area	Subject	Overview
Knowledge /Skills	Mood/weight management/ comorbidities	Discussions – Do we include information on: Mood, weight management, comorbidities (to explore further in interviews?). Balance between a simple intervention focusing on one outcome, or more complex, focusing on multiple behaviours? Decision – If it doesn't match a change objective then shouldn't be included.
Action Planning	Overcoming previous obstacles and recording achievements	Agreement that this could be a useful tool, but also be careful to not upset people who feel they might not have had any previous successes.
Action Planning	Goal Setting	Team agreement - this is an important section. Include self-monitoring. Explore with users during interviews – have the option to 'buddy up' with people locally/online, who have a similar goal to you. Perhaps use a different term to GOAL? Mixed opinion from PIPs, to explore further in user testing.
Social Support	Social support	PIP: 'include something about being confident and being comfortable with asking people for help.'
Social Support	Arthritis and Friendship	PIP: 'Having arthritis can impact on friendships because you are no longer always able to keep up with activities that your friends do. This is hard.' Acknowledgement of the impact that OA can have on friendships. Important to help people to develop new social links.
Social Support	Being active together /Local Activities	Team liked the potential option to search (Map?) for what activities are happening locally. Query – How might this work in the real-world/how would it be kept up-to-date?
Social Support	Stories from others	Team agreement that having examples of how others have developed new social networks would be helpful.
Social Support	Complexity	Keep this section simple, don't over-burden, but give options to link up.
Social Support	Referral pathway options	Agreement that it would be helpful to explore further during semi-structured interviewing when testing prototype. How might potential users like to find out about the website?

Scope

The scope of existing interventions included in the systematic literature review (Chapter 2) varied. Some focused solely on attempting to increase levels of PA, others had multiple aims, covering various aspects of overall self-management of OA. Interventions varied from websites with large volumes of information about different areas of self-management; to much more focused apps, which provided snippets of information and advice.

Scope for this intervention was formed naturally from the identification of practical applications to match the change objectives developed in the earlier steps of the IM approach (chapter 5). Only materials that were intended to directly affect each change objective were eligible for inclusion.

Sequence

There was team consensus that maintaining the focus on autonomy and a self-determination perspective was important. For this reason, it was felt that users should be able to move around the different pages and tasks of the intervention freely. No pages/sections would be blocked, the intervention would not be modular, and users would be able to use whichever aspects of the website they chose, in any order. There was agreement that users could be guided with 'NEXT' buttons, to create a natural flow through the website, but would still have choice to visit other pages if they wanted.

Website Name

The guiding principles formed during this meeting also had a key influence on the name of the website. A team vote was carried out, and the preferred name was:

Enjoying Life and Living with Arthritis – 'ELLA'.

6.3.1.2 Identification and selection of theory and evidence-based methods

Within the IM approach, a theoretical method is a technique or process for influencing change in the determinants of the behaviour (Bartholomew *et al.*, 2011). From this point onwards, the term 'Behaviour Change Technique' (BCT) will be used.

An evaluation of the most commonly used BCTs present in existing digital interventions were described in Chapter 2 and this guided the development of the aims and objectives for the website (See Chapter 5 – Results).

For this sub-task, BCTs were linked to all of the change objectives created during step 2 of the IM approach (Chapter 5). The BCTv1 taxonomy was used to code the BCTs. The Behaviour Change Technique (BCT) Taxonomy v1 (Michie *et al.*, 2013) is an extensive, hierarchically organised, taxonomy of 93 distinct BCTs, which has laid the foundation for reporting BCTs in a reliable and systematic way (Michie *et al.*, 2013).

The initial design documents (See Appendix D1, tables 1-3) illustrate the link between change objectives and BCTs.

6.3.1.3 Select practical applications for applying theoretical methods (Team Consensus meeting)

Practical applications are the ways in which BCTs are presented and delivered in an intervention – ways that are culturally appropriate and acceptable to the population, as well as the context in which the intervention will be delivered (Bartholomew *et al.*, 2016).

Potential practical applications (i.e. stories, videos, national guidelines) were shown to the team by AB during the team consensus meeting. Ideas for choice of practical applications were discussed, and those that were considered to most closely match the change objectives were identified and recorded.

All of the ideas for pages, headings, and practical materials discussed at the team consensus meeting were collated into an initial design document. An example of this document is presented below in table 6.3. The Full document can be found in Appendix D1, Tables 1-3.

Table 6.3: Example of Initial Design Document

Performance Objective	Change objective codings	Change Objective	Possible Headings	Possible Practical applications	Corresponding BCTs
PO 1.1: Understand, and accept the benefits of PA for osteoarthritis	CO1.1.1	Individual to have access to sufficient information so that they are able to understand how PA can help OA	What is Osteoarthritis, and how is it affecting my joints? Your symptoms can improve. How can PA help my osteoarthritis?	Information from FASA and ARUK. Factual information. Possibly animations or videos about - what is OA	5.1 information about health consequences. 13.3. incompatible beliefs, 13.2 framing/re-framing
	CO1.1.2	Individual to understand how others (from a physiological and emotional perspective) have benefited from PA	How have others (with arthritis) benefited from being active? (from physiological perspective - i.e. reduced pain, increased strength - tangible changes etc) HEADINGS - How PA helped my OA - 'My symptoms improved when I became more active'	Stories (text and videos) from ARUK - people with OA, benefits I have seen from being active etc.	6.2 Social comparison 12.6 body changes

6.3.2 Step 4 – Programme Production

The purpose of step 4 was to produce creative programme messages and materials for use in the prototype website. The challenge was to successfully translate the BCTs and practical applications detailed in Step 3, into creative, operational materials that promote and support the key messages of the planned programme. The end product should be materials that remain true to the planning in steps 1, 2 and 3 (Bartholomew *et al.*, 2016).

This step involved four sub-tasks:

- Refine programme structure
- Prepare plans for programme materials
- Draft messages, materials, and protocols
- Pre-test, refine, and produce materials

6.3.2.1 Refine programme structure

For this task, the initial design documents (Appendix D1, Tables 1-3) created in Step 3 were revisited. The purpose being to 'reality check' issues such as the feasibility of producing and delivering the suggested practical materials, and to explore options for producing the prototype website itself.

There are multiple strategies for developing interventions, and these depend on both budget and time frames. A number of options regarding the digital development of the intervention were evaluated by AB. A number of meetings were held with creative and digital designers, both within the University of the West of England and externally. AB also attended a number of digital health events to explore how others had developed and tested early prototypes of digital health interventions. Freely available online prototyping software packages were explored, and advice was sought from colleagues who had developed prototype websites.

Given the tight budget and short time frame for this project, and advice from others about the high standard of freely available software, which could be used relatively easily by non-designers, the decision was made to take this route. A number of online software

packages were explored, such as Balsamiq (Balsamiq Studios, 2018), Invision (Invision Inc., 2018), and Axure RP (Axure Software Solutions, 2018). A decision was made to use Axure RP (Version 8), as it was easy to use, and it was possible to create high-fidelity web-pages which users could interact with (i.e. create goals, or select dates from a calendar), even during this early testing phase. Other packages had reduced functionality options, or were not freely available.

Discussions were also carried out during the earlier team consensus meeting (Section 6.3.1.1) about the feasibility of producing new elements, such as video/audio stories, or animations. Once again, given the timescale and budget of the project, a decision was made that only pre-existing materials would be used, at this stage. If it was felt that some areas might lack materials to adequately meet the intended change objective, then this could be something to be explored later with potential users, or during future iterations of the prototype.

6.3.2.2 Prepare plans for programme materials (Update Design Document and Paper Prototyping)

Key questions asked during this task were:

- What materials were already available to use, how might they be presented in a website; what might it look like?
- Do the available materials enable the change objectives to be met?
- Do the available materials deliver the intended theoretical methods (match BCTs)?

Practical materials used in an earlier face to face intervention were explored (Facilitating Activity and Self-management in Arthritis (FASA Study - ISRCTN66190737) a study within the Centre for Health and Clinical Research, University of the West of England, and led by the Director of Studies on this project) to identify any available materials that could be translated for use in this intervention.

Information from the National Institute for Health and Care Excellence (NICE), and the leading charity for OA in the UK – Arthritis Research UK (ARUK) (Renamed 'Versus Arthritis' in 2018) was also utilised, and other sources were searched for suitable

materials and ideas to meet the change objectives. For example, this included searches for relevant videos and stories from people with OA about their experiences of being physically activity.

A series of paper prototypes were then created to provide an early visual representation of how the available materials might be displayed on website pages. Topics and potential headings identified in the initial design documents were used to guide what content might sit on each individual web-page, and how information could be grouped etc.

Examples of the paper prototypes are shown below (figures 6-2 to 6-6).

Figure 6-2: Paper Prototyping

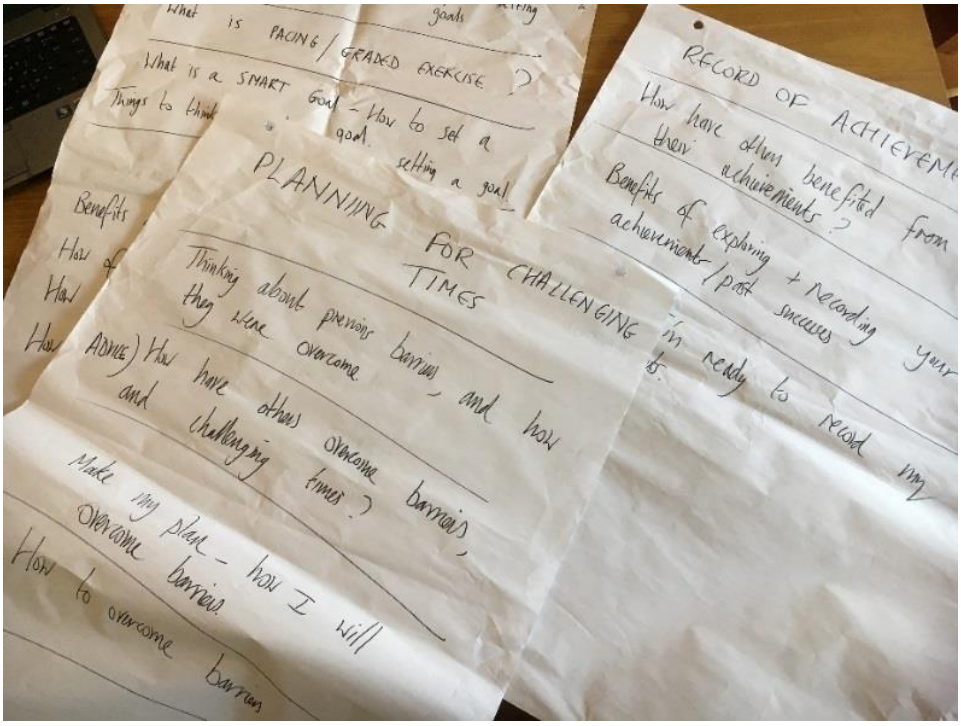


Figure 6-3: Paper Prototyping

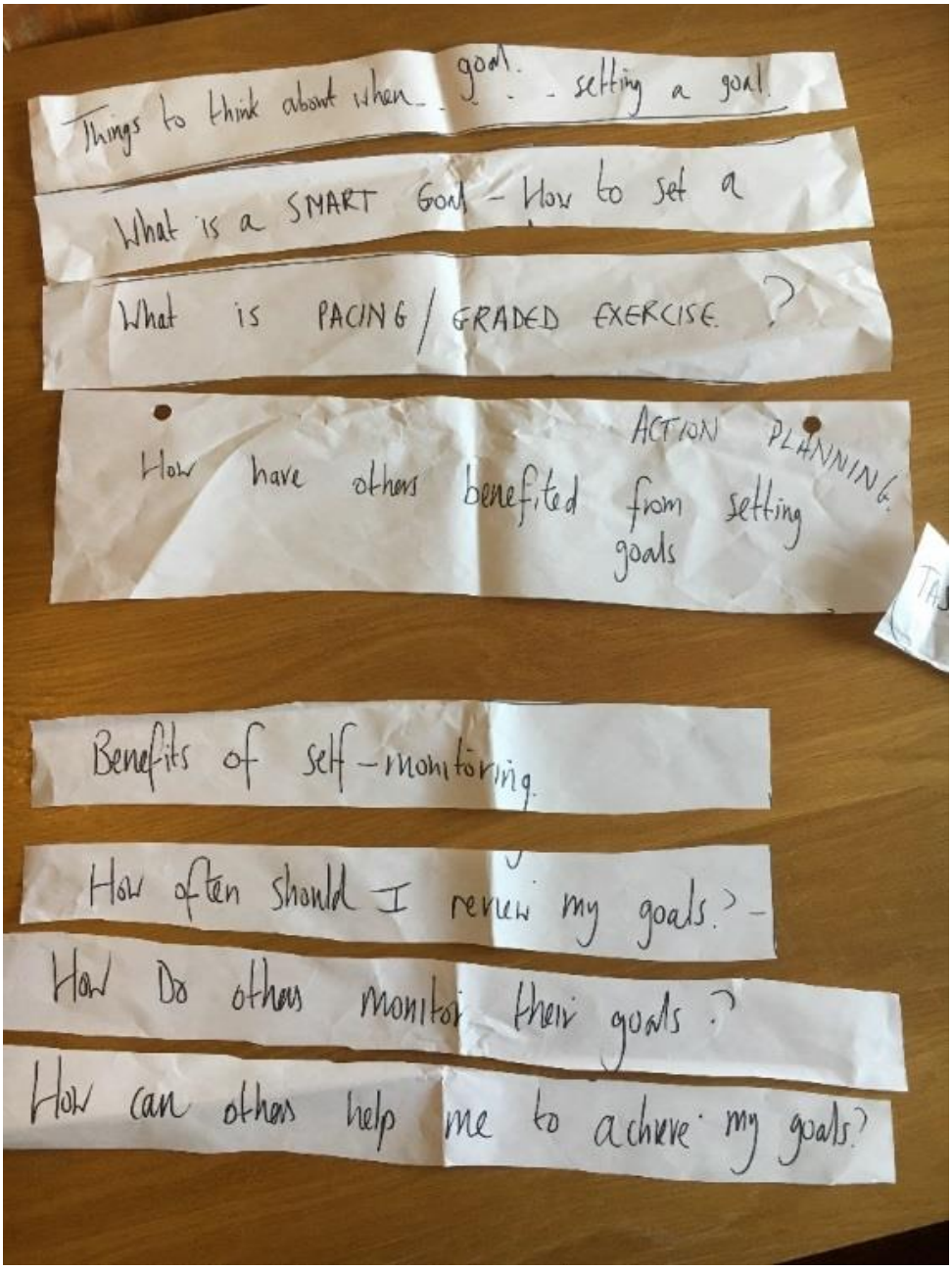


Figure 6-4: Paper Prototyping

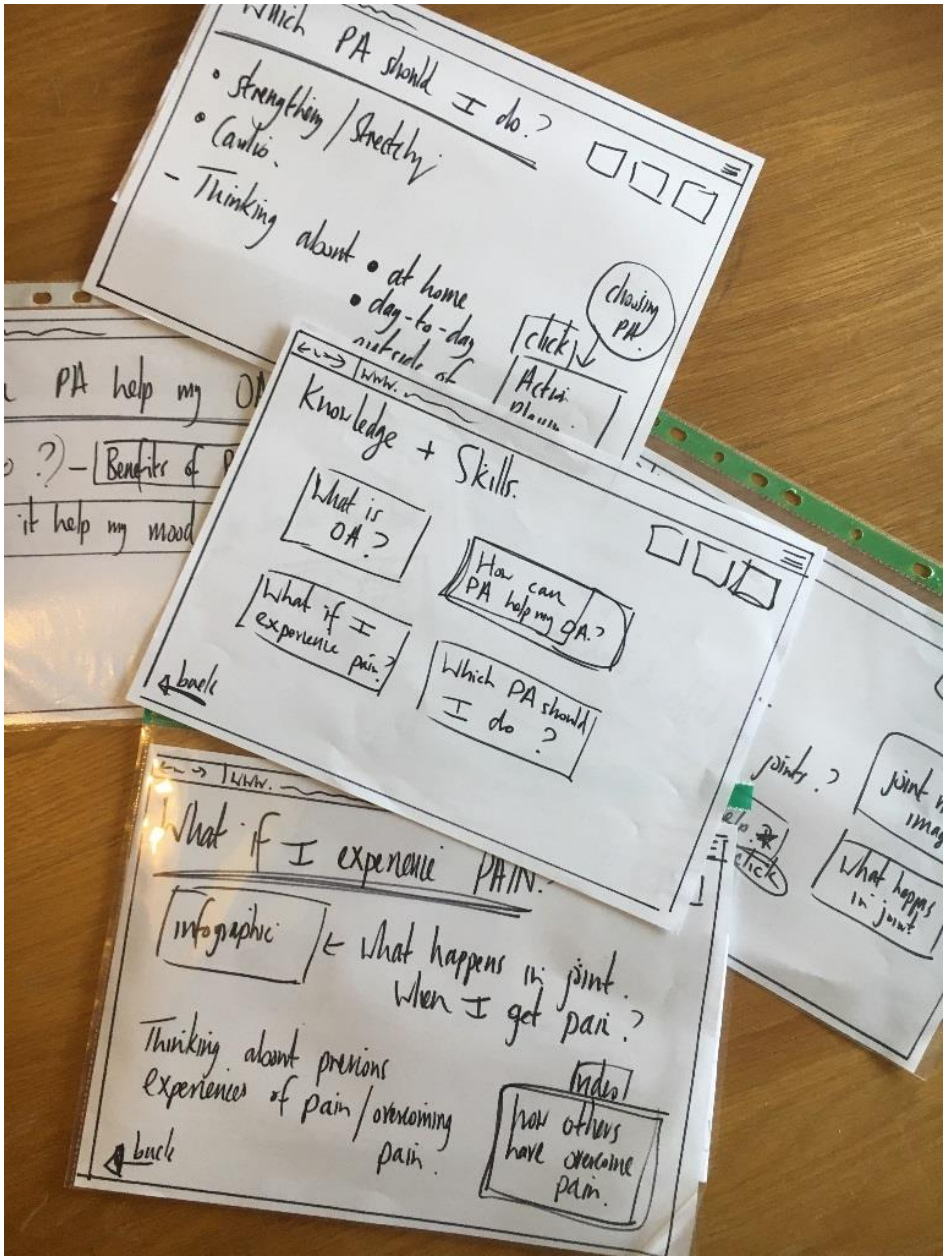


Figure 6-5: Paper Prototyping

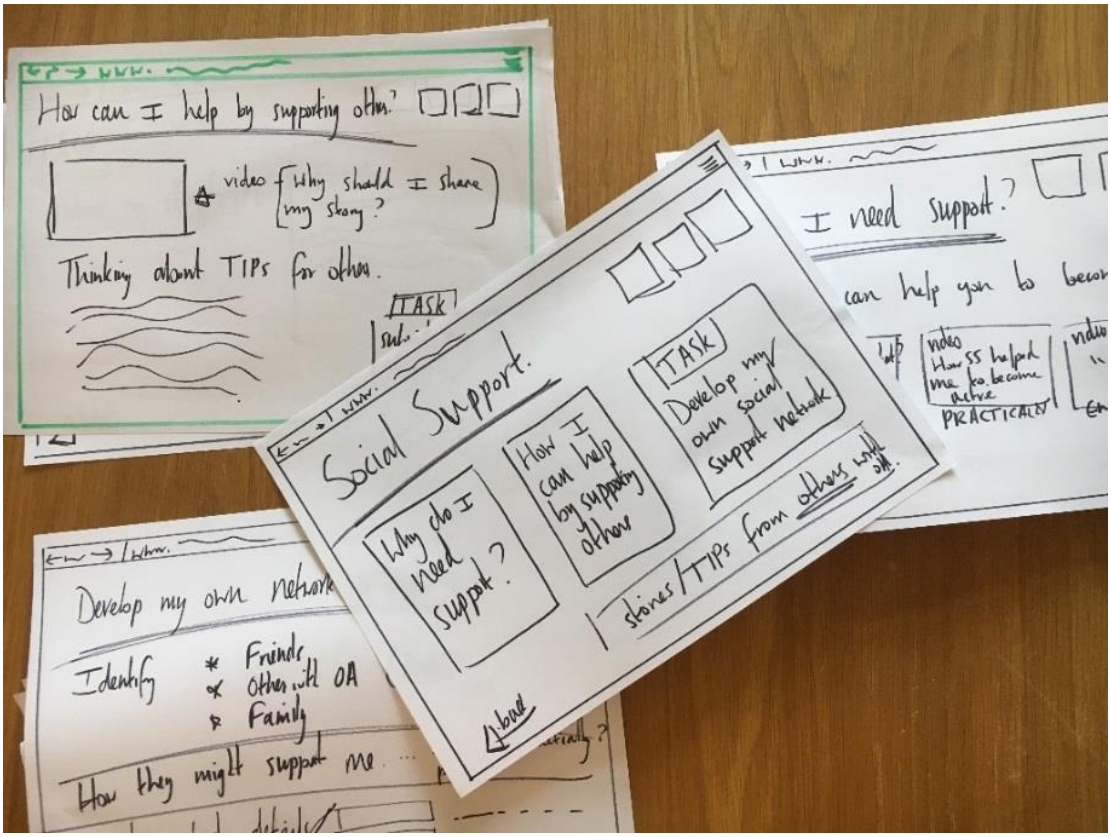
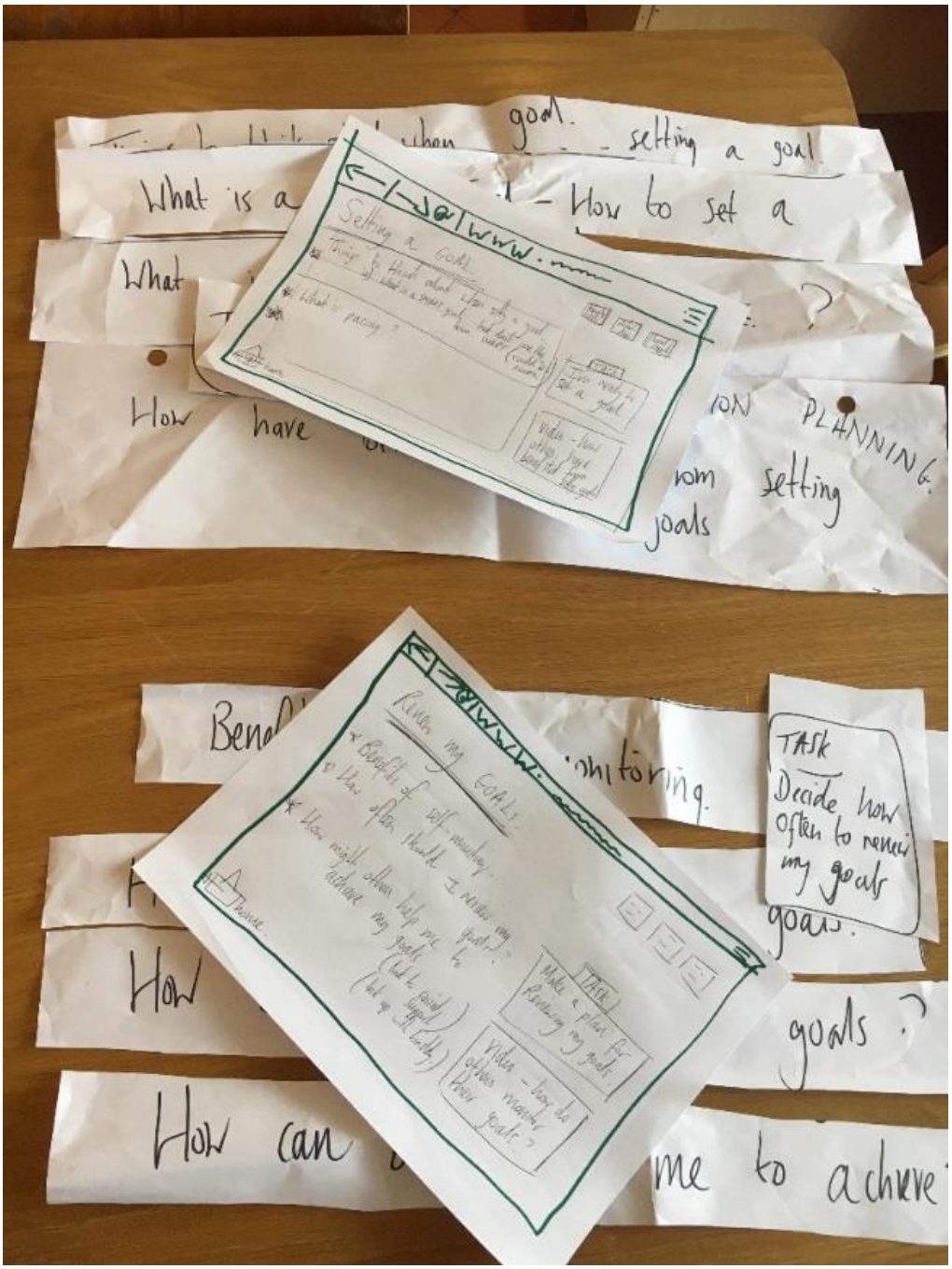


Figure 6-6: Paper Prototyping



6.3.2.3 Draft messages, materials, and protocols (ELLA Version 1, PIP Consensus Meeting)

This step involved creating the first version of the prototype website, using the design document and paper prototypes (sections 6.3.2.1 and 6.3.2.2 above) as guidance. Once a prototype had been created (ELLA – Version 1), the patient insight partners (PIPs) once again met with AB for a group consensus meeting. The purpose of this meeting was to review the materials in this early semi-functional prototype, and to comment on suitability and appropriateness. Guidance/questions provided for this meeting included:

- Does the content fit with the intended audience?
- Are the materials attractive, appealing, and culturally relevant?
- Are all the messages that are needed to influence change objectives included?
- Are the required methods executed appropriately? For example, do role models match the community characteristics?

The software package AXURE XP (Version 8) provided the most-usable and effective prototyping options, with the ability to create clickable, high-fidelity web pages. This meant that the user could, for example, click on buttons, enter information, select dates from a calendar when setting a goal, and scroll down the page. Screenshots of Version 1 of ELLA are shown below in Figures 6-7 to 6-10.

The consensus meeting with AB and both PIPs took place in March 2018. An early version of ELLA (Version 1) was shown, and this enabled the team to discuss both the appropriateness of content, as well as how information might be presented visually.

A number of guiding principles that were formed during the initial consensus meeting were once again highlighted, for example; the website should be simple, and easy to use. Other websites such as ARUK (now Versus Arthritis), and NHS digital were viewed, and there was team agreement that a content list on the left side of every page would help the user to navigate more easily around the website.

A number of changes were also made to the content and layout of the webpages. For example, some text was removed to make sentences shorter and clearer; some pages were simplified or consolidated to reduce the overall number of pages; and the order of pages was changed to make the website flow more easily. Factual information within ELLA - Version 1 was also checked for accuracy by NW.

Figure 6-7: Setting Goals, Action Planning

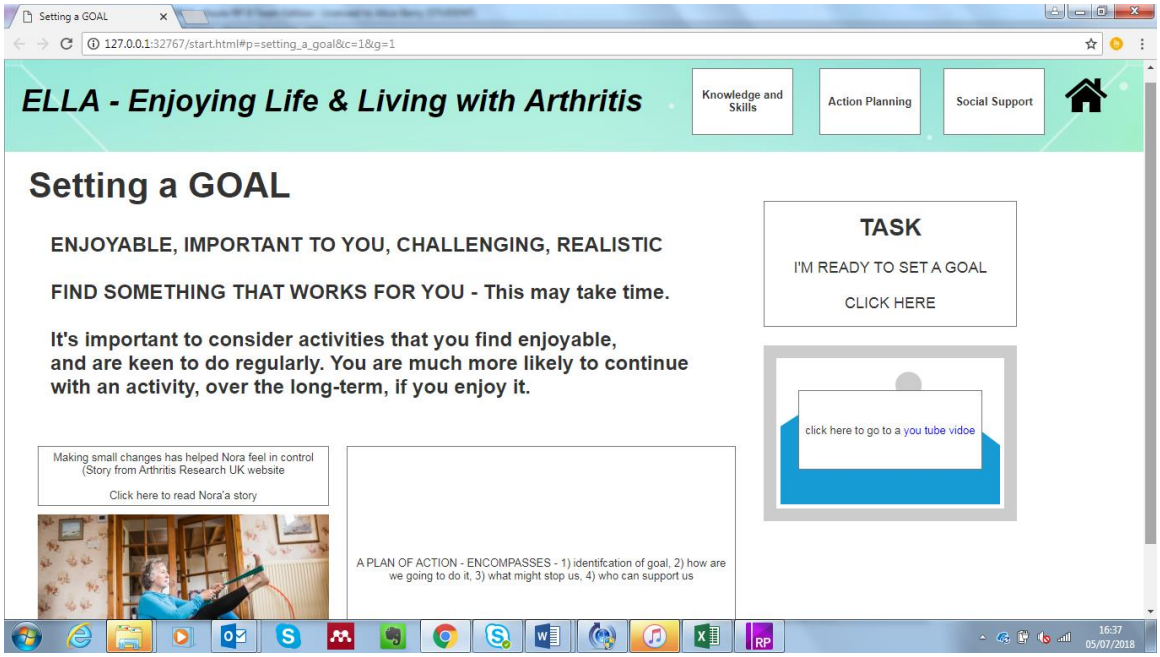


Figure 6-8: Pacing, Action Planning

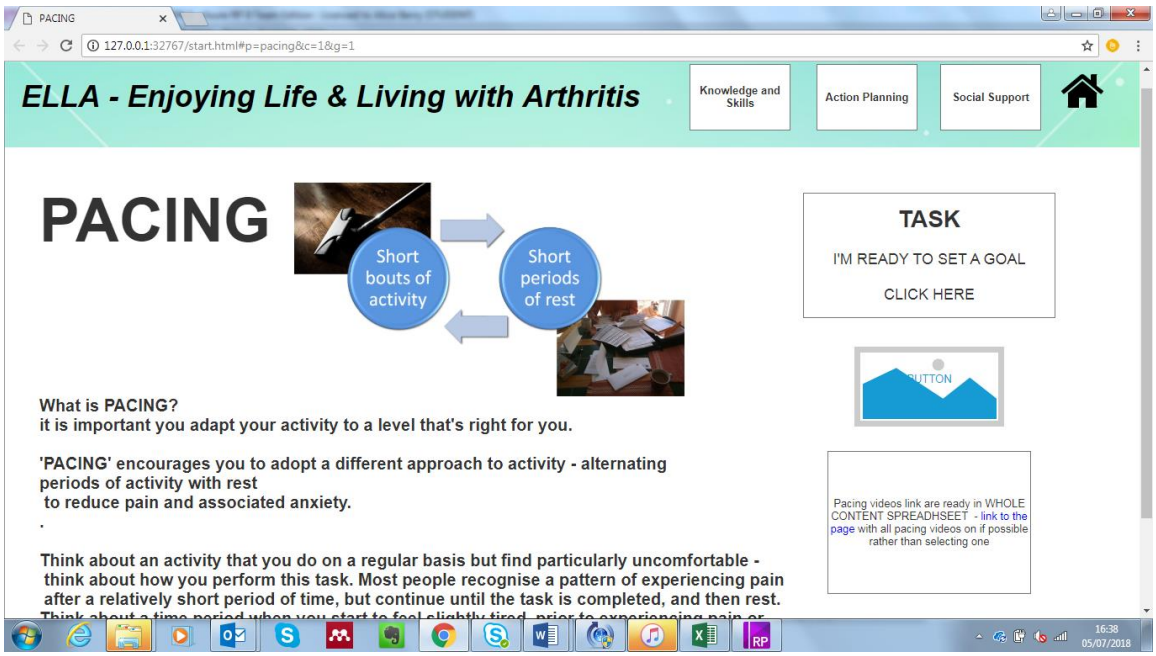


Figure 6-9: Social Support

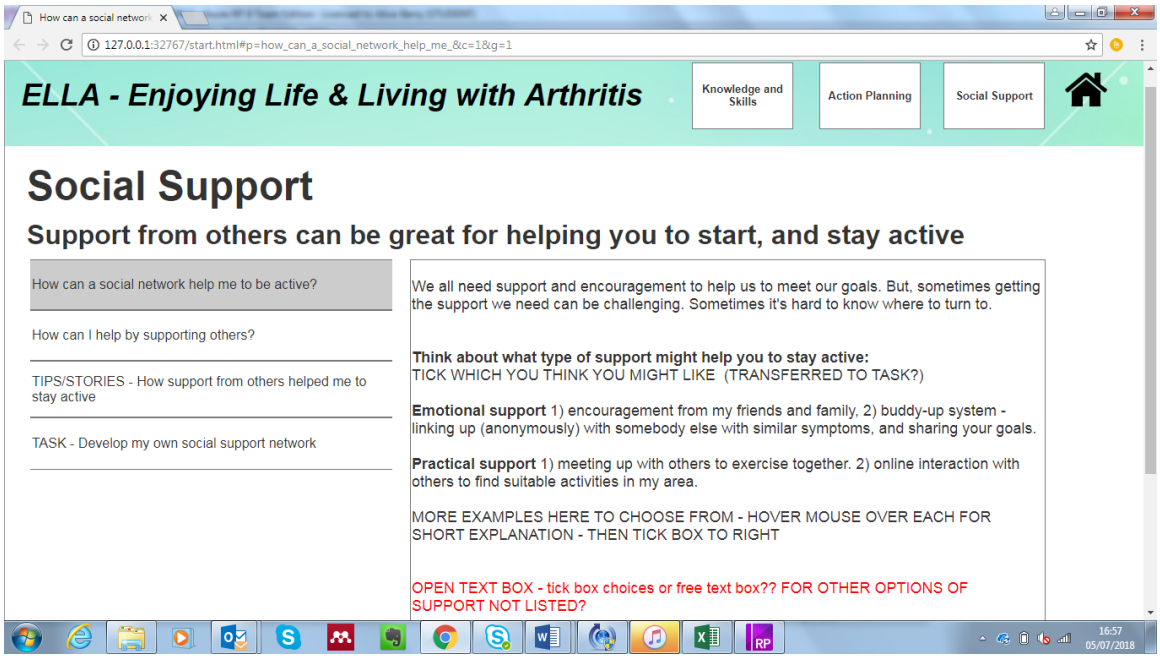
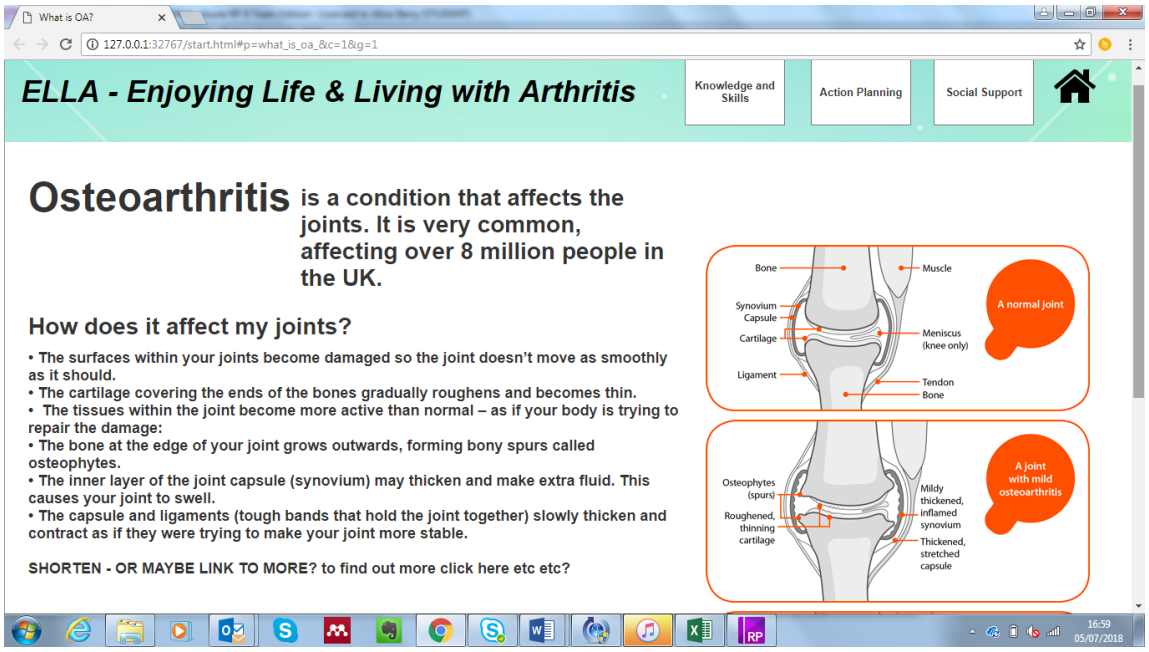


Figure 6-10: Knowledge and Skills, What is OA?



6.3.2.4 Pre-testing with PIPs (ELLA Version 2) and Finalise Design Document

Updates were made to Version 1 of ELLA following the consensus meeting with the PIPs, and Version 2 was created. Content was updated where necessary, and all tasks were made as functional as possible.

This final step involved pre-testing Version 2 of the website, once again with the PIPs, individually. At this stage, they commented on the general usability and functionality of the website, as well as other comments they might have had about content. They were asked to use the website as they would normally, and the researcher observed. This was also an opportunity for AB to pilot the think-aloud method, a technique to be used in the final round of testing with potential users within their own homes (Chapter 7). Small changes were made; pages were simplified, factual information was updated, and key messages were made clearer.

Updates were made to the website and Version 3 was created, ready to be tested with users. A final design document (tables 6.4 to 6.6 below) was created to provide a complete overview of the content on each of the final web pages, showing how the content linked back to the corresponding change objectives and BCTs.

Table 6.4: Knowledge and Skills Section – Final Design Document

Performance Objective 1.1: Understand, and accept the benefits of PA for OA				
Change objective codings	**Page Name**	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**
CO1.1.1	What is OA?	**<u>What is OA?</u>** OA is a condition that affects the joints. 8.75 million People aged 45 and over in the UK have sought treatment for OA (ARUK, 2017). These can all make it difficult to use the joint normally, and do things like climbing stairs. (Two images from ARUK - normal joint, and joint with mild OA). **<u>How does it affect my joints?</u>** Surfaces of your joints become damaged so it doesn't move smoothly. Cartilage covering the ends of the bones roughens and becomes thin. Bone at the edge of your joint grows outwards, forming bony spurs called osteophytes. The joint capsule may thicken and make extra fluid, causing your joint to swell. Ligaments (tough bands that hold the joint together) slowly thicken and contract as if they were trying to make your joint more stable. Two pictures from ARUK - One of normal joint, one with mild OA.	5.1 Information about health consequences.	Less text. More Infographics/ Animations. Should be simple, clear, and easy to understand.

CO1.1.1	Your symptoms can improve	**Your Symptoms can Improve**: Many people think OA is untreatable. This is not correct. There is no cure for the degenerative changes seen in the joints, but this does not mean there is nothing that can be done to help the problem. There is a lot you can do to reduce pain and maximise your ability to do what you want. Having a healthy lifestyle, which includes remaining active, and keeping your weight controlled, can make a significant difference. You can still lead a healthy, active life if you have arthritis. SYMPTOMS CAN INCLUDE: • Pain • Stiffness • Swelling • Grinding sensation when the joint moves	13.3 incompatible beliefs. 12.6 body changes	Ensure this is simple, easy to understand information. Additional infographics & Animations. Less text.
CO1.1.2	How can PA help my arthritis?	**Stories from others**: (VIDEO FROM healthtalkonline - myscrapbook - advice about PA from others. Story (as text) - FROM ARUK - MEL'S STORY (Source: ArthritisResearchUK (www.arthritisresearchuk.org). **'My Symptoms Improved when I Became Active'** 'I decided to exercise to keep mobile, to sleep better and stay positive. Shane, a personal trainer at the gym, knew about my arthritis and created a programme of weights, stretching and resistance training I could do without hurting my knees. I started slowly doing a little each time, stopping if anything hurt. Within weeks I was able to walk upstairs without pain.	13.2 framing/re-framing 6.2 social comparison	Vicarious exp. – people in stories must be relatable, and have had a similar experience to participant.
CO1.1.3	How can PA help my arthritis?	**KEEP MOVING** This approach can help you to feel in control, and to manage symptoms better in the long-term. It doesn't matter how old you are, or how long it is since you last exercised. PA will help to maintain your joints and make you fitter and healthier.	15.1 Verbal persuasion about capability	From a professional? Or person with similar diagnosis.

CO1.1.4	How can PA help my arthritis?	If you have arthritis, regular PA has special benefits above and beyond the general benefits of improved health, including: • Reduced joint pain and stiffness • Improved joint circulation and decreased swelling • Better balance, and greater comfort doing daily activities • Stronger muscles to protect joints by improving stability and absorbing shock • Higher energy levels, and improved mood.	5.1 Information about health consequences. 16.3 vicarious consequences	More SPECIFIC stories from others about how PA has helped my mood. – NOT CURRENTLY AVAILABLE?
CO1.1.5	See CO1.1.2	n/a		
CO1.1.6	PROCESS	Options of NEXT/BACK buttons and side menu - user free to move around pages as they chose.		Autonomy - to have choice of MORE/LESS information.
CO1.1.7	See CO1.1.1	n/a		
Performance Objective 1.2: Understand how to select, and safely perform their chosen type of activity				
Change objective codings	**Page Name**	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**

CO1.2.1	What sort of PA should I do?	**<u>What sort of PA should I do?</u>** Try to find the right balance between rest and exercise. Little and often is usually the best approach. Stretching exercises can relieve stiffness and improve the range of movement in your joints. Strengthening exercises help to build stronger muscles, providing joints with greater stability, and help to improve balance. Aerobic (or cardiovascular) exercise is any exercise that increases your pulse rate and makes you a bit short of breath (for example, a brisk walk or swimming). This type of exercise can improve your general health and well-being, as well as reduce pain (aerobic exercise raises the levels of pain-relieving hormones called endorphins). INFOGRAPHIC - WHAT ARE THE GUIDELINES. HOW LONG, HOW OFTEN ETC.	4.1 Information on how to perform the behaviour. 4.2 Information about antecedent.	Simplify delivery – infographics, animations distinguishing aerobic, strengthening, and stretching.
Co1.2.6	PROCESS	NEXT/BACK buttons, side menu etc		Autonomy
CO1.2.7	See CO1.2.1	See CO1.2.1		More info - about different types of PA
Performance Objective 1.3: Understand that normal physiological responses can be experienced, and how to respond.				
Change objective codings	**Page Name**	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**
CO1.3.1	SEE Action Planning / Record of Achievement	N/A	12.6 body changes. 15.3 focus on past successes.	? QUERY – Be careful to explore past successes with participants who might feel that they have not had any past successes?

				(TAILORING? Only applicable to certain participants?)
CO1.3.2	What if I experience pain?	STORIES FROM OTHERS - CLICK HERE to find out more about how others have overcome pain to STAY ACTIVE - scrapbook - exercising with pain (healthtalk.org).	16.3 Vicarious consequences. 5.1 Information about health consequences.	Relatable videos 'How people with OA (like me!) have overcome barriers such as pain'. NOT CURRENTLY AVAILABLE?
CO1.3.4	As above	As above		
CO1.3.7	What if I experience pain?	You may experience discomfort when you are exercising, or for a day or two afterwards, especially if you are trying something new, or if it's something you haven't done for a long time. Don't worry, this does not mean you have harmed your joints, or that you should stop the activity. It is inevitable that with long-term joint conditions you will sometimes experience aches and pains during exercise or activity. What is important, is that you recognise the need to keep your joints moving, without overdoing it. You will gradually learn what level is right for you. DIRECTION - You will learn more about how to use PACING techniques, in the next section of this website.	5.1 Information about health consequences.	See above.

Table 6.5: Action Planning – Final Design Document

Performance objective: 2.1: Learn about, and set SMART Goals for PA, using pacing/graded tasks			
Change objective codings	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**
C02.1.2	**Setting Goals / Why is Pacing important? Nora's Story** Making small changes has helped Nora feel in control (Source: Arthritis Research UK website) After taking advice from healthcare professionals and doing online research, Nora started an exercise routine that worked for her, incorporating Pilates, low-impact exercise on a cross-trainer or a bike and swimming. **CLICK HERE**: to watch video about how other people have set goals. **CLICK HERE** to watch some videos about how **PACING** has helped other people to achieve their goals.	16.3 vicarious consequences	SPECIFIC stories about how people have SET GOALS. Not currently available? STORIES about how others (like me) have PACED activities – well received – important to include.
CO2.1.3	**Setting Goals – How and Where** In box - THINK ABOUT GOALS THAT ARE - CHALLENGING BUT REALISTIC. **HOW AND WHERE - Enjoyable, important to you, challenging, but realistic**	4.1 Instruction on how to perform a behaviour	More investigation needed into most appropriate format to follow when setting goals – OTHER THAN SMART?

CO2.1.4	**<u>Why is Pacing important?</u>** REMEMBER - It is generally not the activity that causes pain, but the intensity at which the activity is performed. 'PACING' encourages you to adopt a different approach to activity - alternating periods of activity with rest to reduce pain and associated anxiety. Think about an activity that you do on a regular basis but find uncomfortable. Think about how you perform this task. Most people recognise a pattern of experiencing pain after a relatively short period of time, but continue until the task is completed, and then rest. Think about a time period when you start to feel slightly tired, prior to experiencing pain or discomfort, and have a short rest at this stage. **OPTIONAL TASK: Write down an activity that you do regularly. How might you PACE yourself the next time you do it?**	8.7 Graded tasks.	Well-received – important information to include. Perhaps less text, more infographics or animations?
CO2.1.5	See CO2.1.2		
CO2.1.6	**<u>Setting Goals / My Activities</u>** It's much easier to become more active if you set yourself a goal. Setting a long-term goal however may seem scary, so consider the smaller steps that lead to what you ultimately want to achieve. An 'Action Plan' is a record of what you want to achieve, and how you will go about it. It will help you to reach your long-term goal by breaking it down into achievable, short-term aims. It will also allow you to monitor your progress, and help you to decide whether to set a new, slightly harder goal. **OPTIONAL TASK** - Do you have an overall aim? If so, write it here. **MY ACTIVITIES PAGE -** Think about activities that you find enjoyable. You are more likely to continue doing an activity over the long-term, if you ENJOY it. Think about the different types of activities that you could include in your goals: **EVERYDAY LIVING ACTIVITIES** - Things that you do regularly, like walking to the local	1.1 Goal-setting (behaviour)	More research needed with this population to establish preferred method for setting goals – for LONG-TERM ENGAGEMENT. Distinguishing short and long term goals?

	shop, housework, or gardening. This could also include sets of arthritis specific exercises that you can do at home. **STRUCTURED ACTIVITIES** - Things that you would outside of the home, in a more organised environment, like going to a yoga class, or swimming. • Choose a mixture of stretching/strengthening and aerobic activities. • Include an activity that involves some interaction with others. Exercising with others can be more enjoyable. • Be realistic. Think about how your joints are feeling today. Remember that activity can help your joints, reduce pain, and improve mood.		
CO2.1.7	**My Activities – How and Where** **OPTIONAL TASK**: Click on the activities below for more information. Write down some goals, choosing an activity from the lists, or your own. EVERYDAY LIVING ACTIVITIES (tip - Think about how you might add activity into your daily routine). STRUCTURED ACTIVITIES - (TIP - choose activities that you think you might enjoy). Brief Information provided about the following activities - everyday - walking/gardening/general exercises for arthritis/exercises for knee pain/exercises for back pain/exercises for neck pain/exercises for shoulder pain/exercises for hip pain. Then for structured: walking groups, swimming, yoga, Pilates, tai-chi, dancing, cycling, gym, fitness classes. OPTION for user to CLICK on MAP - 'What's on in my area?' How and Where page - **TASK -** WHEN/WHERE/WHAT TIME OF DAY/HOW MUCH/FIRST DATE YOU WILL DO IT - Options to make all of these plans for each goal set.	1.1 goal setting 8.7 graded tasks	As above Interactive MAP – Important to include something like this to enable participants to explore options for activity in their neighbourhood.
Performance objective: 2.2: Learn about self-monitoring and updating goals.			
Change objective codings	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**

CO2.2.1	**Self-Monitoring**: Self-monitoring can help you to decide whether to set a new, slightly harder goal, or whether you want to remain at the same level to gain more confidence in your current task.	1.1 goal setting (behaviour). 1.4 action planning, 1.5 review behaviour goal	CONTENT NEEDED – Stories/videos of how people (like me!) self-monitor, review, update goals.
CO2.2.2	No content/videos found specific to this change objective. Reviewing might be covered in the PACING videos? But not OA specific.	6.2 social comparison 16.3 vicarious consequences	CONTENT NEEDED –as above.
CO2.2.3	No content found specific to this change objective.	3.2 Social support (practical) 3.3 social support (emotional)	FURTHER RESEARCH NEEDED: Optimal methods for linking up participants with relatable others.
CO2.2.4	See CO2.2.2	5.4 Monitoring of emotional consequences	See 2.2.2 More content needed.
CO2.2.5	See CO2.2.2		

CO2.2.6	**Self-monitoring - How often will I review my GOALS?** It is completely up to you to decide how often you review your goals. This could be every week, fortnight, or monthly - you choose. Complete the TASK below to record how and when you will review your goals. **OPTIONAL TASK** - User selects a date from the calendar when they will review their goal. **OPTIONAL:** Would you like us to remind you to review your goal? Yes, please send me a: TEXT / EMAIL.		Autonomy – process – participant to choose how often they review goals/ and how much contact they might have with professional.
CO2.2.7	(see CO2.2.1)		
Performance objective: 2.3: Acknowledgement of past successes of PA			
Change objective codings	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**
CO2.3.2	**Past Successes**: No content for this. - No videos/stories found in relation to this change objective, not specific to OA.	6.2 Social comparison. 16.3 Vicarious consequences.	TAILORING OPTIONS? Only offer this if participant reports being active in the past?
CO2.3.3	**Past Successes**: It can be really helpful to look back at times in the past when you have been active. What did you enjoy, and how did you fit it into your life? Think back about times in the past when you were active, and write them down in the TASK below. Think about how you overcame any challenges to become active.	1.4 Action planning 15.3 focus on past successes	See above
CO2.3.4	PROCESS (see 2.3.7)	13.4 valued self-identity. 15.3 focus on past successes.	See above
CO2.3.5	(SEE CO2.4.2)		

CO2.3.6	**Past Successes**: TASK is OPTIONAL		Autonomy – choice to complete/or not.
CO2.3.7	**Past Successes**: OPTIONAL TASK: What activity did you do in the past? Did you enjoy it? Can you remember how it made you feel? Did anything get in the way? How did you overcome these barriers?		TAILORING/ OPTIONAL
Performance objective: 2.4: Problem solving, and planning for challenging times, including recognition of how others have overcome barriers			
Change objective codings	**Content**	**BCTS (BCTTV1)**	**Parameters (Chapter 7)**
CO 2.4.1	**Stumbling Blocks**: Think about challenges that you might face when trying to stay active, such as not having enough time, or not knowing what activities are happening near to you. **TASK** Look at the possible stumbling blocks in the table below. Click on those that you think might affect you. Tips are provided to help you to overcome these potential challenges. **OPTIONAL TASK** - My plan to overcome stumbling blocks	1.2 Problem solving	FURTHER RESEARCH NEEDED: Not well received. Perhaps only PA specific – do this task AFTER specific activity has been selected – then barriers relevant to that activity. ? ALTERNATIVE – shift focus away from barriers – DO NOT INCLUDE?
CO2.4.2	No videos found that are specific to this topic - i.e. challenges related to OA - do have videos about being active with pain, but not specific to OA, and how challenges have been overcome etc.	6.2 Social comparison	NEW CONTENT NEEDED Stories/videos specific to 'How people (like me!) have overcome barriers'

		11.2 reduce negative emotions	
CO2.4.3	**Stumbling Blocks**: SEE 2.4.1 FOR TIPS	16.3 vicarious consequences	As above
CO2.4.4	**Stumbling Blocks**: SEE 2.4.1 FOR TIPS	1.2 problem solving	See above
CO2.4.5	SEE 2.4.2		
CO2.4.7	**Stumbling Blocks**: SEE 2.4.1		See above

Table 6.6: Social Support – Final Design Document

PO 3.1: Accept the emotional and practical benefits of a social network of support (and plan for).				
Change objective codings	**Page Name**	**Content**	**BCTS (BCTTV1)**	**Parameters (See chapter 7)**
CO3.1.1	How can a social network help me to be active	**Ideas for Practical Support** • Arranging to meet up with friends or family to exercise together • Online interaction (e.g. forum/Facebook group) with others to find suitable activities in your area • Group/buddy-up system for local events	3.2 Social support (practical) 3.3 social support	TAILORING Potential: Dependent on family situation/spouse etc, often keen to meet with others (like me!)
CO3.1.3	How can a social network help me to be active	**How can a social network help me to be active.** **Choosing the right people to turn to** Support and encouragement from others can be great for helping us to meet our goals. Relationships that are good for you will support you, especially at times when you are struggling to reach your goals. Supportive others (eg friends and family) are the people that can remind you of your strengths, and join forces with you to fight the challenges that come your way. **Asking for Support:** We might assume that people know how to be supportive, but this is not always the case. Those supporting you might need to know when and how they can help. Think about what type of support you would find most helpful. This might be somebody at the end of the telephone, to talk about how you are feeling, and what challenges you are facing. Or you could be looking for more practical help, finding out about what activities your friends are doing, or	6.2 social comparison 16.3 vicarious consequences	As above TAILORING. And MORE RESEARCH NEEDED: Optimal ways to link people up.

		arranging to meet up and take part in an activity together. **Ideas for Emotional Support** • Encouragement from friends or family (via email, phone call, text, face-to-face). • Buddy-up system - link up with somebody else with similar symptoms to you, share your goals, challenges, and achievements		
CO3.1.4	How can a social network help me to be active	**How can a social network help me to be active?** We all need supportive people to help us to meet our goals. Sometimes, getting the right kind of support can be challenging, or it can hard to know who to ask. CLICK HERE - To watch a video about a group of people being active (Arthritiscare.com) https://www.youtube.com/watch?v=Ddg8XWucWgY	5.6 information about emotional consequence	Relatedness – stories/videos – must be 'like me'. More relatable content needed?
CO3.1.6	See CO3.1.1	OPTIONAL TASK - see PO3.2 below.	3.1 social support 12.2 restructuring the social environment	SEE ABOVE – MORE RESERCH NEED TO EXPLORE OPTIMAL WAYS TO LINK UP PEOPLE WITH OA.
CO3.1.7	SEE CO3.1.3	See CO3.1.3.		See above
PO 3.2: Identify new social network links – friends/family/active others with OA				
Change objective codings	**Page Name**	**Content**	**BCTS (BCTTV1)**	**Parameters (See chapter 7)**
CO3.2.1	Developing my own support plan. Who can	Who are the people that can help remind you of your strengths and join forces with you to meet your goals? • Different people might help you to tackle different challenges, think about who might be the most suited to help you achieve your current	3.1 Social Support	See above – new content needed.

	support me, and how?	goals. • Complete the TASKs below, by writing down who might be able to support you emotionally and physically.		
CO3.2.2	How can a social network help me to be active	CLICK HERE - To watch a video about a group of people being active (Arthritiscare.com) https://www.youtube.com/watch?v=Ddg8XWucWgY		See above – new content needed.
CO3.2.3	SEE 3.1.3	SEE 3.1.3	SEE 3.1.3	Participants not keen to write down individual names – consider removing?
CO3.2.4	SEE 3.1.3	SEE 3.1.3	SEE 3.1.3	
CO3.2.5		No specific content found - SPECIFICALLY about how people have identified, and started new activities	6.1 Demonstration of the behaviour (social links) 6.2 social comparison	New content needed
CO3.2.6	Developing my own social support plan	OPTIONAL TASK: Complete the TASKs below, by writing down who might be able to support you emotionally and physically. Includes boxes for: Name of support: What would you like them to do to be supportive of you? What specifically could they do to help you out when challenges come up? Would you like us to send them a copy of your PLAN?	Choice	Autonomy – choice to complete or not.
PO 3.3: Accept that one's own behaviour can be an example for others to help them to be physically active				

Change objective codings	Page Name	Content	BCTS (BCTTV1)	Parameters (See chapter 7)
CO3.3.1	How can I help by supporting others	SEE CO3.3.6	13.1 identification of self as role model	IMPORTANT to have autonomy choice to complete this task.
CO3.3.2		SEE CO3.3.5	See above	
CO3.3.3		SEE CO3.3.5	3.1 social support	See above
CO3.3.4		SEE CO3.3.5	13.1 identification of self as role model.	See above
CO3.3.5	How can I help by supporting others	Hearing stories and getting advice from other people with arthritis can be really helpful, and make people feel like they are not alone. Finding out about how others have become active, and how they overcame barriers, found local activities, and set goals can be very useful. Think about tips or advice that you could give to others, or recommendations of activities in your local area.	See above	See above
CO3.3.6	How can I help by supporting others	Option to select yes/no/maybe -Would you be interested in adding your own tips/advice or stories to our website, about your experiences with physical activity? AND OPTIONAL: Would you be interested in joining an online group for people in your local area, to share advice about local activities?	See above	See above

Figures 6-11 to 6-16 provide an example of the final pages of the ELLA prototype website. The final versions of all pages of the ELLA website can be found in Appendix D2.

Figure 6-11: Landing Page of ELLA

Figure 6-12: Knowledge and Skills – What is OA?

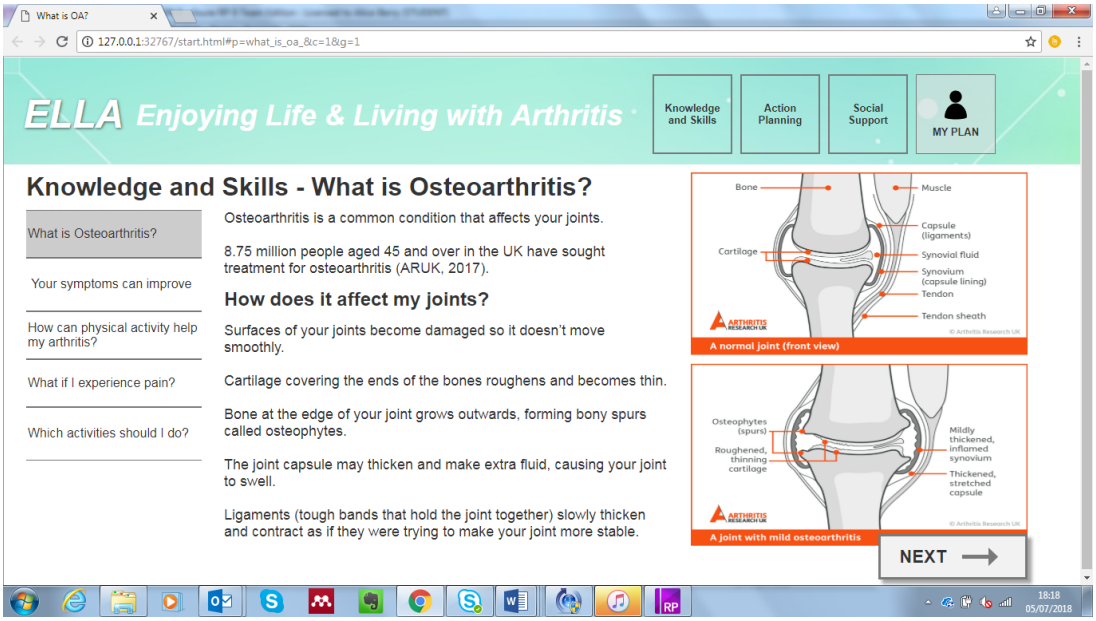


Figure 6-13: Knowledge and Skills – How can PA help my arthritis?

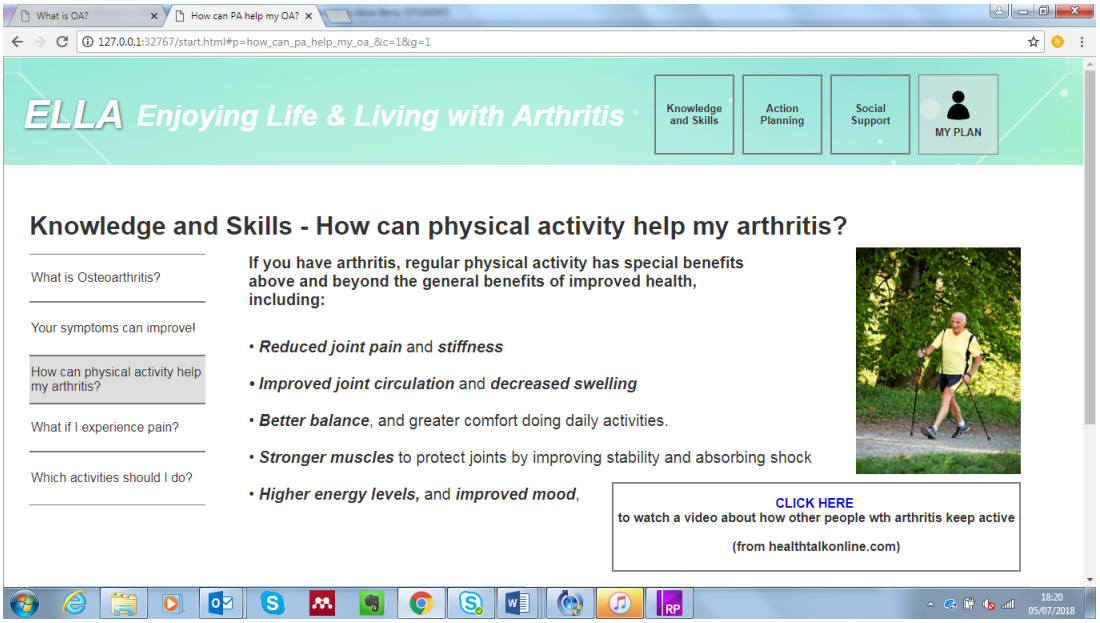


Figure 6-14: Action Planning – Past Successes

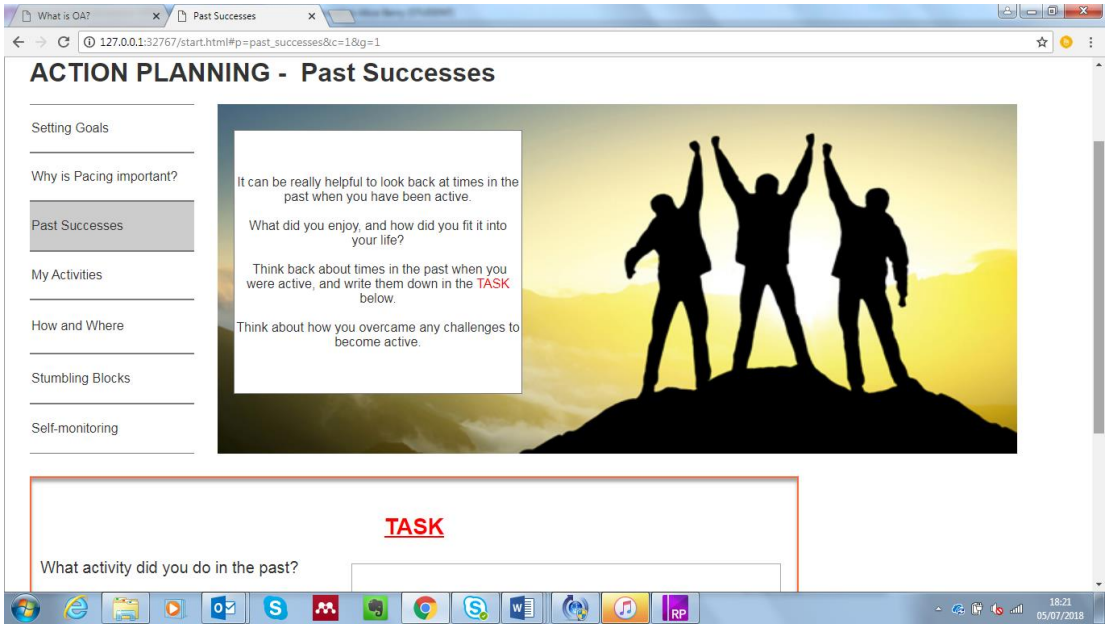


Figure 6-15: Action Planning - Setting Goals

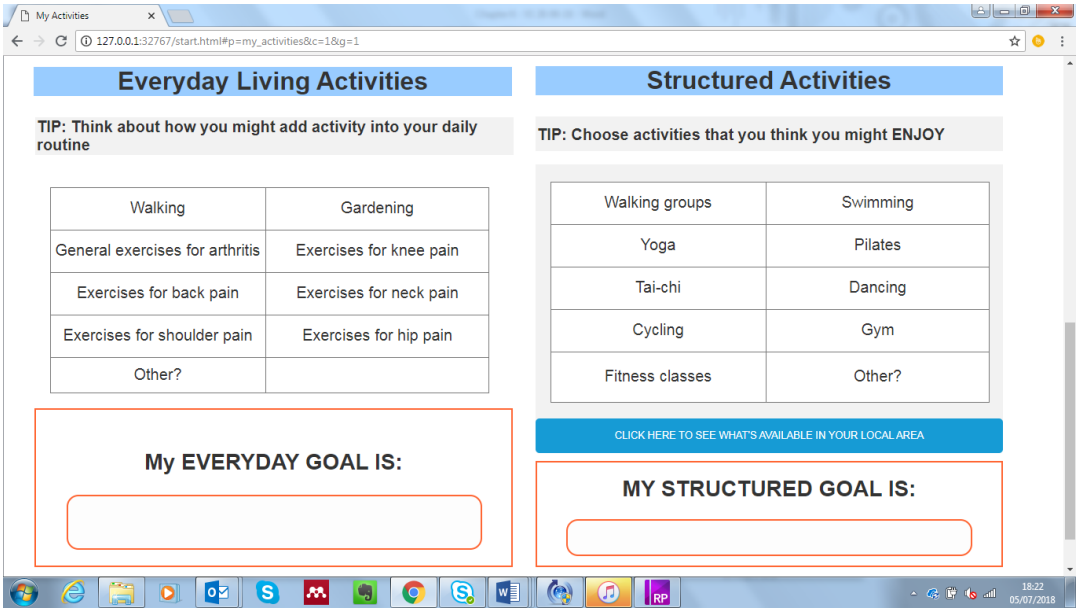


Figure 6-16: Social Support – How can a Social Network help me to be active?

6.4 Discussion

6.4.1 Programme Design

The full team consensus meeting was an extremely valuable exercise, which brought together both expert patients with first-hand knowledge of living with OA, and clinical experts in the field of OA and pain management. Intervention mapping guided the structure of these meetings, and this proved useful, given the scale of the exercise.

There was often overlap between topics relating to content of the intervention, and functionality of the website. However, intervention aims, objectives, and change objectives did provide structure to help guide the discussion. Each patient insight partner (PIP) described quite different experiences of living with OA. These different insights were useful, particularly highlighting certain areas where further questioning with potential users might be beneficial.

An advantage of the IM approach was the ability to regularly refer back to the change objectives. It proved very useful to have a way of documenting how each theoretical construct linked to a BCT, and overall programme objective. This provided a structure to ensure that the development process did not get lost within the huge discussion of 'what should be included?' The planning documents provided a tool to allow for checking for suitability of content, these documents guided production to ensure that programme materials and activities were culturally relevant, met the programme objectives, and matched the corresponding change objectives (Bartholomew *et al.*, 2016).

6.4.2 Programme Production

The production of the prototype website was not linear, and moved back and forth between the sub-tasks of Step 4. This phase naturally became a highly iterative process, which continued to focus on idea generation around the target behaviour, increasing physical activity, as well as being guided by ongoing insights from the patient insight partners, as potential users. In a field where digital technology is young and the best ideas are likely yet to be uncovered, a highly divergent approach in co-developing possible solutions may maximise the likelihood of identifying the most potent solutions (Mummah *et al.*, 2016b).

The paper prototyping exercise was valuable, as it allowed for some initial consideration about the volume of information on each page, and how the flow of pages/information might work best. It also provided useful guidance when developing the early pages of the prototype website.

Co-designing with the PIPs was very useful, once again providing first hand insight into the suitability and acceptability of potential programme materials, creating a dynamic team work group environment. A hallmark of productive work groups is the ability to generate many ideas from both the most accessible information and experience available to members and use this information to make decisions, and choose goals and direction (Bartholomew *et al.*, 2016). It was felt that this was successfully achieved during the team consensus meetings held, which produced a number of ideas, and decisions, which went on to guide the production of the prototype website. Co-development was carried out in a fluid and iterative fashion, where the focus was on gathering initial user impressions, and inspiring further divergent ideation, with the goal being to inform concept refinement and focus (Mummah *et al.*, 2016b).

The use of freely available, prototyping software enabled the researcher to develop the website at no cost, and to create new versions and updates at any time. The software was easy to use, quick to learn, and provided a mock-up of a fully functioning, clickable website that potential users could use in real-time.

6.5 Strengths and Limitations

A key strength of the IM approach was the ability for it to provide structure to the design and production stages of intervention development, resulting in a newly created programme supported by products and materials specifically designed to address the change objectives needed to influence the determinants of the behaviour.

Co-production added depth to the development, with the patient insight partners providing a valuable insight into the impact that OA can have on a daily basis. Participatory research, co-design meetings, and user-centred design help to make health interventions attractive, clear, and relevant to the user (Araujo-Soare*s et al*, 2018).

The IM approach was also able to highlight the issue of potentially missing content. Time and resources were limited, meaning that only existing materials were used to develop the prototype website. It was felt that some of the change objectives would be better met with new or updated materials. In particular, stories from others about their specific experiences of becoming active were lacking. Future development should allocate time and resources to allow for the production of relevant, up-to-date content, to best meet the change objectives of the intervention.

6.6 Conclusion

The IM approach supported an in-depth development and reviewing process, which encapsulated the nuances of the different constructs that make up self-determination theory and self-efficacy. It was a complex exercise, with multiple sub-tasks, but each provided helpful guidance on how to move from initial ideas and goals, to workable, practical materials. It also allowed for regular 'sense-checking' back to the change objectives, ensuring that the practical materials selected matched the aims and objectives of the programme. At the same time, the IM approach can be moulded to suit each individual setting, by selecting steps and sub-tasks that are most relevant to the situation.

This chapter provided a comprehensive overview of how a prototype website was designed and produced, and focused on Steps 3 and 4 of the IM approach.

The next chapter also sits within Step 4 of the IM approach, and covers the pre-testing of the prototype website with a small group of potential users, using an approach called 'Think-Aloud' and semi-structured interviews.

Chapter 7: Acceptability and Usability of a Digital Intervention

7.1 Overview

Chapters 5 and 6 documented the planning, design, and development of a prototype website, using Intervention Mapping (IM) to guide the process. Chapter 5 showed how content of the website was linked back to theory, and Chapter 6 described the design and production of the prototype website. This chapter covers the pre-testing stage of the prototype website with potential users, exploring both usability and acceptability.

7.2 Rationale

Once a digital intervention has been fully planned and a prototype version created, further qualitative research is essential to gain insight into whether the intervention is acceptable, interesting, persuasive, easy to use and feasible for people to adhere to (Yardley *et al.*, 2015).

This stage of the project used qualitative methods to explore what a group of potential users thought about the digital intervention, not only in terms of how easy it was to use, but importantly, how acceptable the content was; including its relevance, coherence, and the perceived amount of effort required to use the intervention. This important final step of 'pre-testing' was the process of trying out specific programme materials with the intended participants, prior to the final production of a 'testable' intervention (Bartholomew *et al.*, 2016).

Previous chapters highlighted the issues of non-usage and high attrition associated with digital interventions. Therefore, it was important during the development stages that any issues related to use and acceptability were identified, before committing to full development with creative design teams.

7.3 Aim

The aim of this study was to explore the usability and acceptability of a prototype digital behaviour change intervention, aimed at facilitating sustained engagement in PA, for people with OA.

7.3.1 Objectives

1) EASE OF USE: To explore how people with OA used the prototype digital intervention.

2) ACCEPTABILITY: To explore how acceptable, and useful, the content of the digital intervention was for potential users.

7.4 Design and Methods

The purpose of this study was to assess whether the prototype digital intervention was usable and acceptable for people with OA, including an exploration of how they might choose to use it as part of everyday life.

Two qualitative data collection methods were used: Information about how potential users might use the core elements of the intervention were explored using a 'think-aloud' method (Lewis and Rieman, 1993); and semi-structured interviews were carried out to investigate how acceptable and relevant the content was to people with OA . More detail of each data collection method is presented below.

7.4.1 Ease of use – Think Aloud Method

The think-aloud protocol is a widely used method for evaluating the usability of websites (Alhadreti and Mayhew, 2018). It stems from the field of cognitive psychology, and was specifically developed to gather information on the cognitive behaviour of humans performing tasks (Jaspers, 2009). The method attempts to observe what will happen when real users start to use an intervention, by testing it with a representative sample of the anticipated end-user, and observing them when using the intervention in real-time (Lewis and Rieman, 1993). During recorded sessions, users 'interact' with a prototype intervention while verbalising their thoughts, feelings and actions. Analyses of these

verbal reports provide valuable information, including detailed insight into potential problems encountered by users, which can be used to inform future iterations and improve usability (Alhadreti and Mayhew, 2018; Jaspers, 2009).

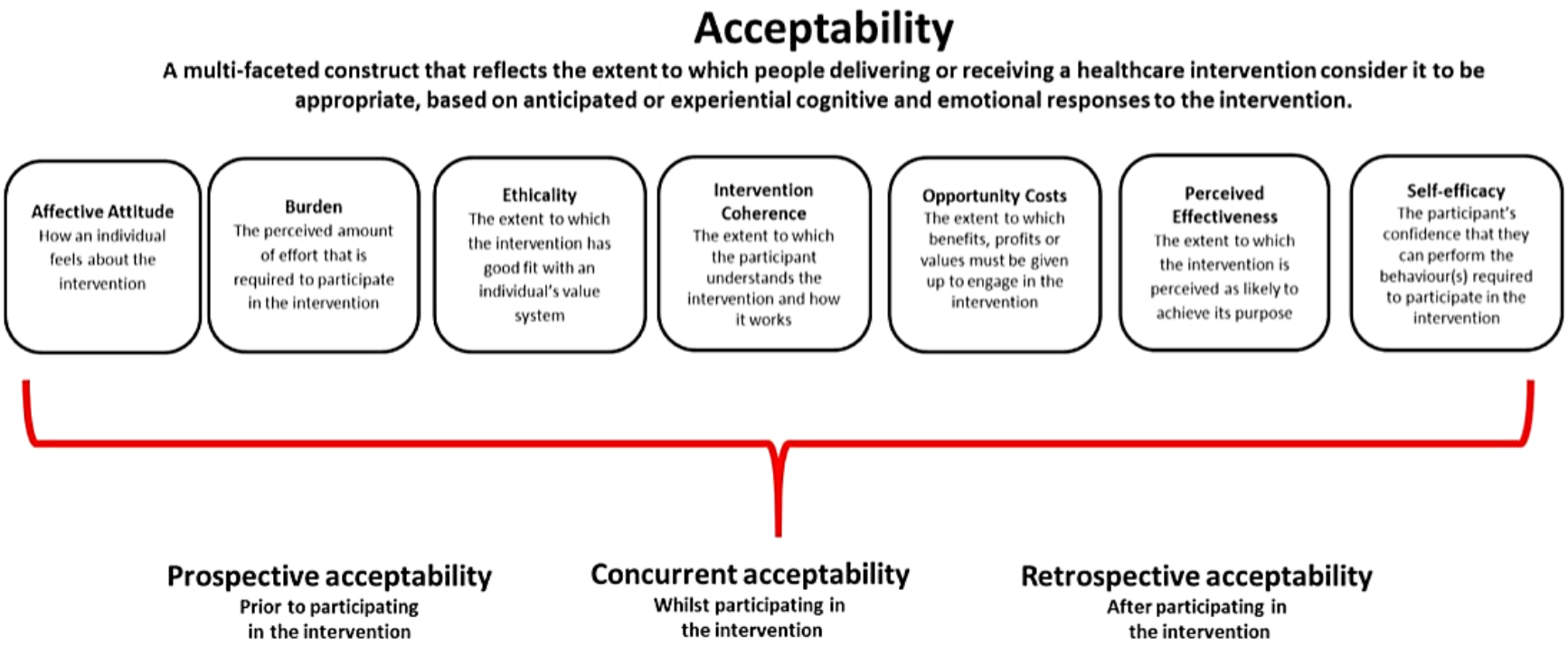
There are a number of different think-aloud methods that can be utilised to assess usability. These include the use of concurrent (when participants TA at the same time as carrying out experimental tasks), retrospective (when participants verbalise their thoughts after completing the experimental tasks), or a combination of methods used in tandem (referred to by some as the hybrid method (Alhadreti and Mayhew, 2018)). A tandem approach offers a means of enriching the collected data, and strengthens the validity and reliability of verbal protocols through the triangulation of concurrent and retrospective data.

At this stage in the intervention development process, it was considered important to gain as much information about usability and acceptability as possible during the individual home visits. For this reason, a hybrid approach, collecting data both during and immediately after the participant viewed the website was chosen. A think-aloud session (concurrent) was combined with a semi-structured interview (retrospective).

7.4.2 Acceptability – Semi-structured interviews

Interviews were carried out to explore how acceptable the intervention was to potential users. The interview schedule (Appendix E1) was developed in accordance with the recently published Theoretical Framework of Acceptability (TFA) for health interventions (Sekhon, Cartwright and Francis, 2017). It is proposed that the TFA will be helpful in assessing the acceptability of healthcare interventions within all stages of intervention development described by the MRC guidance on complex interventions (Craig *et al.*, 2008). The TFA distinguishes between prospective and retrospective acceptability. It maintains that assessment of anticipated acceptability prior to participation can highlight which aspects of an intervention can be modified to increase acceptability, and thus participation (Sekhon, Cartwright and Francis, 2017). Figure 7-1 below describes the seven constructs evaluated by the TRA.

Figure 7-1: The Theoretical Framework of Acceptability (TFA) (Sekhon, Cartwright and Francis, 2018, open access)



7.4.3 Identifying the sample population

It is vital for intervention developers to consider who they need to talk to, so that they can sample a diverse range of users who vary in characteristics that are considered important (Yardley *et al.*, 2015). For the purposes of this project a convenience sample of participants were identified from the sample recruited in a previous stage of the thesis (Chapter 3).

7.4.4 Recruitment

An invitation to participate (Participant Information Sheet, Appendix E2) was emailed to approximately 80 participants who took part in an earlier part of this PhD project (Chapter 3 - UWE REC REF No: HAS/15/06/184) and who had provided consent to be contacted via email about future projects.

7.4.4.1 Recruitment Procedures

All potential participants were instructed to reply to the email within 2 weeks if interested in participation – no follow-up reminders were sent. When a potential participant replied to the email invitation, further contact was made to ensure inclusion criteria were met, to respond to any other queries and to discuss the procedure. An appointment was then made by the lead researcher (AB) to carry out a home visit. Informed consent was carried out at the start of each home visit, in advance of data collection.

7.4.4.2 Inclusion Criteria

The following inclusion criteria were applied to all participants, and were checked prior to all home visits:

Inclusion criteria:

- Diagnosis of OA (Note: All participants had previously taken part in a research study in the Centre of Health and Clinical Research led by Professor Nicola Walsh; Facilitating Activity and Self-management in Arthritis (FASA Study -

ISRCTN66190737. All participants from the FASA study had a confirmed clinical or radiographic diagnosis of OA/degenerative joint pain, and were aged 50 or over).

- Access to the internet at home – All participants needed to be able to access the prototype website.

Exclusion criteria

- Did not have a diagnosis of OA.
- Did not have an internet connection at home.
- Could not understand the English language.
  (Note: Funding to cover the cost of any translations was not available)

7.4.4.3 Sample size

The think-aloud method provides a rich source of data, therefore a small sample (approx. 6-8 subjects) is sufficient to gain a thorough understanding of the main usability issues with an intervention (Nielsen, 1994).

Decisions about sample size for interviews were guided by; what do we want to know, what will have credibility, what will be useful, and what can be achieved given the available time and resources (Braun and Clarke, 2013). A recommendation of between 6-10 participants are suggested for a small project involving the use of interactive data collection methods such as interviews (Braun and Clarke, 2013).

Taking into consideration the above guidance from the fields of usability and thematic analysis, a sample size of between 6 – 8 participants was considered appropriate for this stage of early pre-testing with potential users.

7.4.4.4 Informed consent

A copy of the study consent form can be found in Appendix E3. Informed consent was obtained at the start of each home visit, after the researcher had answered any questions about the study.

The participant information sheet (Appendix E2) provided detail about the purpose of the study, and assured participants that all responses would remain confidential and anonymous. It also provided detail about how any quotes might be used (and how these would remain anonymous).

7.4.5 Data Collection

In line with previous stages of the project, demographic information was collected, including: gender, DOB, postcode, marital status, level of education, and co-morbidities. Each participant was also asked to complete self-efficacy (Gecht *et al.*, 1996) and motivation (Strömmer, Ingledew and Markland, 2015) questionnaires, and report current level of PA (in line with the previous study (Chapter 3)), to gather up to date information about these key factors (see Appendix E4 for study questionnaire).

Participants used a UWE laptop to access the prototype website. This was the most convenient method, as all video links and website pages were downloaded and ready to be viewed.

7.4.5.1 Ease of Use - Think-aloud data collection

Prior to the start of the session, each participant was given a short introduction to the website by the researcher. Once the session began, the participant was encouraged to talk out loud, describing their thinking whilst completing various actions. The researcher only intervened if the participant stopped talking. At this point, the researcher prompted the participant by asking the participant to 'keep on talking' (Jaspers, 2009).

The sessions were video and audio-recorded in order to record how users interacted with each of the web pages. Notes were taken during the think-aloud sessions, and these notes were combined with the video recordings to collect usability data.

7.4.5.2 User Feedback Session - Semi-structured interviews

An interview schedule (informed by the TFA) was used to guide the in-depth, semi-structured interviews. The schedule can be found in Appendix E1. Interviews were audio-recorded.

7.4.6 Data Analysis and Storage

7.4.6.1 Ease of use - Think Aloud session

Recorded data from the think-aloud sessions were used to identify and review any user-computer interaction problems, such as difficulty entering information into a text field, or selecting options from a list. Notes were taken during the think-alouds, and audio transcripts were studied to identify the key issues surrounding functionality and usability. A full thematic analysis on all aspects of the discussion was not carried out, as the objective here was to explore the function of the website rather than interpret participant's attitudes and opinions about the website (explored later with interviews).

7.4.6.2 User Feedback Session - Semi-structured interviews

Recorded data from the interviews were transcribed and analysed using Thematic Analysis (TA) (Braun and Clarke, 2006). TA is a method for identifying and interpreting patterns of meaning ('themes') within qualitative data. It offers a tool, or technique, that can be applied across a range of theoretical frameworks and research paradigms (Clarke and Braun, 2017). This approach can be used for both inductive (data-driven) or deductive (theory-driven) analyses, and is a method that works both to reflect 'reality', and to unpick or unravel the surface of 'reality' (Braun and Clarke, 2006).

For the purposes of this study, the TA approach was used in a deductive manner, using the Theoretical Framework of Acceptability (TFA) (Sekhon, Cartwright and Francis, 2017).

TFA is a recently developed multi-construct theoretical framework of acceptability of healthcare interventions, with seven constructs including; affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy. A codebook (see table 7.1 below) provides an overview of the seven constructs which make up this framework. AB coded all of the interviews. One transcript was also coded independently by NW and CM, to check for consistency and validation.

Table 7.1: Codebook based on the Theoretical Framework of Acceptability (TFA)

Code	Name	Definition	Related Questions
AA	Affective Attitude	How an individual feels about the intervention	What are your thoughts about the website? How do you feel about using it in the future?
B	Burden/ Intended Use	The perceived amount of effort that is required to participate in the intervention	How do you feel about the amount of time and effort that was required to use the website? How often do you think you might use the website in your day-to-day life? Would you use all elements of just some?
E	Ethicality/ Value	The extent to which the intervention has good fit with an individual's value system	The aims of the website are to: increase knowledge, help you to set goals, and to develop a support network – How important are these things to you? Is it relevant to you?
IC	Intervention Coherence	The extent to which the participant understands the intervention and how it works	Was it clear? Is there anything that could be clearer?
OC	Opportunity Costs	The extent to which benefits, profits, or values must be given up to engage in the intervention	Do the potential benefits of using the website outweigh the amount of time and effort needed to use it? Is it worth it?
PE	Perceived Effectiveness	The extent to which the intervention is perceived to be likely to achieve its purpose	How much do you think this website could help you to be active, or not? What about over the longer term?
SE	Self-Efficacy	The participant's confidence that they can perform the behaviour(s) required to participate in the intervention	How confident are you that you can complete the TASKS on the website?

7.4.6.3 Data Storage

Data collected during the study, including questionnaire data, recorded think-aloud data (visual and audio files) and audio recordings of the semi-structured interviews were stored on firewall-protected laptops/computers. All data in paper format was locked in secure filing cabinets (Glenside Campus, University of the West of England) at all times. AB was the only person with access to the dataset. Back-up copies of electronic data were made regularly onto the main secure drive of the University computer system.

7.4.7 Ethical Considerations

Ethical approval from the Faculty Research Ethics Committee at the University of the West of England was granted in May 2018 (UWE REC REF No: HAS.18.04.140) (See Appendix E5).

All participant data were kept completely anonymous at all times throughout the study, by allocating a unique identification (ID) number to each individual. The unique ID number was used throughout the project. No identifiable data were used at any time during the dissemination of the results.

7.5 Results

Results are reported in two sections:

1) Usability – How did participants use the intervention, and what did they think about the design and functionality of the website?
2) Acceptability – How acceptable was the intervention, and what did the participants think about the content?

7.5.1 Demographics

Table 7.2 below provides details of the demographics of the sample. 86% of the sample were female, and the mean age was 73yrs. (SD = 13.2). The most common co-morbidity reported was hypertension.

Table 7.2: Sample characteristics of participants

		N = 7
Gender	Female	6 (86%)
	Male	1 (14%)
Age (years)	Mean (SD)	73 (13.2)
	Minimum	60
	Maximum	93
Marital Status	Married/partner	3
	Divorced/separated	1
	Widowed	3
Highest level of education	GCSEs or equivalent	1
	University degree or equiv.	1
	Post-graduate qualification	3
	None	2
Co-morbidities	Hypertension	2
	Mental Health Condition	1
	Other	1 (Anxiety attacks)
Duration of OA (years)	Mean (SD)	10 (4.9)
	Minimum	3.5
	Maximum	20
Self-Efficacy and Motive Scores		
ESE (mean/SD)	SE for exercise	2.71 (0.93)
	Barriers	2.28 (1.16)
	Benefits	3.73 (0.24)
	Impact of PA on OA	3.52 (0.59)
EMGI (mean/SD)	Appearance/weight management	1.63 (0.76)
	Social engagement	2.01 (0.51)
	Enjoyment/revitalisation	1.89 (0.86)
	Negative health	1.42 (0.89)
	Health and fitness	1.91 (0.87)
Level of PA (n=6, 1 currently inactive)		
Days per week	5-7 days	6
Minutes per day	Mean	115
	Minimum	20
	Maximum	300
FASA Intervention participant		
	Yes	5
	No	2

7.5.1.1 Level of physical activity

Table 7.2 above shows how participants reported their current level of PA. One participant reported that they were currently not active. The rest of the sample reported being currently active over an average of 5-7 days per week. Mean number of minutes active per day was 115 minutes, and activities included walking, swimming, and gardening.

7.5.1.2 Motives and Self-efficacy scores

Participants also completed up-to-date self-efficacy (ESE) (Gecht *et al.*, 1996) and motivation (EMGI) (Strömmer, Ingledew and Markland, 2015) questionnaires (Appendix E4).

Mean scores are reported in table 7.2 above. Mean EMGI scores ranged from 1.42 to 2.01 across sub-categories of the EMGI questionnaire. Mean ESE scores ranged from 2.71 to 3.73 across sub-categories.

7.5.2 Usability

The think-aloud sessions ranged from 27 to 55 minutes in length. Sessions were video and audio recorded. The video data was used to record how each user interacted with the prototype website, and notes were made throughout about any difficulties with certain aspects such as buttons, or navigation. The video recordings also captured how users chose to complete the optional tasks, and notes were taken about what was written, or where tasks were not completed.

Audio recordings of the think-alouds also contributed to the later acceptability analysis. Relevant data was coded in the same way as the interview data, this process is described in more detail in section 7.5.3 below.

Table 7.3 below provides details of the pseudonyms adopted within this study, and provides brief demographic information including age and gender.

Table 7.3: Pseudonyms used for each participant

ID	Pseudonym	Details
P1	Sylvia	Female, 65
P2	Anne	Female, 63
P3	Patricia	Female, 64
P4	Susan	Female, 60
P5	Bernard	Male, 81
P6	Betty	Female, 85
P7	Winnie	Female, 93

The results reported in this section refer to Objective 1: EASE OF USE - To explore how people with OA use the prototype digital intervention.

The primary focus here was on what potential users thought about the design and functionality of the website. Results are reported in line with usability as defined by Nielson et al.

> *'**Usability:** a quality attribute that assesses how easy user interfaces are to use.'*
>
> (Nielsen, 2000).

Nielson (2000) describes five main components of usability including: learnability, efficiency, memorability, errors, and satisfaction. For this study, which tested an early prototype on just one single occasion, three of these components were considered most important:

- Learnability – could users accomplish basic tasks the first time they encounter the website?
- Errors – How many errors did users make? In addition, could they easily recover?

- Satisfaction – How pleasant did participants find the design?

Findings relating to these components are reported below.

Introduction Video

On the first (landing) page of the website, an introduction video provided information about how to use the website. This was an early draft video. Most participants chose to watch the video, and there was a mixed reaction, with some noting that it was a bit rushed, and suggesting there was perhaps too much information to take in.

Navigation

Participants learnt to navigate the website relatively quickly, during the first few pages. The majority were able to learn that they needed to scroll down to the bottom of the page to see the 'NEXT' button. One had to be prompted to do this on the first page. There was some confusion about the purpose of the side bar menu options, and some participants were unsure if they should use the 'NEXT' buttons, or the side-menu. Those that chose to use the side menu worked more randomly through pages, not following the intended order, this caused confusion when they ended up visiting a page they had already viewed.

Complexity of tasks

Some of the participants were confused when different elements of the same task were presented over a succession of pages, they were unsure if they had moved on to a different page. Most participants did not complete the task boxes throughout the website. Some completed a small number, none completed all. They explained complex attitudes and beliefs about the completion of tasks, and this is described in more detail in Section 7.5.3.

Some of the participants did not click on the range of activities, where they would have seen more information about each activity as it was not clear that the buttons were interactive.

The videos opened in a separate window outside of the website, and most participants had difficulty returning to the original pages once they had finished watching the videos. Again, this would be resolved in future iterations.

Generally, the response to the website was positive. Participants read and agreed with a lot of the text, and some made positive comments about the images. However, some questioned if the website would really capture future users' attention. One participant thought the website should be more colourful, stimulating, with less information, and be more intuitive (Patricia, 64).

Textual Information

Some of the participants thought there was too much text. They agreed that it would be useful to have the option to view more information, but only via, for example, a 'learn more here' button, so that it was optional. Some users wanted less information. Others suggested different ways of presenting the texts, preferring, for example, bullet points, rather than large sections of texts.

Infographics

Participants liked the infographics, in particular the one providing details of guidance for PA (Figure 7-2 below).

Figure 7-2: Example of infographic in prototype website

Images

The images appeared to have a positive impact on the participants. A number complimented the images, in particular those of people doing various activities, and in some cases prompted the participants to suggest they might try the exercises they were demonstrating. Others suggested they would like to see more animations, and would be keen to see the people in the images doing exercises, using short videos for example.

Videos

The participants did not like the fact that clicking on a video link took them out of the website. This caused confusion, and some needed guidance to be able to return to the website. This was expected, as there were some issues with embedding the videos into the prototype. It was explained to the participants that this issue would be resolved in further iterations.

Participants also commented on the relevance/relatability of some of the videos – questioning whether in fact the people had OA or chronic pain relating to another condition. Others commented that the people in the videos seemed quite down and depressed, and that it might be more helpful to have happier, more upbeat people.

They also thought the videos were too long (Average 2-3 minutes), and that they should be much shorter (perhaps one minute maximum). They also thought sound quality was poor.

Map

Most participants were very positive about the mock-up of the map (Figure 7-3 below), which would show details of activities going on in their area. They suggested they would be very keen to use such a facility, to find both local classes, and to potentially 'buddy-up' with others local to them.

Figure 7-3: Mock-up of a map showing local activities

7.5.3 Acceptability

The results reported in this section refer to Objective 2 of the study:

2) ACCEPTABILITY: To explore how acceptable, and useful, the content of the digital intervention is for potential users.

Results were coded deductively, using the theoretical framework of acceptability (TFA). Three team members coded one interview independently, to check for consistency of coding. Most of the coding was consistent across the three team members. In cases where multiple codes were present, the candidate (AB) made the final decision about the dominant code(s), using the TFA to guide this decision. A sample of this independent coding exercise is illustrated in Appendix E6.

Five key themes were identified, and each is described separately below. Each theme (and sub-themes) often covered several constructs of the TFA, however, individual constructs dominated, and these are illustrated by the figures found within each theme (See below).

7.5.3.1 Theme 1: Knowledge was valued, and beliefs about the benefits of PA for OA were positive

This theme related to the knowledge and skills section of the prototype website, which provided information about the benefits of PA for OA, and detailed the benefits of both cardiovascular exercise and strengthening exercise. The information in this section prompted participants to describe their existing understanding of the benefits of PA for OA. They expressed a positive attitude towards PA and valued the benefits that it could have on OA. They also thought that it was important to choose activities that were enjoyable. They agreed with the information provided about pacing, but were less sure about the usefulness of exploring potential barriers to activity.

Figure 7-4 below illustrates the dominant TFA constructs within the theme (darker green = most dominant). Table 7.4 provides an overview of each of the sub-themes. Key points are then described in more detail, and quotes provided.

Figure 7-4: Theme 1 – TFA Constructs

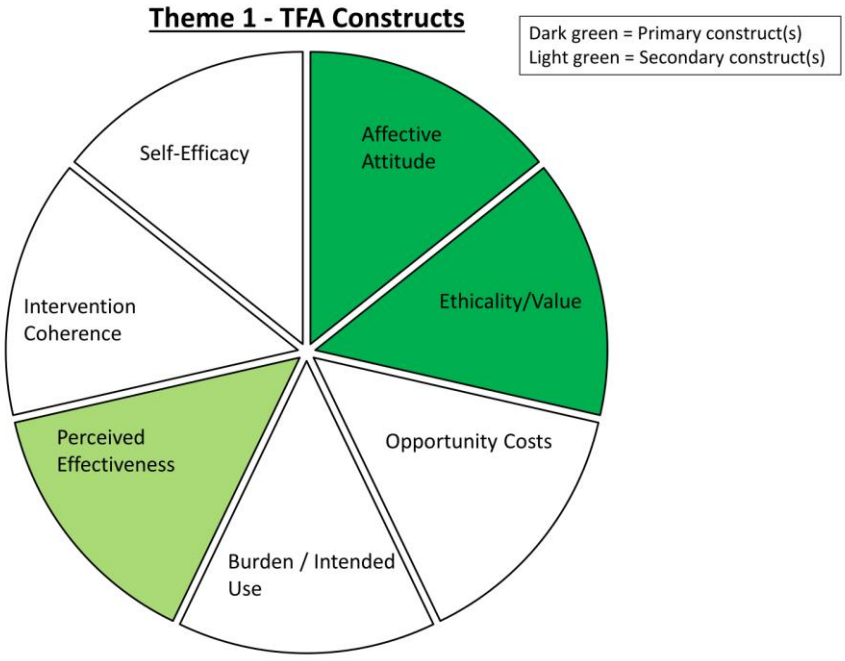


Table 7.4: Sub-themes for Theme 1

Sub-Theme Name	Summary of Participants' Descriptions	TFA Construct(s)
Depth of knowledge about OA	We already have a good knowledge of OA – some might want more, some might want less.	Affective attitude
Beliefs about the benefits of PA for OA	We know about, and value the benefits of PA for OA. For some, PA becomes less of a priority when they are well.	Affective attitude / Ethicality/Value
Enjoyment is important	We agree that enjoyment is important - we choose (and value) activities that we enjoy.	Ethicality/Value
The importance of pacing and reviewing potential barriers	We value the information about Pacing, this is important, and difficult to get right. We don't think you should highlight the negatives (stumbling blocks).	Ethicality/Value Perceived effectiveness

Depth of knowledge about OA

The participants were already familiar with the background knowledge about OA, and the benefits of PA. Some would have liked more information, and others felt that the knowledge section of the website would be of most benefit to those with a recent diagnosis.

> 'The average person doesn't need to know all this stuff, there is only some of us that want to know what's going on here'.
>
> Anne, 63

They agreed that the language should be simple, and easy to understand.

> 'I think when you first get diagnosed with arthritis of any description, you want to know about it. You know, if its rheumatoid arthritis or osteo because it's different. So I would want some knowledge but…. I wouldn't want it to be medical knowledge.'
>
> Patricia, 64

Beliefs about the benefits of PA for OA

Attitudes towards PA were positive, participants understood the benefits of PA for OA, and placed value on it. They were clear that they knew what activities they should be doing, but acknowledged the gap between intention and behaviour.

> 'I mean, I know what I should be doing, walking, and swimming, you know,'
>
> Betty, 85

Some of the participants also described how the value of activity might change as symptoms, such as pain, improved.

> 'Every now and again the doctor will print out something, and I will do it, but once the issue has gone, you stop doing it,….and it sounds really stupid, but you stop doing it, the issue reappears, and you don't think to do that, do you, ...
>
> Susan, 60

Enjoyment is important

Participants agreed with the guidance on the website about choosing an activity that was enjoyable. They described how they were more likely to carry on with an activity if they enjoyed it, and were more likely to stop if they didn't.

'I did get myself a bike for myself in the house, had it, got rid of it, I didn't enjoy it! I think that's probably why the walking is still going, because that is something that I do enjoy.'

Susan, 60

The importance of pacing and reviewing potential barriers

The importance of pacing was highlighted just prior to the action planning section within the website. Participants very much agreed with the importance of pacing, and a number of them described their difficulties in getting it right.

'I know you should pace, but it's so difficult, sometimes I crawl back from the garden, you know, and I go to bed with my electric blanket, and I take my glucosamine, and then do gardening again.'

Patricia, 64

'Yep, that's the difficulty – with getting the right level of exercise, we've all been there, and done too much occasionally. I agree that little and often is often the best approach. That's been learnt through experience, and making mistakes.'

Anne, 63

Conversely, they questioned the need for an overview of potential 'stumbling blocks', provided to help with planning for activity. They described them as not being necessary, or particularly useful, even suggesting they could have a negative effect.

'No, I don't think you should give people stumbling blocks - why put it into their head before they've even done it? We all don't have time, we all might forget to do it, we won't go out if it's raining anyway, yeah.... don't put stumbling blocks in, it's very un-positive. Negative that is, because it puts ideas into people's heads before they've even got going....'

Patricia, 64

7.5.3.2 Theme 2: The value (and burden) of setting goals

This theme focused on the participant's opinions and attitudes about goal setting, a task found within the Action Planning section of the website. Several participants described a negative attitude towards setting 'SMART' goals. Self-efficacy and age were also identified as important factors. Figure 7-5 illustrates the dominant TFA constructs within the theme. Table 7.5 provides an overview of the sub-themes, and each is then described in more detail.

Figure 7-5: Theme 2 - TFA Constructs

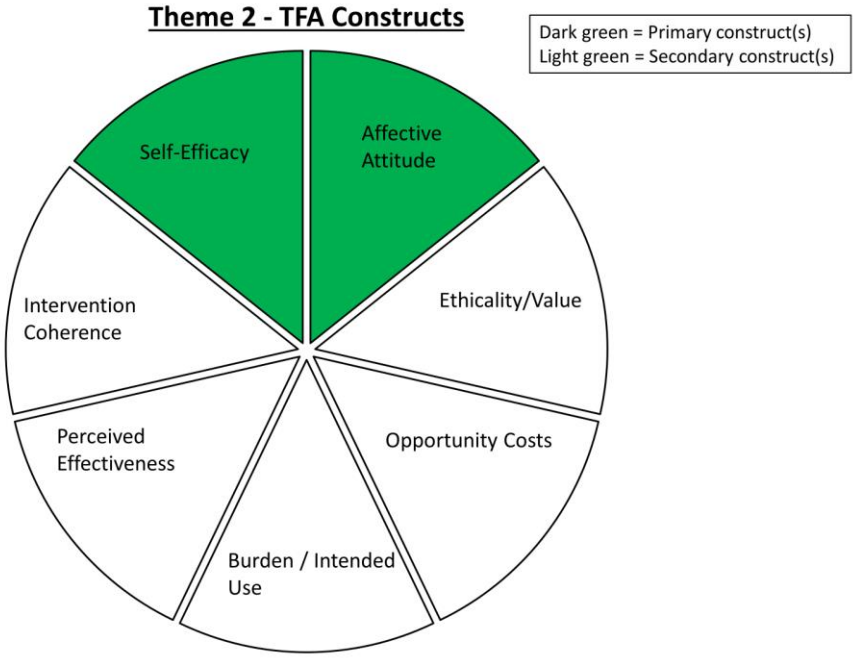


Table 7.5: Sub-themes for Theme 2

Sub-Theme Name	Summary of Participants' Descriptions	TFA Construct(s)
Attitudes and autonomy towards goal setting	SMART goals are too much work, I keep my goals in my head. But it could be good for others.	Affective attitude
Fear of failure/Self-efficacy	If you write them down, it's worse if you fail. I'm just not very good at xxxx.	Self-efficacy (for goal setting?)
Age and past successes	The relevance of past successes was different for 60 vs. 80 years olds. We're older now, we have a different pace of life.	Affective attitude/Self-efficacy

Attitudes and autonomy towards goal setting

The prototype website included a section where participants were prompted to enter information to develop their own personalised 'SMART' goals for PA. Some of the participants thought it was too detailed, describing it as being 'too work-like' or 'childish'.

'We're retired now, we don't want to do goals anymore [laughs]! It's too work-like….. It's in my head or I have got my Google calendar which is my plan anyway, what am I doing this week and you know….So I already have a vehicle for my plan.'

Anne, 63

''My structured goal?' - I never have a structured goal, are you kidding me! I think I'd complete what days of the week, but I'd leave out what time of the day, yeah.... too specific.'

Patricia, 64

'It's very childish isn't it?'

Winnie, 93

However, some participants were more positive towards the idea of setting goals. The potential benefit to those who were less active, or newly diagnosed with OA, was also highlighted.

'I think it seemed alright (goal setting section). It takes some time to think about, because I think about setting goals and things for me. I think maybe somebody who does need some support would find that useful. It doesn't seem too bad to me.'

Sylvia, 65

The majority of participants within the sample reported being moderately active, therefore were able to reflect on their experiences of being active in everyday life. They described less structured, more abstract goals, often keeping them in their heads rather than writing them down.

'No, it's in my head…… Yeah every other day, after breakfast if I can, I know what I will do and where to. I think they are needed, but I have got them in my mind already.'

Bernard, 81

'I am not really up to much on goals although I understand the need for it. I suppose me walking up the road trying to do it once a day is a goal but I don't put it that way.'

Susan, 60

Some of the participants were more positive about completing the goal setting exercise, though were unsure of the likelihood of returning to review them.

'Wow, yeah, that's quite good, I could fill all of this out, and print it out, and pin it out on my board.'

Betty, 85

'I always fill in boxes, so, yes, I would.... but would I look at it again afterwards? Because in my head I know what my overall aim is.... It wouldn't make any difference if I wrote it down or not...'

Patricia, 64

Fear of Failure/Self-efficacy

Despite most participants reporting a moderate level of PA, some remained cautious about writing down specific goals.

'Probably that I don't want to write it down because when I don't achieve it, I don't like failure.'

Susan, 60

'In my case I tend to be more retrospective, rather than thinking 'I'm going to do this' I think it depends on your personality and if you are an achiever, you know, you don't really want a restriction or something – you may have a fear of failure which I know I do have, so I don't want to set a task or a pace, and I'll go with it, and I'll push and push.'

Anne, 63

The action planning section of the website provided some ideas for different activities to try, to guide users when formulating their goals. Some of the participants were cautious about trying something different, despite already being moderately active.

'I saw the lady with the yoga (image on webpage), some of the things she was doing. I thought yes that's me but I couldn't ever, my yoga is hopeless. I know everyone always says there are worst people than you but there isn't, I am the worst one.'

Anne, 63

‘Dancing, oh, I would love a dancing partner, oh, I'd love somebody to say shall we go dancing, oh, I love dancing, but that's out of the question obviously.... I suppose fitness classes are another one, but I don't think I could cope with fitness classes to be honest with you, I don't want to be in a class where I am sat down, doing this..... (Moves arms).’

Betty, 85

Age and past successes

Also included in the action planning section was an option to reflect on past successes. There was an interesting contrast in how participants talked about their past successes. For some, generally the younger in the sample, it revived a sense of achievement and seemed to motivate them to re-start an old activity.

‘Oh, I like this, I like this idea (recording past successes), this has got me straight away. But then I suppose others might say that's not obtainable. I would look at that and think 'yes!' I've got to do Scafell, Ben Nevis, well, I did Snowdon.....’

Patricia, 64

‘Swimming, now there's something I must motivate myself, because I used to go a lot, yeah’

Sylvia, 65

However, for the older participants, past successes seemed to now be out of reach.

‘I don't think about things I enjoyed too often actually, um, how, whether it’s got any relevance now, I don’t know, yes..., it depends what age you are, I've always been active..... and I have to accept that I’ve had a number of operations…….’

Bernard, 81

‘Obviously you can’t suddenly take part of a team. I can’t do that. And I couldn’t play tennis, I really couldn’t. I couldn’t move about. I probably ought to do, I never did yoga’

Winnie, 93

'Dancing, I love dancing, but that's out of the question obviously.... '

Betty, 85

7.5.3.3 Theme 3: The impact of competing life priorities

The website prompted participants to describe and analyse the problems they encountered with trying to maintain regular PA. Participants described a number of competing life commitments and priorities such as work patterns, caring for family members, elderly parents and grandchildren. This theme is important in understanding the external pressures that participants felt, and provides some explanation of the competing opportunity costs that appeared to affect whether the participants felt able to engage with the website. Table 7.6 provides an overview of the sub-themes, and each is then described in more detail. Figure 7-6 illustrates the dominant TFA constructs within the theme.

Figure 7-6: Theme 3 – TFA Constructs

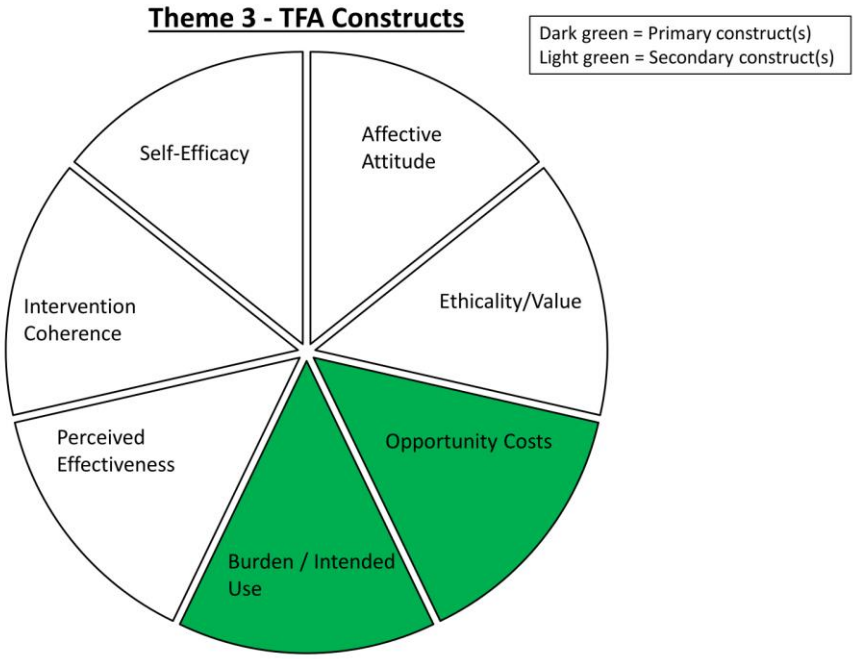


Table 7.6: Sub-themes for Theme 3

Sub-Theme Name	Summary of Participants' Descriptions	TFA Construct(s)
Our lives are full	Family – children, grandchildren, elderly parents, caregivers, work.	Opportunity costs
Not enough time, and the impact of interruptions	Life is busy and unpredictable, it's difficult to stick to a routine. Circumstances change.	Opportunity costs
Access to local services	I can/cannot get to local classes and groups.	Burden/Intended use

Our lives are full

Nearly all of the participants described full and busy lives. Some viewed PA as just a normal part of everyday life, becoming successful at fitting in regular activity, despite other commitments.

'I don't think about exercise, I think about what I like to do, because that's why I'm alive, to enjoy myself….. I try to build in my exercise into my everyday so that it doesn't become a chore, although we do it depending on what other activities are going on, erm… being a pretty busy family.'

Anne, 63

'I go to work, I walk a lot at work, I don't use the escalators, I never use a lift, I always walk up the stairs, I make myself go from the basement to the top. I just make myself do that. It's just general life.'

Patricia, 64

Not enough time

Some of the participants described how a lack of time influenced level of PA. Others described the difficulty of committing to a regular time each week, because of competing life priorities.

‘Now the great problem really is of course, um, how long, exercise takes time, it's always in short supply,’

Bernard, 81

‘Committing to getting to a particular class at a particular time is where I would find difficulty…..its Sod’s law says that's it’s on a Tuesday. Tomorrow I'm not going because I've got a lunch with people I used to work with, normally, we've met on a Wednesday, so it's just different, things happen…. but that is something that is important’

Sylvia, 65

Other participants described the impact that interruptions might have on their plan for regular activity.

‘.....things happen, like change of job what have you, and other lifestyle things got in the way,’

Sylvia, 65

‘For me, it's random, week by week, I wish it was more, the same every week, I would like it to be like that, but it's not practical, because I work every other weekend, my friend works Mon-Fri, so that's why we meet every other Sunday, but it's all gone to pot since this wedding business, and I’ve been on holiday.’

Patricia, 64

Access to local services

Some of the participants lived in rural areas, therefore were far away from many social activity groups. This affected the likelihood of them being able to attend groups and classes.

'Well we haven't got a local shop so I couldn't walk to that. We haven't got a shop nearer than a mile at least. I think that's too much. I have done Pilates and I used to go to a group but I don't know whether there is a group anywhere at the moment that I can go to.'

Winnie, 93

7.5.3.4 Theme 4: Being active with others, and social support

This theme represented the key issues arising when participants explored the social support section of the prototype website. This section of the website included ideas for developing practical support, to help maintain PA. There was a strong positive attitude about the benefits of being active with others, and the majority of participants were keen to explore options for linking up with others 'who are like me'. They were less positive about using online forums to connect with others, and some felt that they didn't currently want, or need, support from others. Table 7.7 below provides an overview of the sub-themes. Key points are then described in more detail, and quotes provided. Figure 7-7 illustrates the dominant constructs from the TFA.

Figure 7-7: Theme 4 - TFA Constructs

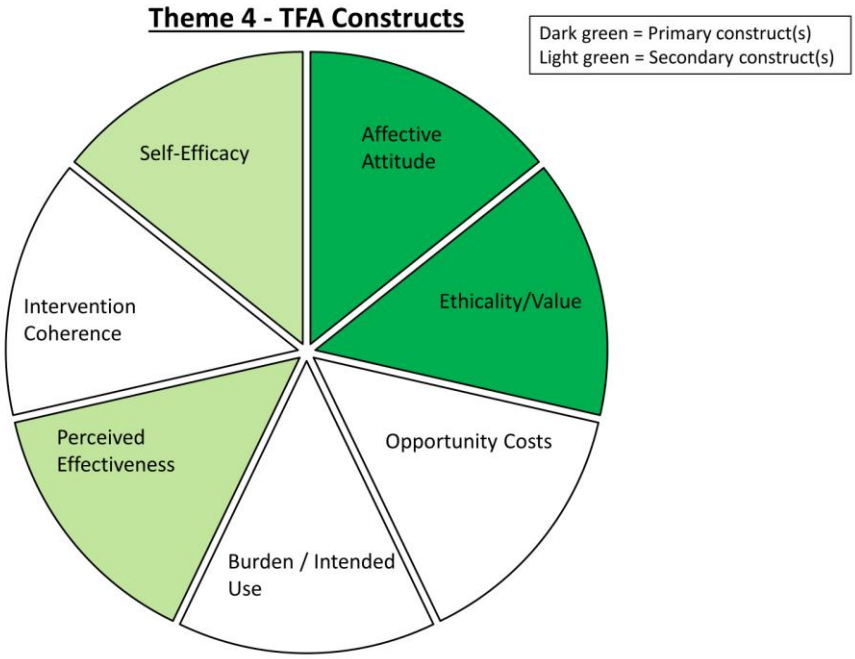


Table 7.7: Sub-themes for Theme 4

Sub-Theme Name	Summary of Participants' Descriptions	TFA Construct(s)
The enjoyment of being active with others	It's so much nicer being active with others. I don't like being alone.	Affective attitude. Ethicality/Value
Relatedness	They must be like me.	Affective attitude.
No to Facebook!	We're keener to link up with people face-to-face, than to get support from others online.	Affective attitude. Ethicality/Value
The impact of personal relationships	I get support from my partner, we exercise together/I feel guilty if I leave my partner/I have no support, it's hard.	Affective attitude
Self-efficacy for social interaction	I don't need this type of support at the moment/I haven't got much to offer, to others.	Self-efficacy. Perceived effectiveness.

The enjoyment of being active with others

The majority of participants described being active with others as more enjoyable when compared with being active alone.

'It's so much nicer when you're doing it with somebody else....'

Susan, 60

'I mean so many people think they can do it on their own, but I realised, I've got a Pilates machine down there, it's been sitting there for 4 years, hasn't been used, but I'll go to the Pilates class. I mean you almost need a neighbour..... People don't want to go to groups, but maybe say to their neighbour, or the person across the road, do you walk, or something.'

Patricia, 64

Relatedness

Some of the participants also had clear expectations about the type of people that they would choose to spend time with. It was important for them to be relatable, and they needed to have common interests (not just OA).

'I enjoy walking and talking, and discussing philosophy and ancient history and things like that.....similar interests.'

Bernard, 81

'I wouldn't necessarily want to go to a group, yeah, this is going to sound dreadful, but my groups are like – the people I meet in the bridge club, because I need to have the intellectual stimulation. I'm not very good with small talk and I don't have enough life left to spend it on small talk [laughs!]. I know it sounds awful [laughs].'

Anne, 63

'I think saying about a social network, if you make friends with somebody, because with some people you can can't you, and then they are a friend for life, that's fine, but other than that…. like 6 weeks at the hospital (exercise group), once that was over, that was it. Although we did all start having a cup of tea afterwards in the cafe, but it didn't continue. No, I mean I was out of their age group to be honest with you, I was quite, I was one of the youngest ones there, definitely.'

Susan, 60

No to Facebook!

Participants held strong views about the use of online social networking sites, describing how they didn't want to use them.

'Oh, I hate social networks..... laughs, it doesn't appeal to me at all, no.'

Bernard, 81

'I think I am happier seeking it out myself. I am a bit mistrustful of a lot of these group things on computers.'

Sylvia, 65

'It's quite frightening. No! No. No to Facebook! I just don't like it.'

Susan, 60

Participants were more positive about meeting up with people, face-to-face, in particular the option of a 'buddying-up' service to meet local people with a similar diagnosis.

'No, no, what I need to do is find out if there are a group of people doing things, where they can then say, oh, come and join us, that's what I need, so, ...'

Betty, 85

'Yeah I would actually like to buddy up with somebody local, if it was somebody who had the same time as me, because that's what it is isn't it, if, I mean, because you've got to talk to people and what have you to, you know.'

Susan, 60

The impact of personal relationships

Throughout both the think-aloud sessions and the semi-structured interviews participants described how partners (or lack of), influenced their ability to maintain PA, recounting both positive and negative consequences.

'I am so lucky that I have a fantastic husband, who used to run marathons and all the rest of it….We do tend to talk about what we are going to do during the day and both of us are trying to build in exercise with everything, and if we have a day that we can't exercise then we make up for it by doing a long walk or something.'

Anne, 63

'Yeah, my husband does keep on, you haven't done your exercises, yeah, and he is very into activities anyway…. He does try to encourage me….. If my husband comes home and says 'Have you been up the road today?' I hate it when I have got to say 'No I haven't' because I know his thoughts.'

Susan, 60

Self-Efficacy for Social Interaction

When the participants were asked if they thought that the social support section could help them to maintain activity (perceived effectiveness), a number of them suggested that they didn't currently need this type of support.

'I don't really need a lot of support at the moment because I feel I'm sufficiently active, I've not got problems at the moment…….I am not sort of starting at the bottom of the ladder. If I was, sort of like post-operative for instance then I would want to be starting with small steps and building up to bigger activities, but I feel I am sort of already fairly well up the ladder at the moment.'

Sylvia, 65

'Not really, but I would be able to access it at some stage if I needed to, but I don't think at the moment I would, and it's unlikely that I will, but I like to know that I've got that in my rucksack if you like, as an option.'

Anne, 63

One participant described not having the confidence to join a local group.

'So perhaps if, like, local groups, I say local groups, we do have a local walking group, but I'd never have the courage to go, yeah, I don't know why, I just don't.'

Susan, 60

At the end of the social support section of the website, a question asked: Would you be interested in adding your own tips/advice or stories to our website, about your experiences with PA? A number of participants felt that they didn't have any advice to offer, despite having personal success with maintaining a moderate amount of activity.

'I always like to listen to other people, I don't know if I've got very much to offer myself, I might, I don't know, again I'm rather busy in the evenings too. I think if anyone asks me, I would offer advice, I don't know if I would volunteer anything unless I'd been asked.'

Bernard, 81

'It's difficult, I don't know whether my experience is sufficiently useful to anyone else, well, having said that, there has been a couple of people that I know that have got arthritis that I have photocopied the exercise sheet that I got and passed it on, whether they've done anything or not, I can't say.....'

Sylvia, 65

7.5.3.5 Theme 5: Maintaining professional support, whilst independently self-monitoring

The action planning section of the prototype website prompted participants to describe their attitudes and opinions about self-monitoring, and the value of professional support. In general, the participants placed value on professional support, however, didn't want to be disturbed with too many notifications and updates. Table 7.8 provides an overview of the sub-themes, and each is then described in more detail. Figure 7-8 illustrates the dominant TFA constructs.

Figure 7-8: Theme 5 – TFA Constructs

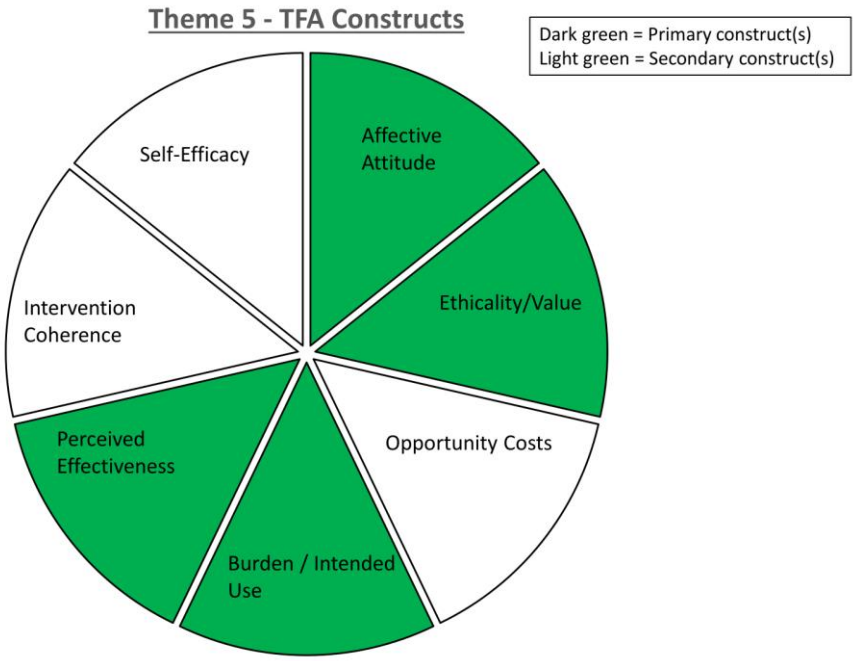


Table 7.8: Sub-themes for Theme 5

Sub-Theme Name	Summary of Participants' Descriptions	TFA Construct(s)
Value of professional support	We would like to maintain some sort of link to professional support.	Ethicality/Value.
Autonomy to self-monitor	We want to be in control of how often we receive a notification/email/text etc. We don't want too much involvement.	Affective Attitude.
Self-efficacy for self-monitoring	We don't need help to monitor our goals. We already have established ways of doing this.	Perceived effectiveness. Burden/Intended use.

Value of professional support

Participants were keen to have the option of being in contact with a professional, if needed.

'My preference is actually just to talk it through with someone, is there anything else I should be doing really. It's that because I can think about what I need to do and my motivation comes from within but as I said recently I got into a pickle and couldn't understand why I couldn't get out of pain and I realised, when I spoke to somebody that I had, I hadn't done the pacing properly.'

Anne, 63

'I think if you are talking to someone who knows what they are talking about of course, that is far better. Oh yeah. I think that is quite a good idea actually.'

Betty, 85

Autonomy to self-monitor

Participants valued having the freedom to choose how they monitored their plan and goals. Some preferred not to have any form of external reminder, others were keen to have a reminder, but not frequently.

'No, I don't want you to text me, because I review myself.'

Sylvia, 65

'I do it in my head, um, but other people might like this…..mentally, I monitor it mentally. I think they are needed but I have got them in my mind already. There might be a discipline on me, yes. I don't want a "Hi, how's things going?"'

Bernard, 81

'I don't really need reminding, I know I have to do it, I just got to keep a record of what I'm doing, it's like with some medication, I have to write it every day in my diary, what I've taken, when I've taken them, so, um, ...'

Betty, 85

A number of participants were keen to receive reminders via email. They were less keen about being monitored via apps, and didn't particularly like getting notifications on their phones.

'Emails. Yes. Because you can reply to them in your own time. One to one chat with somebody, I am not sure. Like I say I don't do Facebook or Twitter and all those other things, I am not into that.'

Sylvia, 65

'I think an email….every 6 months…. would be good to remind me. Just say, OK, Hi, have you, you know, its 6 months since your last appointment, would you like to review what you said last time. I think that would be great because that's as much as I personally would probably need.'

Anne, 63

'It would be nice to have the choice. Because I did switch off the notifications because I am not keen, you get too many. I've got a Garmin activity watch that used to drive me nuts, because I be sitting watching a film, and it would tell me to move, so that's no good.'

Patricia, 64

One participant was very clear that they wanted to choose and monitor their own activity, and did not want a computer choosing for them. However, they also appeared to be potentially willing to incorporate some technology to help them to self-monitor their activity.

'No, No I don't, I want to do what I want to do not what it tells me to do. Mind you, thinking about it I suppose if I was really into it, the stepometer or whatever it's called, the pedometer, that would, I quite like this.'

Susan, 60

Self-efficacy for self-monitoring

Some comments highlighted that participants had experienced specific issues with Apps. They described having problems setting up the Apps initially, and didn't like that some were automatically programmed to set-up what they felt were, unobtainable goals.

'Yeah I have tried the App on the phone, where you walk and it tells you how far you've walked, and all that. I did try that, but.... there goals are a little bit high, that's what I found, and like I said, I live on a hill, so wherever I go....'

Susan, 60

'I just feel like a complete ignoramus as far as smart phones….. It's only last year that I was given a smart phone and I wouldn't know how to put Apps and things on it. I really am a complete beginner at that. If someone was going to talk me through how to use this phone that I have got and how to put Apps on it, I could use it.'

Sylvia, 65

7.6 Discussion

In line with other projects which have iteratively developed digital health interventions, the methods of inquiry adopted by this study sought to uncover the potential users interests in the overall product, potential impediments to usage on a regular basis, and suggestions for improvement (Mumma*h et al*, 2016a). The combination of a think-aloud session with a semi-structured, in-depth interview, enabled a wealth of data to be collected. The hybrid model, using both the think-aloud protocol and the theoretical framework of acceptability (TFA) to guide the interviews, produced data about how users interacted with the website, as well as their thoughts and opinions on it helping them to be active over the long-term.

The motives and self-efficacy scores (gathered using the ESE and EMGI questionnaires) were similar to scores reported in the survey study (Chapter 3), sitting in line with those who were identified as being in either the low-active or high-active categories (see tables 3.5 and 3.6, Chapter 3). Given that the sample reported in this study were mostly active, it was expected that ESE and EMGI scores would be similar to those reported in the active groups within chapter 3.

Findings related to usability, and those relating to acceptability are now discussed separately.

7.6.1 Usability

The usability findings in this study contrast with other similar projects that have used think-aloud methods alone, where only 5% of the verbalisations were described as being richer sources of information about users underlying motivations, and where most verbalisations were simply reading text, or carrying out a task within the website (Cooke, 2010). The think-aloud sessions within this study uncovered a number of minor issues relating to the usability of the prototype website, which could guide future development. Issues such as navigation options, and clearer instructions for interactive buttons are relatively simple issues to resolve. Other findings, such as relatability to videos and

stories, recommendations for different types of activity, and availability of local services, highlight potential areas where interventions could be tailored to each individual.

Turning wordy guidance into snappy infographics

It is worth noting the favourable response given to the few, simple infographics included in the intervention. Positive comments about these were made, and participants seemed to relate to the information in a quick and coherent way, getting the intended message across to participants. An infographic is a multimedia graphic which aims to present complex information in a way that is more engaging, and easy to understand (Martin, 2018), and research shows that information displayed in this medium is more quickly understood, and more likely to be remembered for longer (Krum, 2013). The addition of creative and well-designed infographics, could be an area of future exploration, and could reduce the amount of information presented using simple text, which some participants criticised.

A map for social connectedness

Similarly, the availability of a map function was welcomed by participants. Even though it would be a potentially complex instrument to have within an intervention, requiring on-going maintenance, the important finding here is that participants welcomed new ways to find out about what activities were happening near to them. This is an important finding, and future research should explore novel ways to link up professional advice given in a specific chronic disease self-management setting, with local facilities offering suitable activities and peer support. Future research could also explore optimum methods for linking up interventions with community exercise opportunities, exercise referral schemes, and community initiatives.

7.6.2 Acceptability

The data gathered on acceptability of the website was rich, descriptive, and in-depth. The hybrid approach combining the think-aloud session with an in-depth interview provided an opportunity to gather a large amount of valuable data, the website appeared to act as a prompt for participants to reflect on their own personal attitudes, values, and beliefs about PA.

7.6.2.1 Affective attitude and ethicality

Within the context of the TFA, Affective attitude refers to how an individual feels about an intervention, and ethicality is the extent to which the intervention has a good fit with the individual's belief system. Findings from this study showed that attitudes about PA, and the value placed on it, were important to the sample group. Enjoyment and social connectedness were also important. These findings are in line with self-determination theory, which highlights the importance of both enjoyment, and relatedness with others (Deci and Ryan, 2000; Teixeira *et al.*, 2012; Silva *et al.*, 2010). Simply providing somebody with knowledge about the benefits of PA may not be adequate. Additional (optional) support could also be provided to; 1) help users to select a specific activity that they think they might enjoy, and 2) to provide tools for developing social connectedness with others locally.

The knowledge and skills section of the website appeared to have a good fit with the individuals' belief system, with users voicing their general agreement with the information provided. Despite these positive attitudes, users highlighted the difficulty of the intention-behaviour gap. This finding highlights the potential additional information that could be added into this section. It could be beneficial to both acknowledge this gap between knowledge and practice, to reassure the users that this is a problem that others experience (vicarious experience).

7.6.2.2 Perceived effectiveness

The TFA refers to perceived effectiveness as the extent to which the intervention is perceived as likely to achieve its purpose. Within this study, a number of discussions focused on the potential to be active with others locally. Participants did not perceive the use of online forums as a likely tool to help them to be active. They were also not keen to identify specific friends or family who could provide them with emotional and practical support, suggesting that this wasn't necessary, or wouldn't be effective.

Instead, they were very keen to have access to a map facility, to search for potentially suitable local activities. They were also positive about exploring potential ways to 'buddy up' with local people diagnosed with OA. They welcomed tools to provide them with up-to-date information about relevant and suitable activities and groups happening in their area. This area is often neglected within existing digital self-management interventions, possibly because of the complexity of keeping such an instrument up-to-date and relevant.

Future research should investigate how social connectedness within this population can be strengthened, and integrated into digital health behaviour change interventions. A final important finding is the value of a credible source, a similar finding to previous research (Pearson *et al.*, 2016). Any tools to identify local activities need to come from a trusted and approved source, so that users are confident that an activity they choose to attend is going to be of an acceptable standard.

7.6.2.3 Opportunity costs and burden

With reference to the TFA, 'opportunity costs' refer to the extent to which benefits, profits or values must be given up to engage with the intervention, and 'burden' refers to the perceived amount of effort that is required to participate in the intervention.

Within this study, users highlighted several issues relating to competing life priorities and suggested that this ongoing balancing act would likely affect if and when they would use the website. This finding is in line with previous research which has cited 'lack of time' as a barrier to engagement and participation in activity (Bennell, Dobson and Hinman, 2014). It is important to recognise that patients with OA often have full and busy lives, and the balance between wellness and competing life priorities is in constant flux.

7.6.2.4 Self-efficacy for goal setting and self-monitoring

Action plans are a way of making a commitment to achieve skills mastery and future behaviour change (Lorig *et al.*, 2014b). Existing digital interventions have focused on action planning and goal setting as a key technique in helping people with OA to become and stay active. In this study, 'SMART' goals were viewed as being too complex and work-like. For some, a fear of failure, and self-efficacy for specifically setting a goal or action plan appeared to impact on their likelihood of completing the goal-setting tasks within the prototype website. This is an important finding, and it potentially contributes to the understanding of the issue of non-usage and attrition often seen in digital interventions.

A number of studies have explored how self-efficacy may operate as a moderator in relation to the planning-behaviour relationship (Lorig *et al.*, 2014b; Luszczynska *et al.*, 2011). Despite action planning being reported as a positive predictor of PA maintenance, one study (Luszczynska *et al.*, 2011) also reported that individuals with lower perceived self-efficacy at baseline may benefit less from planning interventions because they fail to apply their plans when encountering situations that appear challenging.

Age also appeared to be a factor affecting self-efficacy for setting future goals. Those who were older tended to be less keen to look back at previous successes, feeling that despite positive experiences in the past, these activities were now beyond their current ability. Conversely, the younger participants appeared to be motivated by reflecting on activities they had previously enjoyed. This highlights the diverse nature of the OA population and the important issue of tailoring, recognising that how each individual chooses to set a goal will differ. A similar digital intervention developed to promote PA among insufficiently active adults with type II diabetes, purposely left out any focus on past successes, as it was considered that this strategy could have undermined the basic need for competence for those who had never experienced any past PA success (Moreau et al, 2015). Conversely, Lorig *et al* (2014) carried out further analysis of the adherence to actions plans within their self-management programmes, and found that older age was positively associated with the number of action plans written and completed ($p=0.02$). While numerous studies have linked generic goal setting, or action planning to short-term

behaviour change, little is known about the importance of the various components of action planning and their effects on longer-term behaviour (Lori*g et al*, 2014b)

Self-monitoring is the most widely employed strategy in interventions aimed at promoting health and wellness (Orji *et al.*, 2018). The strengths of self-monitoring have been established as being able to; raise user's consciousness, foster reflection, and reveal problem behaviours, however, findings specifically from within a digital health setting have highlighted that a weaknesses of self-monitoring strategies is that they can be viewed as being tedious and boring (Orji *et al.*, 2018). This is in line with findings reported here within the acceptability study, with suggestions that setting goals and self-monitoring was potentially too work-like, and childish. There is a need for further exploration, particularly within this population, to further understand optimal methods for setting and monitoring goals.

7.7 Informing the parameters of the digital intervention

Data gathered in this chapter also provided validation for data gathered in previous stages of intervention development, in particular by adding insight into the parameters of the content in the digital intervention (Tables 6.4 to 6.6, Chapter 6).

Bartholomew *et al* (2016) pay particular attention to the parameters of the chosen methods, defined as 'the conditions under which the methods are shown to be effective – during the translation from method to application, and to programme' (p346).

A challenge for developers is that content must fit both the context and characteristics of the programme participant, as well as any theoretical parameters of the selected methods. For example, if a planning team decides to use modelling (method), they must ensure that their programme's role-model stories (practical application) include models with which participants can relate to (Bartholome*w et al*, 2016).

7.8 Strengths and Limitations

A key strength of qualitative research is that it can examine and theorise contextual effects. This piece of qualitative research demonstrates sensitivity to context by showing awareness of the participants' perspectives, the sociocultural context of the setting, and how these may influence what participants say and how it was interpreted by the researcher (Yardley, 2017).

The hybrid approach of utilising both the think-aloud session and semi-structured interviews meant that some of the questions asked during the interviews were partly answered during the think-aloud, as the website acted as a natural prompt and users started to describe their beliefs and attitudes. Despite this overlap between methods, the combined data were considered more valuable. If the think-alouds were carried out in isolation, certain elements of acceptability would not have been explored. Conversely, if users did not view a website, but, for example, an intervention was described by text, or using paper prototypes, data gathered may have lacked depth.

Future research might consider combining the approaches by integrating questions into the think-aloud process, however, there is potential for this to distract the user, reducing the potential for usability issues to be highlighted. Previous research compared a concurrent think-aloud with a hybrid method, and found the concurrent method to be quicker, recommending it as the best approach (Alhadreti and Mayhew, 2018).

A limitation within this study was the educational level of the sample. In particular, three out of the seven participants held a post-graduate qualification. Other internet delivered PA studies have reported similar sample bias, including Lawford et al (2018) who reported that 75% of those in the intervention arm of their study had completed some tertiary education. Previous literature has identified educational level as having a moderating effect on level of PA in recently retired individuals, suggesting that to a certain extent, distinct approaches could be preferable to optimally reach high- and low- educated individuals in future interventions (Dyck, Cardon and Bourdeaudhuij, 2017). A sample with a more balanced level of education might have been more representative of the

general OA population, and future studies should attempt to gain a more representative sample.

7.9 Conclusion

This chapter described a qualitative study that adopted a hybrid approach to pre-testing of a digital behaviour change intervention. This method provided a wealth of data, which uncovered some key issues surrounding burden and intended use of a website to facilitate PA in this population. Findings at this pre-testing stage guide future iterations of the digital intervention, with the intention of streamlining the content, making it more acceptable to its intended users.

Chapter 8: Discussion of findings and implications for future research

8.1 Overview

This thesis focused on exploring the most effective ways to motivate people with osteoarthritis (OA) to become and stay physically active, and utilised these findings to develop and test a digital behaviour change intervention (DBCI). The main findings from the thesis and contributions to knowledge are now discussed, as well as the implications for future intervention development and research.

8.2 Aim of the Thesis

The overall aim of this thesis was to develop and pre-test a digital behaviour change intervention to motivate people with OA to become and stay active.

Four objectives were identified:

1) To determine the effectiveness of existing digital interventions for promoting PA in people with OA.
2) To explore the beliefs and motives associated with PA in people with OA.
3) To design and produce a prototype DBCI.
4) To explore the usability and acceptability of a prototype DBCI.

A mixed methods sequential design was adopted, where qualitative data were used to help explain and build upon earlier quantitative results. The process of intervention development was iterative, with each stage creatively guiding the next by identifying key issues that needed further investigation. The findings presented in this thesis contribute to knowledge in a number of ways, and an overview is first presented in Box 8-1 below, before being discussed in more detail.

Box 8-1: Contribution to Knowledge

- DBCIs have significant potential to engage people with OA to be physically active. A number of existing digital interventions have been shown to be effective at increasing levels of PA in this population for up to 12 months, providing evidence to support the use of such interventions in this field. Those DBCIs with a clear aim, which focused on simple, autonomous goals, had stronger outcomes.

- Higher levels of self-efficacy and more autonomous forms of motivation were associated with increased physical activity in a sample of people with OA. Significant differences in levels of self-efficacy were also seen for those more active, over a period of time. These findings highlight the potential benefits of developing interventions that are theoretically guided by the constructs of self-efficacy and self-determination theory.

- This thesis provides a detailed example of the application of the intervention mapping (IM) approach to guide intervention development. It highlights the resulting high level of transparency, evidencing how theoretical constructs can be linked to practical elements of an intervention, and provides useful guidance for future digital intervention developers.

- Novel use of the Theoretical Framework of Acceptability (TFA) to explore acceptability of the intervention emphasised the value of clear, easy to understand information, which focuses on activities that are enjoyable. It also highlighted the importance of increasing social connectedness, as well as the potential burden of goal-setting, and impact of competing life priorities, highlighting the need for future investigation into these areas.

8.3 Contribution to Knowledge

This thesis described the development of a DBCI, based on theory and systematically developed using a clear mapping approach, in line with MRC guidance on developing complex interventions (Craig *et al.*, 2008). To the author's knowledge, this is the first time that a DBCI has been developed in this way for this population. Key areas where it contributes to knowledge are described separately below.

8.3.1 DBCIs for motivating people with OA to be physically active

This thesis has highlighted the potential utility of DBCIs for motivating people with OA to become and stay active. In particular, it has distinguished elements which might be considered most important for maintaining engagement with PA, in particular, fostering autonomous motivation for PA and strengthening one's self-efficacy to carry out PA, providing valuable guidance for future digital intervention developers.

The review of literature highlighted the fast-paced environment within which DBCIs are being developed and tested, with three out of the eight RCTs reviewed being published in the first half of 2018 alone. This speed of development highlights the growing interest in the potential use of DBCIs to guide health behaviours, adding to the argument for clear reporting of content and development methods (such as those used within this thesis), so that future interventions can be reproduced and replicated for differing contexts and settings. This is important given the ongoing findings in the literature of: wide variations in the quality of online information for arthritis management (Barrow *et al.*, 2018); a digital landscape saturated with apps which have limited data on effectiveness and user experience (Bondaronek *et al.*, 2018); and the great potential for apps/digital interventions to support more comprehensive interventions, highlighting a missed opportunity for PA promotion (Bondaronek *et al.*, 2018; Walsh, Salmon and Pearson, 2016).

There is significant potential for digital interventions to engage people with PA. The current landscape of digital health is calling out for more rigorously developed, evidence-based interventions, which meet the needs of specific populations, and are able to

provide useful, acceptable tools, which guide engagement with healthy behaviours such as PA.

The focus of the intervention developed within this thesis was on engaging individuals with OA to maintain an adequate level of PA. Because of this, future development and implementation of the intervention should focus on identifying the most important components that encourage the maintenance of PA. Findings from the studies reported in chapters 3 and 4 highlighted the potential importance of increasing both self-efficacy and more autonomous forms of intrinsic motivation to develop better 'quality' motivation for long-term sustained engagement and maintenance of PA. These findings were therefore used to purposively select behaviour change techniques identified as influencing the long-term positive maintenance of PA in this population.

As highlighted in the introduction chapter of this thesis, interventions that have targeted the development of new PA habits in this population often report impressive rates of initial behaviour change, which are then not translated into long-term adherence (Rothman, 2000). Furthermore, the majority of studies also fail to evaluate any sustained PA behaviour change for longer than 12 months (Fjeldsoe *et al.*, 2011; Marks and Allegrante, 2005).

One review attempted to identify and differentiate components between initiation and maintenance phases, and found for example, that coping planning strongly predicted longer-term PA maintenance, and was less influential in the earlier phase of initiation (Stralen *et al.*, 2009). Future research would benefit from focusing on both longer periods of follow-up to assess any maintenance of behaviour change more thoroughly, as well as an increased focus on identifying the similarities and differences between the initiation and maintenance phases of behaviour change.

Future testing of the intervention developed within this thesis, with a variety of sub-groups, spanning inactive to high active participants, could highlight which components might be most useful at fostering the maintenance of PA over the long-term. These issues need to be further explored in both longitudinal and experimental studies (Stralen *et al.*, 2010).

8.3.2 Fostering autonomous motivation and self-efficacy

A number of previous interventions identified in the systematic literature review were described as being guided by self-efficacy, but it was often unclear which elements of the interventions were the intended 'active ingredients'. It was considered essential to learn more about how such theoretical constructs might influence behaviour, prior to the development of the digital intervention within this thesis.

Primary data were therefore gathered to learn more about the beliefs and motives for PA, and the potential collective importance of self-efficacy and autonomous forms of motivation. These data identified a positive relationship between self-efficacy, autonomous motivation, and PA behaviour. By evaluating the sub-constructs of both self-efficacy and self-determination theory in more detail, it was possible to tease out detailed information about specific areas of importance such as enjoyment, and the positive benefits of PA reported in the sample. These findings went on to guide the later development stages of the intervention, by helping to develop more focused change objectives in chapter 5, rather than simply referring to the more abstract concept of 'self-efficacy' as one single idea.

The findings relating to self-efficacy add to other literature which has explored the effects of self-efficacy on levels of PA in people with OA (Hammer *et al.*, 2015; Gecht *et al.*, 1996; Gyurcsik, Estabrooks and Frahm-Templar, 2003; Marks and Allegrante, 2005; Marks, 2014; Peeters, Brown and Burton, 2014) by using a self-efficacy questionnaire specific to PA for arthritis. They also add new insights into the relationship between self-efficacy and levels of PA over time, in this population.

Novel findings were reported regarding gains from engaging in PA, using data gathered by the EMGI (Strömmer, Ingledew and Markland, 2015). Those who were currently active reported gaining more than they originally expected, both in terms of social engagement and enjoyment/revitalisation. These findings support the argument for interventions that focus on increasing autonomous and intrinsic forms of motivation, in particular focusing on strengthening social connectedness, as well as the importance of identifying activities that provide the most enjoyment to each individual. These findings highlight that being active produces unexpected rewards, and these positive outcomes should be highlighted as benefits in future interventions. Arguably, these findings hold particular significance for

this population, where research has highlighted negative beliefs about the value of physical activity (Hurley *et al.*, 2010, 2018). This issue was also highlighted during production of the prototype website, where little existing content about the specific gains from physical activity in this population could be found. The production of more stories from people with OA, talking about the gains they have seen from becoming and staying active, would be a valuable additional resource for both future iterations of the prototype website described within this thesis, as well as for future interventions.

8.3.3 Using theory to guide digital health intervention development

The data regarding self-efficacy and autonomous motivation informed the development of the digital intervention within this thesis in a number of ways. For example, particular behaviour change techniques and practical materials were chosen to meet the change objectives developed in chapter 5, these included stories and videos from people with OA /or in pain, describing how they had set goals, or how they had overcome pain to become active. Where possible, stories were identified which would provide positive vicarious experience of others, i.e. seeing other people, similar to oneself succeed at a particular behaviour. Another example was the inclusion of simple, easy-to-understand information about the benefits of PA on OA, linking back to the behaviour change technique 'shaping knowledge', and affecting the theoretical determinants of behaviour – competency and mastery skills. Acceptability and usability testing provided further support for the value of these theoretical constructs, with potential users highlighting, for example, the importance of enjoyment, and the value of hearing stories of success from people who had experienced similar difficulties (relatedness/vicarious experiences).

This in-depth evaluation of the relevance of theoretical sub-constructs of motivation, particularly in regard to self-efficacy and self-determination theory, helped to identify and produce the intended 'active ingredients' of the digital intervention. This aids any future process evaluation of this intervention, by providing a blue-print of practical elements which can be further refined in response to continued user testing (described in more detail in section 8.4.1). In turn, these future refinements might go some way to highlighting which clusters of BCTs might be considered essential to include in PA

interventions for this population, and others that may be considered obsolete, or less useful.

Identifying the 'active ingredients' of an intervention is difficult, and has been recognised as a problem when reporting intervention development (Michie *et al.*, 2013). Authors have emphasised the importance of documenting and evaluating how individual components work, and how this influences the effectiveness of an intervention (Aalbers, Baars and Rikkert, 2011). If research is able to assess this in a more rigorous way it could highlight areas where interventions should focus and areas that could be removed, in turn encouraging users to engage with an intervention over a longer period of time. The MRC guidance for intervention development also highlights this issue, suggesting that only by addressing this kind of question can we build a cumulative understanding of causal mechanisms, design more effective interventions and apply them appropriately across different groups and settings (Craig *et al.*, 2008).

Whilst the literature and guidelines agree that a coherent theoretical basis to interventions is crucial (Moore and Evans, 2017), recent commentary has expressed concern that assumptions that an intervention explicitly based on theory is inherently superior to one not based on theory carries significant risks (Moore and Evans, 2017). This is further supported by the results of the review of literature within this thesis, which reported how despite 'self-efficacy' being a commonly used theory to guide intervention development, not all effective interventions were exclusively guided by this theory and indeed some were not guided by theory at all.

Moore and Evans (2017) also highlight the importance of developing a clear understanding of the problem under consideration, suggesting that care be taken not to isolate components of an intervention from their contexts. This thesis used a number of methods to investigate the problem of motivation and inactivity in this population, before using in-depth acceptability testing to gather knowledge about the different contexts affecting the potential effectiveness of the intervention.

This thesis provided a detailed overview of how content was linked to theory, showing how change objectives were created in relation to the identified determinants of the behaviour. This process of intervention mapping (IM) allowed implicit links to be made between theoretical constructs and individual elements of the intervention, and integrated the findings from previous stages of the thesis, providing evidence that it is possible to document the development of an intervention in detail illustrating the often missing link back to theory.

To the author's knowledge, this is the first time that a digital intervention designed for people with OA has been developed in this way. It adds to other literature which has used the IM approach to document the development of digital interventions (Direito *et al.*, 2018; Muir *et al.*, 2017), in line with the MRC guidance for complex health development (Craig *et al.*, 2008).

In October 2018, the Theories and Techniques of Behaviour Change Heat Map Tool was launched by the Human Behaviour Change project (run by University College London). This is an interactive resource, which, for the first time links behaviour change techniques to their mechanisms of action. This urgently needed guidance on how BCTs affect the mechanisms that change behaviour provides a resource for behaviour change intervention designers, researchers and theorists (Johnston *et al.*, 2018). The tool will help to describe the links between theory and intervention content, making it easier to learn about the active components of an intervention, allowing further refinement and more focused behaviour change interventions. The field of complex health intervention development is changing, and this is highlighted by a decision made by the MRC and the National Institute for Health Research (NIHR), who have jointly commissioned an update to the MRC developing and evaluating complex interventions guidelines (Craig *et al.*, 2008), acknowledging that considerable developments have been made in this field since 2006. The new guidance is due to be published in 2019.

Future interventions should be underpinned by theoretical reasoning, and described in relation to accepted behaviour change taxonomies. This thesis provides an example of how this can be done, and this depth of development should become commonplace in the future, making it easier for 'active ingredients' of an intervention to be optimised.

8.3.4 What do users want? Exploring the acceptability of a digital intervention

Development of digital interventions is a highly iterative process, with continual testing required at every stage. Testing acceptability with potential users should play an equally substantial role as effectiveness evaluations (West and Michie, 2016).

Acceptability has been explored in a number of different ways within digital health interventions. Within this thesis, a rigorous method to explore acceptability was adopted, that resulted in valuable, in-depth data, which by examining usability alone would not have been captured. This is the first time that the Theoretical Framework of Acceptability (TFA) has been used to guide data collection about a digital health intervention for people with OA. The data provided a unique insight into how digital interventions might fit into people's everyday lives, and contributed to new knowledge about potential user's attitudes, beliefs and values for a digital intervention.

Within this thesis, potential users valued information about the benefits of PA for OA and believed in these benefits. They valued guidance for setting goals, though described how they found action planning to be burdensome; they also highlighted the impact of competing life priorities. Finally, they strongly valued the idea of social connectedness and establishing links with others nearby, in a similar situation to themselves. These findings provided insight into specific areas of an intervention, which once refined, could improve engagement and ultimately lower usage attrition, both issues associated with digital health interventions.

Acceptability has become a key consideration in the design, evaluation and implementation of healthcare interventions, yet without a shared understanding of what acceptability refers to it remains difficult for intervention developers to assess it effectively (Sekhon, Cartwright and Francis, 2017). The seven constructs of the TFA include: attitudes, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy. An evaluation guided by this framework might gather more information than general acceptability questions such as 'what do you think about the intervention, what did you like, what didn't you like' etc.

Taking examples from the data collected within this thesis, users initially described how they liked the intervention, found the website useful, and easy to navigate. When asked in more depth (guided by the TFA) they reflected about the perceived effectiveness of the website, how they valued different parts, and described opportunity costs associated with competing life priorities. On the surface, there were no major complaints, but delving deeper revealed that perhaps its value and perceived effectiveness was not as positive as initially described.

This prompting of more intangible opinions and thoughts enabled the researcher to understand more about the attitudes and values of the sample group. For example, it became clear that the way people plan and set goals over a longer period of time might look quite different to the same actions in the earlier stages of behaviour change. Some intervention techniques may be effective when tested in an RCT but not widely acceptable to the target audience, while other techniques might be highly acceptable but show smaller effect sizes (Araujo-Soares *et al.*, 2018). Better understanding of acceptability might be able to produce more effective interventions, in turn improving adherence to the behaviour.

This is an exciting new area of research, and one that adds a more comprehensive exploration and understanding of the complexities of acceptability, with the TFA enabling the findings to be collected and reported in a coherent manner.

The process of acceptability testing also highlighted the importance of social support and connectedness. A key finding from potential users was the desire to link up with others 'like me'. This area has perhaps been overlooked previously in digital interventions, where the focus has been on setting individual action plans and self-monitoring goals. The development of new technologies offers opportunities to enhance the scope of delivery of interventions to support behaviour change and self-management at scale (Araujo-S*oares et al*, 2018).

The findings relating to acceptability and usability of the prototype intervention provide a stepping-stone to future development, including future iterations/refinement of the current design, as well as guiding future exploratory research into the most acceptable

methods for goal-setting and linking up with others. These ideas for future research are discussed more in section 8.4.

8.3.5 Model of a DBCI

Methods adopted within this thesis enabled a DBCI to be clearly described, which linked all practical content back to theoretical determinants. It described a process of pre-testing of the digital intervention with potential users, which highlighted elements of the intervention that were most acceptable to potential users, as well as highlighting areas which could be further refined in future iterations.

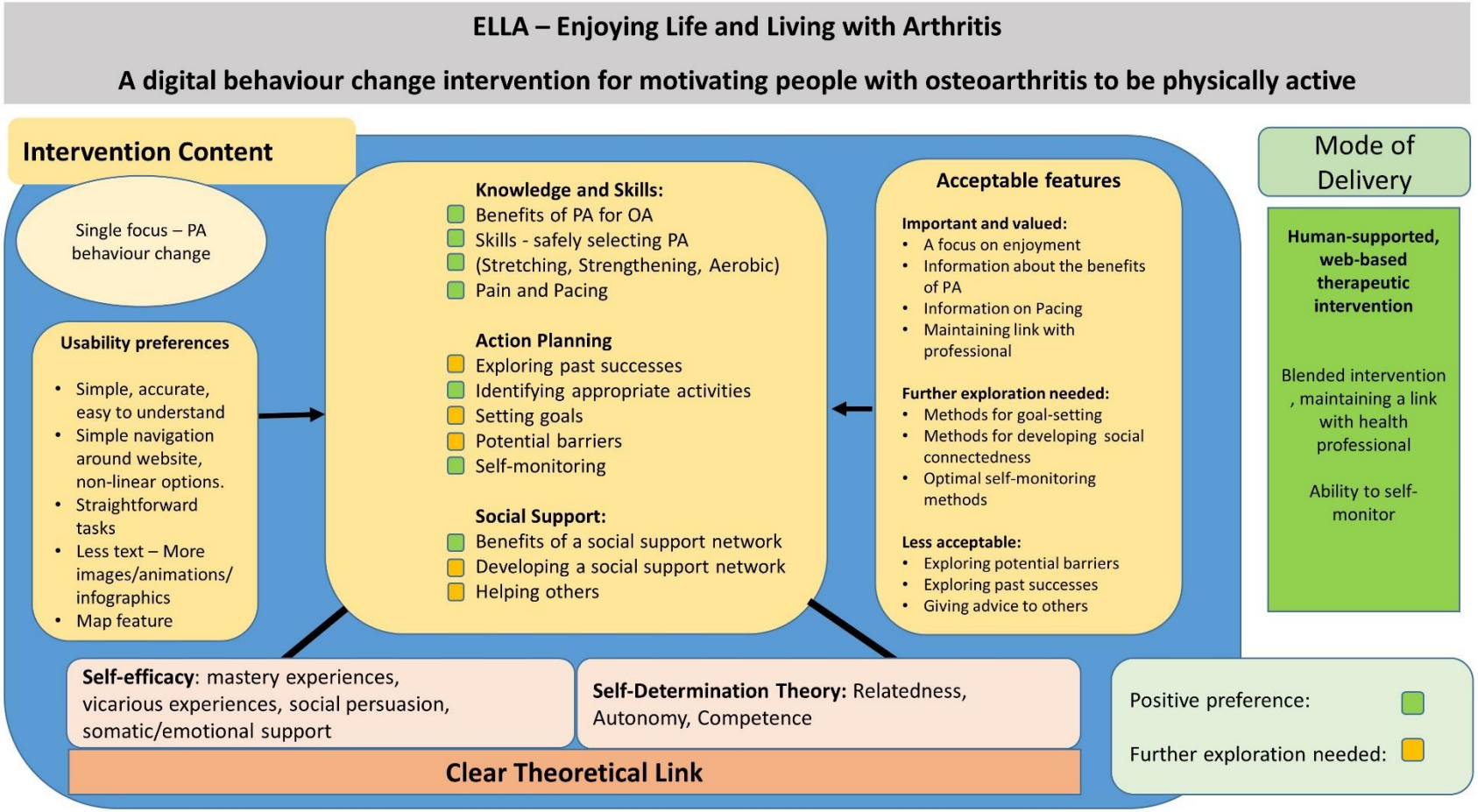
In overview, findings from this thesis indicate that a digital behaviour change intervention for engaging people with OA to become, and stay active, should be complex (in terms of its content and link to theory), yet simple and easy to understand by users. If possible, a link to a professional/health service should be maintained. Other optimal content should include: an up-to-date tool/method to develop social connectedness with others locally, also diagnosed with OA ; a simplified approach to goal-setting and action planning, guiding the user, but maintaining full autonomy; on-going tools/methods to allow for self-monitoring; less text, and more infographics/animations/images (which should all be relevant and relatable).

This thesis was able to highlight areas that might help people with OA to achieve increased motivation for long-term engagement with PA. Future interventions that are also attempting to create an optimal environment for autonomous motivation and self-efficacy for PA might consider the following:

- Enjoyment – Support the user to choose an activity that they think they will enjoy.
- Social connectedness – Integrate tools into the intervention that allow the user to identify local groups/buddies to encourage activity with others, and to develop relatedness to others.
- Action Planning – Support the user to form a plan of action, being mindful of the time/effort required to develop the plan/goals. Keep this as simple as possible, and allow the user to create their own structure with the plan to strengthen autonomy.
- Professional link/Blended care – Integrate options for linking up with professionals if specific advice is required to maintain relatedness.
- Recognise that competing life priorities (as well as OA specific barriers) will affect engagement with PA at times, that this is common and that this is okay. Support user/participants to plan for interruptions, whilst also acknowledging that other people have highlighted the difficulties of competing life priorities when trying to make plans.
- Knowledge/Skills/PA guidelines – Ensure all information about PA is simple, accurate, easy to understand and up to date. Avoid prescribing personal 'doses', the key message to get across should be any movement is good.
- Include information on pacing and graded activity, and incorporate advice about being active despite the presence of pain.

The figure below (figure 8-1) illustrates a current model of the DBCI informed by this thesis, illustrating how content was linked back to theoretical constructs. It also highlights elements of the content reported to be acceptable, and areas where future research is required.

Figure 8-1: Model of ELLA



8.4 Implications for Future Research

8.4.1 Further development and evaluation of the digital intervention

Developing digital health interventions in a rapidly changing, fast-paced technological landscape (Michie *et al*, 2017) presents new challenges, particularly around engagement, both with the technology and the intended behaviour. Recommendations from a recent international workshop recommended that it is useful to establish what constitutes 'effective engagement', that is sufficient engagement to achieve the intended outcomes.

Complex intervention development should focus on including materials and processes that best fit the intended behaviour change. Findings from this thesis were able to highlight specific areas that warrant further investigation, prior to planning for implementation and evaluation testing. These include:

- Production of videos/stories with more relevance to the specific topic (change objective) and relatedness to the population.
- Further exploration of goal-setting tools and action planning methods, including learning more about potential users preferred methods for monitoring goal progression.
- Further exploration of using technology to develop social connectedness, such as development of digital tools which enable real-time mapping of relevant, local activities.
- Developing strong working relationships with human-computer interaction design specialists, to produce relevant and acceptable animations and infographics.
- Professional links should be maintained. Potential for digital interventions to become one part of a larger package incorporating face-to-face support with a healthcare professional ('blended care').

Recent studies identified in the literature review have highlighted the potential benefits of 'blended care' (Kloek *et al.*, 2018; Li *et al.*, 2018). Such interventions have shown positive outcomes, and 'blended care' fits well within the self-determination model, by maintaining a level of relatedness with a health professional, whilst also having autonomy to control one's actions. Data gathered during the acceptability interviews highlighted the

value of maintaining a link with a professional, albeit from a distance, but allowing for interaction if needed. Further development of the prototype website should explore options for retaining this link, which would involve developing working groups with health professionals to establish optimum implementation routes for such an approach.

Finally, before the prototype website is implemented and effectiveness is evaluated, further usability testing should occur with human-computer interaction developers, to assess usability in a more formal way, using recognised usability questionnaires such as the System Usability Scale (SUS) (Brooke, 1986).

Future development of the prototype website should be guided by the final steps of IM, which cover implementation and evaluation issues. This would create a natural next step, which covers tasks such as stating the outcome measures and details of process evaluations to be carried out. A systematic review of existing digital interventions aimed at chronic disease self-management reported that a majority of included interventions did not sufficiently evaluate implementation quality, including formal process evaluations to assess programme fidelity (Stellefso*n et al*, 2013).

The depth of development carried out within this thesis, which covered steps 1-4 of the IM approach, facilitates a smooth progression to process evaluation and later implementation. In particular, context, parameters and moderators of change have already been identified which will be particularly helpful in future evaluations. The next steps of development would include: development of an implementation plan to enable adoption, implementation, and maintenance of the digital intervention; and development of an evaluation plan based on previous steps (Bartholomew *et al.*, 2016).

Within a digital health intervention setting, process evaluation is particularly important to: identify best-practice strategies; reduce the potential for technical difficulty; determine the optimal amount of time patients are willing to spend using the digital intervention to support PA levels; and estimate the amount of human and financial resources necessary for high-quality delivery (Stellefson *et al.*, 2013). It is only after this has all been completed, when future effectiveness evaluations can then be planned, to explore the actual impact that the digital behaviour change intervention might have on PA levels.

8.4.2 Methodological considerations

The mixed methods approach adopted by this thesis allowed findings from a number of data collection and analysis methods to be integrated. Motivational factors were explored quantitatively, intervention development approaches utilised participatory research methods, and rich qualitative data provided insight from potential users. Arguably, other methods might not have been able to capture such a wide range of relevant information to guide the development of the intervention.

A solely positivist, quantitative approach could have provided more generalisable data to the wider population, however as the review of the literature revealed, having firm data about level of non-usage and attrition levels, whilst useful, does not contribute to our understanding of the reasons for this non-usage. An important aim of this thesis was to explore how participants might use digital interventions over the long-term, how usage might affect PA behaviour, and attempted to understand why existing interventions continue to see high levels of attrition.

Specifically, adoption of the IM approach to guide development was considered valuable because of its ability to link theory to content, and it will be utilised to guide the planning of further process evaluation steps of this intervention development project at post-doctoral level.

Future development of digital interventions might also consider how more digitally focused development models could be combined with the IM approach. Later stages of IM (steps 5 and 6) focus much more on planning for implementation. In a digital setting it might be useful to incorporate models such as the Behavioural Intervention Technology model (BIT) (Moh*r et al*, 2014) to describe the functionality of a digital intervention in more detail, and recent literature has demonstrated a method for combining these two approaches (Direito *et al.*, 2018).

Overall, a mixed methods approach worked well for this intervention development project and future intervention developers should consider adopting a similar research design.

8.4.3 The wider determinants of physical activity in OA

In line with other literature in the field, it is acknowledged that despite the fact that SE and autonomous motivation/SDT appear to contribute to the understanding of PA maintenance in OA, it is unlikely that these concepts alone provide a complete understanding of all of the factors impacting PA behaviour in this population (Bartholomew *et al.*, 2016). Chapter one described how a range of facilitators and barriers have previously been associated with PA in this population.

Findings in this thesis highlighted the relative importance of social connectedness, as well as the importance of access to physical activity services such as local groups and classes. The focus of the intervention developed within this thesis was on individual-level behaviour change; however, the findings highlight the potential need to incorporate the wider determinants that might affect motivation in this population. Individual approaches take us only so far, it is important to recognise that behaviour is affected by wider social and environmental influences (Biddle, Mutrie and Gorely, 2015).

Future interventions might consider integrating other models of behaviour change, which include the wider determinants of PA behaviour (such as: the Health Action Process Approach (HAPA) model (Schwarzer *et al.*, 2008), the Physical Activity Maintenance (PAM) model (Nigg *et al.*, 2008), or the Social Ecological model (Stokols, 1992)) in an attempt to understand other aspects of behaviour which contribute to long-term engagement with PA.

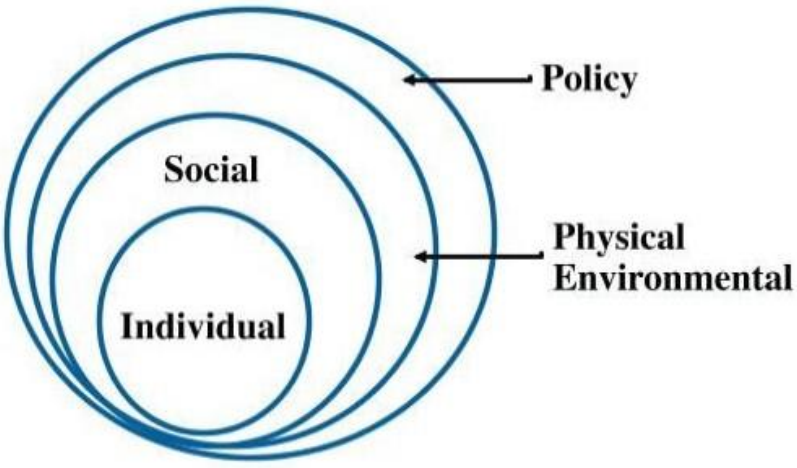
Biddle et al (2015) recognise that much focus has been placed on individual-level psychological factors when developing behavioural interventions. They highlight the value of adopting a wider ecological framework (see figure 8-2), recognising that psychological influences coexist with social, environmental, and wider policy/legislative influences. There is a need to create supportive environments in which people can operate, yet provide individuals with the psychological tools to change and regulate their own behaviour (Biddle, Mutrie and Gorely, 2015). This involves taking a step back and acknowledging the importance of wider determinants such as social systems, the physical

environment, as well as considering how local policy might contribute to PA levels across different regions of the UK.

An increasing focus by the UK government to enable individuals to self-manage their own health and healthy behaviours is highlighted in a recent publication which provides guidance about how individuals can live healthier, longer lives (Department of Health and Social Care, 2018). This focus on the individual however, fails to take into consideration the wider determinants of health. Arguably, future research should place a greater focus on identifying and attempting to impact the wider determinants of healthy behaviours such as PA, prior to focusing in on individual level change.

Previous literature also recognises that there continues to be a paucity of PA studies that include participants from varying socio-economic or ethnic groups (Foster *et al*, 2013). Digital behaviour change studies need to ensure that they recruit representative samples which cover a wider range of education level and socio-economic status, alongside other demographics such as age and gender to avoid selection bias (Aalbers, Baars and Rikkert, 2011).

Figure 8-2: Ecological Framework (Biddle et al, 2015, permission granted from Routledge (Taylor and Francis).



8.5 Strengths and Limitations

The strengths and limitations for each study were reported separately within each relevant chapter. Overall strengths and limitations of the thesis as a whole are reported here.

The mixed methods design adopted by this thesis resulted in a variety of quantitative and qualitative data being collected to guide the development of the complex digital intervention. This is in line with the MRC guidelines for complex intervention development. The use of the intervention mapping approach allowed rigorous and in-depth development to be thoroughly documented, resulting in the development of a theoretically based intervention, once again, in line with MRC guidelines.

Importantly, this thesis demonstrates the value of bringing together expert patients with first-hand experience of living with OA, and clinical experts in the field of OA and pain management. A number of consensus meetings helped to shape the design of the prototype website. In addition, importantly, a number of issues raised during these meetings by the patient insight partners went on to guide the future acceptability work when the website was tested with potential users. The patient insight partners added additional insight from a 'lived experience' perspective about the daily struggles associated with OA. It was also useful to share each iteration of the prototype website with the patient insight partners, who provided useful input at each stage. This meant this part of development could be carried out over a relatively short period of time, and a number of iterations could be completed over just a couple of weeks. In the fast-paced world of digital technology, this speed is important.

A limitation of the project was the lack of formal heuristic evaluation with human-computer interaction (HCI) professionals. Future research should integrate this method of testing into the development phase of health interventions.

In addition, the focus on individual-level behaviour change potentially narrowed the focus of the intervention. Future iterations might benefit from widening the focus to include socioeconomic and environmental factors affecting physical activity behaviour change.

The samples recruited throughout this thesis were predominantly active, highlighting the issue of potential recruitment bias. The majority of participants in the studies reported in

chapters three, four and seven were already active, although in chapter four the sample was split and it was possible to follow a sample of non-active participants over a period of time, albeit a small one. The important finding was the significant difference of total self-efficacy score between those who were inactive or who didn't maintain an adequate level of PA, and those who increased the amount of PA to an adequate level, over a period of 7.5 months. The non-active group reported the lowest self-efficacy scores, and the 'improvers' group reported the highest change in self-efficacy score. This suggests that differences do exist between activity sub-groups, illustrating the potential benefit of increasing self-efficacy in groups who are less active.

Like other research, this project highlights the challenges of recruiting inactive participants into PA research studies (Cooke and Jones, 2017; Vandelanotte *et al.*, 2015). It is recognised that people already meeting PA recommendations are often attracted to PA interventions, even though they are typically not the target audience for such interventions (Vandelanotte *et al.*, 2015). People that are more active are known to be more responsive to PA messages than people who are less active, even in the absence of a specific intervention. With this in mind, there is a strong argument for recruiting a sample that is resistant to change in the absence of an intervention (i.e. less active people) (Dyck, Cardon and Bourdeaudhuij, 2017).

Previous studies have attempted to identify optimal recruitment processes for engaging with inactive and under-represented groups. Reviews of existing PA interventions demonstrate that current recruitment strategies tend to engage predominantly white, middle-class, middle-aged women unless they are clearly designed to target specific characteristics, such as gender or ethnicity (Cooke and Jones, 2017; Waters *et al.*, 2011). Furthermore, even those which attempted to target specific characteristics continued to achieve underrepresented levels for the remaining untargeted characteristics such as socioeconomic status (Cooke and Jones, 2017). These findings are important, as ethnic-minority, low-income, and less-educated groups often bear the highest burden of chronic disease related to physical inactivity (Waters *et al.*, 2011). Mechanisms for achieving adequate recruitment and engagement of hard-to-reach groups into sport and PA

interventions remain unclear, largely due to inadequate reporting and evaluation. (Cooke and Jones, 2017).

Exploring the difficulties and barriers experienced by those who are active, can provide insight into the potential difficulties that affect even the already active. However, it doesn't tell us if there are additional factors associated with those who are not active, and it is recognised that such issues may not be encapsulated in the sample represented in this project. The project does however, provide insights into the factors affecting the maintenance of PA in a sample of people who are already active, and indeed a large focus of this project has been on how people with OA can be motivated to maintain their level of activity over the longer term.

Given the large numbers of people with OA who are inactive, future research should focus on establishing the beliefs, attitudes, and needs of the sub-groups, which might benefit the most from PA interventions. Strategies for engaging and involving inactive participants from under-represented groups with PA research need to be further developed.

8.6 Thesis Summary

This thesis has highlighted the potential that DBCIs have to engage people with OA to become and stay active, and a greater utilisation of such interventions could take pressure off scarce NHS resources. It has illustrated the value of identifying motivational factors associated with engagement with PA, and used these findings to build the theoretical foundations of a DBCI, which attempts to foster autonomous motivation and self-efficacy for physical activity, in an OA population.

Developing DBCIs should be person-centred and iterative, using mixed methods to progressively refine them until user requirements are fully established (Mic*hie et al*, 2017). DBCIs should be based on theory, and interventions should be adequately described so that it is clear how theory is linked to content. Acceptability and usability testing with potential users prior to feasibility testing of an intervention can help to further understand how users might choose to integrate the use of DBCIs into their everyday lives.

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Appendices

Appendix A1: Search Strategy

1	'physical* activ*'
2	'active lifestyle'
3	leisure activit*
4	walk*
5	Exercis*
6	Bicycling
7	Cycling
8	Yoga
9	Pilates
10	Tai chi
11	Swimming
12	Sport*
13	Self-management
14	Self-care
15	'behaviour change'
16	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
17	Internet
18	'internet-based'
19	'computer-based'
20	'computer-delivered'
21	Digital
22	Multimedia
23	Web*
24	'Web-based'
25	e-health OR ehealth
26	Email OR e-mail
27	e-learning OR elearning
28	Online OR on-line
29	'mobile health'
30	M-health or mhealth
31	'serious games'
32	Gamification
33	17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32

34	Osteoarthritis
35	Arthritis
36	34 or 35
37	16 AND 33 AND 36

Appendix A2: Data Extraction Form – Study Design and Intervention Characteristics

Study design and participant characteristics

Author(s)	Name
Location of Study	Country
Study Design	RCT/quasi-experimental
Study Aim	1) Main Aim/Objective of the study 2) Secondary Aims/Objectives
Gender	Male/female distribution
Population	OA Pts?
Age range of participants	Age range (and mean if detailed)

Intervention features

Intervention type	e.g. educational/self-guided/human-supported/tailored (Barak, Klein and Proudfoot, 2009)
Intervention Focus	Targeted behaviour - e.g. physical activity, weight loss, diet changes
Simple or Complex Intervention	SIMPLE / COMPLEX (one component or multiple components)
Intervention Components	Details of programme content, multimedia use/choices, provision of interactive features - Any tailoring/type of tailoring - Interactive features - Barak et al? - Anything additional to internet?
Intervention tailored	YES/NO (details of how the intervention was tailored)
Theory/Model of behaviour used for intervention development	YES/NO
Theory/Model of behaviour – details (if YES above)	Details of how theory was used to select/develop intervention techniques
Behaviour change techniques used	Details of behaviour change techniques used (Link to BCT Taxonomy) (Michie *et al.*, 2013)

Primary Outcome Measure	Details of the primary outcome measure, including quality - reliability/validity of tool(s) used.
Secondary Outcome Measures	Details of secondary outcome measures, including quality - reliability/validity of tool(s) used.
Duration of intervention and assessment/follow-up points	Details of intervention duration and all assessment time-points

Intervention Results

Sample Size	Whole study and group sizes
Findings	Main statistical findings / effect sizes (including effect size at follow-up)
Number of intervention contacts	Number
Website Usage	Average log-on, average duration of log-on etc., drop-out Details of any reported attrition figures

Appendix A3: Risk of Bias Results

Risk of Bias Results (Guided by The Cochrane Collaboration's tool for assessing risk of bias) (Higgins JPT, 2011)

Allen et al (2018)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Computer generated by a statistician with stratification by recruitment source	low
Allocation Concealment	Participants given their randomisation assignment via telephone by study coordinator	low
Blinding of participants and personnel	Not blinded due to nature of the study	high
Blinding of outcome assessment	Baseline, 4 month and 12 month assessments were conducted by trained research assistants blinded (via database restrictions) to participant's randomisation assignment.	low
Incomplete outcome assessment	ITT with multiple imputation, and per protocol all reported. All outcomes fully reported	low
Selective reporting	Reported as per protocol.	low
Other sources of bias	Participants paid $30 for completion of assessments at each time point.	high

Bossen et al, 2013a (RCT)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Random assignment – method not clear	Unclear
Allocation Concealment	For concealment, a researcher not involved in data collection distributed sequentially numbered opaque sealed envelopes with allocation details.	Low
Blinding of participants and personnel	Due to the nature of the study (waiting list controlled), neither the study staff nor the participants were blinded to group allocation.	high
Blinding of outcome assessment	Due to the nature of the study (waiting list controlled), neither the study staff nor the participants were blinded to group allocation.	high
Incomplete outcome assessment	Findings were analysed using an intention-to-treat (ITT) analysis. Non-response analysis completed to compare responders and non-responders. General Estimating Equations (GEE) approach used. No imputation methods used.	Low
Selective reporting	All primary and secondary outcomes reported	Low
Other sources of bias	None identified	Low

Kloek et al, 2018 (RCT)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Randomised at level of PT practice to avoid contamination. 1:1 ratio.	low
Allocation Concealment	Computer generated, then allocation emailed to each PT practice.	low
Blinding of participants and personnel	PT therapists not blinded because they had to deliver according to randomisation (nature of study). Participants masked to the study hypothesis but not masked to comparator intervention.	High
Blinding of outcome assessment	PTs measured physical functioning objectively at baseline and after treatment (nature of study).	high
Incomplete outcome assessment	Re: missing data – no imputation methods were used. Non-response analysis performed.	low
Selective reporting	All outcomes reported. Attrition reported in all outcomes.	low
Other sources of bias	No financial incentives were offered.	low

Li et al, (2018)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Randomisation using computer generated random numbers in variable block sizes.	low
Allocation Concealment	1:1 allocation to immediate or delayed, so couldn't be blinded due to nature of the study.	high
Blinding of participants and personnel	No blinding due to nature of the study.	High
Blinding of outcome assessment	Statistician was blinded.	Low
Incomplete outcome assessment	ITT reported.	Low
Selective reporting	All outcomes reported.	low
Other sources of bias	None.	low

Lorig et al, (2006)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Randomised – but method of sequence generation not clear	Unclear
Allocation Concealment	No details present in paper	Unclear
Blinding of participants and personnel	No details present in paper	Unclear
Blinding of outcome assessment	No details present in paper	Unclear
Incomplete outcome assessment	Unclear how any missing data was handled.	Unclear
Selective reporting	All outcomes reported	Low
Other sources of bias	None identified	Low

Lorig et al, (2008b) (USA)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Paper describes that participants were randomised, but no details of sequence generation given	Unclear
Allocation Concealment	No details given regarding how participants were allocated to groups	Unclear
Blinding of participants and personnel	No details given.	Unclear
Blinding of outcome assessment	No details given.	Unclear
Incomplete outcome assessment	Intention to treat used. Last reported values used for any missing data – Last observation carried forward (LOCF).	Low
Selective reporting	All outcomes reported	Low
Other sources of bias	Control subjects were sent a $10 Amazon.com certificate for each completed questionnaire. Participants in intervention group received a copy of the Arthritis Help-Book in the mail.	High

Skrepnik et al, (2017) (USA)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	1:1 stratified by site – to intervention or control. Generated by study sponsor.	Low
Allocation Concealment	Sealed envelopes, numbered in an ascending order for use, were provided to each site. The envelopes were opened according to ascending sequence to ensure proper randomization.	Low
Blinding of participants and personnel	Open-label study - nature of the study	High
Blinding of outcome assessment	Intervention group were un-blinded to wearable data activity. Control group were blinded to wearable data activity.	High
Incomplete outcome assessment	Attrition reported. Modified intent-to-treat methods used.	Low
Selective reporting	All outcomes reported	Low
Other sources of bias	None identified	Low

Trudeau et al, (2015)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	Computer generated / Stratified block randomisation	Low
Allocation Concealment	Allocation sequence was generated by the study data manager. Research coordinator enrolled and assigned participants to conditions.	Low
Blinding of participants and personnel	No blinding after assignment to condition because all measures were self-report.	high
Blinding of outcome assessment	Unclear	Unclear
Incomplete outcome assessment	Intention to treat approach. Linear mixed models (LMM) used – accounts for missing data.	Low
Selective reporting	All outcomes reported	Low
Other sources of bias	All participants were compensated a total of $250 for completing all assessments.	High

Bossen et al, (2013b) PILOT

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	N/A	N/A
Allocation Concealment	N/A	N/A
Blinding of participants and personnel	N/A	N/A
Blinding of outcome assessment	N/A	N/A
Incomplete outcome assessment	No attrition from study, therefore all data collected and analysed successfully.	Low
Selective reporting	All outcomes are reported	Low
Other sources of bias	None identified	Low

Jaglal et al, (2013)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	N/A	N/A
Allocation Concealment	N/A	N/A
Blinding of participants and personnel	N/A	N/A
Blinding of outcome assessment	N/A	N/A
Incomplete outcome assessment	Attrition reported, but no information given on how missing data was managed.	Unclear
Selective reporting	All outcome measures reported	Low
Other sources of bias	No other sources of bias identified	Low

Lorig et al, (2008a) UK

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	N/A	N/A
Allocation Concealment	N/A	N/A
Blinding of participants and personnel	N/A	N/A
Blinding of outcome assessment	N/A	N/A
Incomplete outcome assessment	Intention to treat analyses – and Last observation carried forward (LOCF) method used. Multiple imputation methods now more acceptable.	Low
Selective reporting	No evidence of selective reporting	Low
Other sources of bias	No other sources of bias.	Low

Lorig et al, (2013)

Domain	Review authors' judgement	Risk of Bias
Random Sequence Generation	N/A	N/A
Allocation Concealment	N/A	N/A
Blinding of participants and personnel	N/A	N/A
Blinding of outcome assessment	N/A	N/A
Incomplete outcome assessment	Programming error meant that 58 participants did not complete 6 month follow-up questionnaire.	High
Selective reporting	No selective reporting identified	Low
Other sources of bias	No other source of bias identified	Low

Appendix A4: Exercise measure

The following description taken from - (Lorig *et al.*, 1996)**.**

SELF-MANAGEMENT BEHAVIOURS

Exercise

During the past week (even if it was **not** a typical week), how much **total** time (for the entire week) did you spend on each of the following? (Please circle one number for each question)

None	Less than 30 minutes/week	30-60 minutes per week	1-3 hours/week	More than 3 hours/week
0	1	2	3	4

1. Stretching or strengthening exercises (range of motion, using weights, etc)
2. Walk for exercise
3. Swimming or aquatic exercise
4. Bicycling (including stationary exercise bike)
5. Other aerobic exercise equipment (Stairmaster, rowing or skiing machine)
6. Other aerobic exercise – specify: _____
7.

Scoring: Each category is converted to the following number of minutes spent:

None	Less than 30 minutes/week	30-60 minutes per week	1-3 hours/week	More than 3 hours/week
0	15	45	120	180

Time spent in stretching or strengthening exercise is the value for item 1.
Time spent in aerobic exercise is the sum of the values for items 2 through 6.

Appendix A5: BCT Taxonomy (v1)

Electronic Supplementary Materials Table 3. BCT Taxonomy (v1): 93 hierarchically-clustered techniques

Grouping and BCTs	Grouping and BCTs	Grouping and BCTs
1. Goals and planning	**6. Comparison of behaviour**	**12. Antecedents**
1.1. Goal setting (behavior) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behavior goal(s) 1.6. Discrepancy between current behavior and goal 1.7. Review outcome goal(s) 1.8. Behavioral contract 1.9. Commitment	6.1. Demonstration of the behavior 6.2. Social comparison 6.3. Information about others' approval	12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behavior 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes
2. Feedback and monitoring	**7. Associations**	**13. Identity**
2.1. Monitoring of behavior by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behavior without feedback 2.6. Biofeedback 2.7. Feedback on outcome(s) of behavior	7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning	13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5. Identity associated with changed behavior
3. Social support	**8. Repetition and substitution**	**14. Scheduled consequences**
3.1. Social support (unspecified)	8.1. Behavioral practice/rehearsal 8.2. Behavior substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behavior 8.7. Graded tasks	14.1. Behavior cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behavior 14.8. Reward alternative behavior 14.9. Reduce reward frequency 14.10. Remove punishment
	9. Comparison of outcomes	**15. Self-belief**
	9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of future outcomes	15.1. Verbal persuasion about capability 15.2. Mental rehearsal of successful
	10. Reward and threat	
	10.1. Material incentive (behavior) 10.2. Material reward (behavior)	

3.2. Social support (practical) 3.3. Social support (emotional)	10.3. Non-specific reward 10.4. Social reward 10.5. Social incentive 10.6. Non-specific incentive 10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11. Future punishment	performance 15.3. Focus on past success 15.4. Self-talk
4. Shaping knowledge	**11. Regulation**	**16. Covert learning**
4.1. Instruction on how to perform the behavior 4.2. Information about Antecedents 4.3. Re-attribution 4.4. Behavioral experiments	11.1. Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions	16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences
5. Natural consequences		
5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.6. Information about emotional consequences		

Appendix A6: Coding of Included Interventions

Description of the Arthritis Self-Management Programme – ASMP

Papers used to code intervention = (Lorig, Ritter and Plant, 200*5; Lorig et al*, 2008b).

Description of content	Taxonomy coding	Code description
Overview of self-management principles	4.1 6.1	Instruction on how to perform the behaviour Demonstration of the behaviour
Identifying common problems among participants	1.2	Problem solving
Relaxation/cognitive techniques (for pain management) and distraction / self-talk	4.2 13.2 15.4	Information about antecedents Framing/re-framing Self-talk
Making an action plan/goal setting	1.4 1.1 1.6 2.3 2.4	Action planning Goal setting (behaviour) Discrepancy between current behaviour and goal Self-monitoring of behaviour Self-monitoring of outcome(s) of behaviour
Feedback/problem solving	2.2 2.7 1.2	Feedback on behaviour Feedback on outcome(s) of behaviour Problem solving
Dealing with negative/difficult emotions (such as fear, anger, frustration)	11.2 5.6 13.3	Reduce negative emotions Information about emotional consequences Incompatible beliefs
Exercise/fitness	4.1 5.1 8.1 6.1	Instruction on how to perform a behaviour Information about health consequences Behavioural practice/rehearsal Demonstration of the behaviour
Fatigue and energy conservation / endurance exercise / sleep	8.7 11.3 12.6	Graded tasks Conserving mental resources Body changes
Better breathing	12.6	Body changes
Muscle relaxation	12.6	Body changes
Pain and fatigue management	12.6	Body changes
Healthy eating	12.6	Body changes

Communication skills	-	
Use of medication	11.1	Pharmacological support
Making informed treatment decisions	-	
Depression management	11.2	Reduce negative emotions
Positive thinking	13.4 15.1	Valued self-identity (includes self-affirmation) Verbal persuasion about capability
Guided imagery	16.2 15.2	Imaginary reward Mental rehearsal of successful performance
Working with your healthcare professional	-	
Future plans / looking forward	1.4 1.5 1.9	Action planning Review behaviour goal(s) Commitment
The Discussion centre (web-based bulletin board discussion group)	3.1 3.3	Social support (unspecified) Social support (emotional)
Email reminders	7.1 10.4	Prompts/cues Social reward
Credible source (Stanford University)	9.1	Credible source

(cont)

Description of the Chronic Disease Self-Management Programme – CDSMP

Papers used to code intervention = (Lorig, Ritter and Plant, 2005; Lorig *et al*, 2006).

Description of content	Taxonomy coding	Code description
Overview of self-management principles	4.1 6.1	Instruction on how to perform the behaviour Demonstration of the behaviour
Identifying common problems among participants	1.2	Problem solving
Differences between acute and chronic illnesses		-
Relaxation/cognitive symptom management (for pain management) and distraction / self-talk	4.2 13.2 15.4	Information about antecedents Framing/reframing Self-talk
Making an action plan/goal setting	1.4 1.5 1.1 1.6 1.9 2.3 2.4	Action planning Review behaviour goal(s) Goal setting (behaviour) Discrepancy between current behaviour and goal Commitment Self-monitoring of behaviour Self-monitoring of outcome(s) of behaviour
Feedback / problem solving	2.2 2.7 1.2	Feedback on behaviour Feedback on outcome(s) of behaviour Problem solving
Dealing with negative/difficult emotions (such as fear, anger, frustration)	11.2 5.6 13.3	Reduce negative emotions Information about emotional consequences Incompatible beliefs
Exercise/fitness	4.1 5.1 8.1 6.1	Instruction on how to perform a behaviour Information about health consequences Behavioural practice/rehearsal Demonstration of the behaviour

Fatigue management / endurance exercise / sleep	8.7 12.6	Graded tasks Body changes
Better breathing	12.6	Body changes
Muscle relaxation	12.6	Body changes
Pain and fatigue management	12.6	Body changes
Healthy eating	12.6	Body changes
Communication skills	-	
Use of medication	11.1	Pharmacological support
Making informed treatment decisions	-	
Depression management	11.2	Reduce negative emotions
Positive thinking	13.4 15.1	Valued self-identity (includes self-affirmation) Verbal persuasion about capability
Working with your healthcare professional	-	
The Discussion centre (web-based bulletin board discussion groups)	3.1 3.3	Social support (unspecified) Social support (emotional)
Email reminders	7.1 10.4	Prompts/cues Social reward
Credible source (Stanford University)	9.1	Credible source

(cont)

Description of PainAction.com – Arthritis (Trudeau *et al.*, 2015)

Description of content	Taxonomy coding	Code description
Informational articles – chronic pain mngt / knowledge base	5.1	Information about health consequences
Self-check assessments	2.3 2.4 2.5	Self-monitoring of behaviour Self-monitoring of outcome(s) of behaviour Monitoring of outcome(s) of behaviour without feedback
Challenges of living with pain	1.4 11.2 4.1 5.4	Action planning Reduce negative emotions Instruction on how to perform a behaviour Monitoring of emotional consequences
Personal stories / anecdotal solutions	3.3 6.2 16.3	Social support (emotional) Social comparison Vicarious consequences
Communication with healthcare professionals / productive partnerships		
Self-efficacy – cognitive therapy	13.2	Framing/re-framing
Emotional support / challenge negative thinking	11.2 13.3 12.6	Reduce negative emotions Incompatible beliefs Body changes
PA – (Arthritis specific pages) • Pick a goal • Assess your current health • Moving past obstacles – time mngt, restructuring physical environment	1.1 1.3 1.4 1.5 1.6 1.9 2.3 12.1 12.2 12.6	Goal setting (behaviour) Goal setting (outcome) Action planning Review behaviour goal(s) Discrepancy between current behaviour and goal commitment Self-monitoring of behaviour Restructuring the physical environment Restructuring the social environment Body changes
Specific information about exercise	4.1 8.1 6.1	Instruction on how to perform a behaviour Behavioural practice/rehearsal Demonstration of the behaviour
Problem solving	1.2	Problem solving

Description of Join2Move/e-exercise interventions

(Bossen et al (2013), Kloek et al (2018)

Content	Description	Taxonomy coding	Code description
Educational messages	Not pain relief, but improvement of functioning is the primary goal of the treatment. Exercise and PA are recommended. The performance of PA should not depend on the amount of pain. Information about OA Information about lifestyle Dealing with negative emotions	4.1 5.1 4.1 5.1 5.3 10.4 11.2 11.3	Instruction on how to perform a behaviour Info about health consequences Instruction on how to perform a behaviour Info about health consequences Info about social/environmental consequences Social reward Reduce negative emotions Conserving mental resources
Activities	Problematic activities (maximum of 3) are selected by patients on activity list. Individually tailored exercises, to improve impairments limiting the performance of these activities, are selected.	1.2	Problem solving
Goals	For each activity and each exercise, short-term and long-term goals are set and recorded in a treatment agreement form.	1.1 1.4 1.6	Goal setting (behaviour) Action planning Discrepancy between current behaviour and goal
Baseline values	To determine baseline values, patients perform the selected activities until (pain) tolerance during 1 week and record these activities in a diary.	2.3	Self-monitoring of behaviour
Gradually increasing	An individually based scheme is made on a time-contingent basis for each activity and exercise, starting slightly under	1.4	Action planning

exercise programme	baseline values and gradually increasing towards the pre-set short-term goal. Patients should neither underperform nor over perform this gradually increasing scheme.	8.7	Graded tasks
Visual reproduction	Performance charts are used to record and visualize the performance of activities and exercises	1.5 2.3	Review behaviour goal Self-monitoring of behaviour
Reinforcement	Positive reinforcement is given towards healthy and active behaviour; pain behaviour is extinguished. (automatic emails/texts without human support)	7.1	Prompts/cues
Credible source	Netherlands Institute for Health Services Research	9.1	Credible source
Accelerometer	Use of accelerometer	2.6	Biofeedback

Description of OA GO (Skrepnik et al, 2017)

Description of content	Taxonomy coding	Code description
Log your pain	2.3	Self-monitoring of behaviour
Log your mood	2.3	Self-monitoring of behaviour
Log your steps daily	2.3	Self-monitoring of behaviour
Information/advice about finding a partner/social support	1.4 3.2 3.3	Action planning Social support (practical) Social support (emotional)
Trends/graphs of personal outcomes - logs	1.5 2.3 2.4	Review behaviour goals(s) Self-monitoring of behaviour Self-monitoring of outcome(s) of behaviour
Motivational messages – i.e. 'today you met 25% of your goals'	1.6 2.7	Discrepancy between current behaviour and goal Feedback on outcome(s) of behaviour
Goal setting	1.1 1.3	Goal setting (behaviour) Goal setting (outcome)
PA tracking/monitoring of behaviour, and comparing to goals	1.7	Review outcome goals
Set your goals 'step goals'	1.1	Goal setting
OA Education – information about the benefits of PA	5.1 5.2	Information about health consequences Salience of consequences
Motivational messages 'congratulations – you have met your goal today'	7.1	Prompts/cues
Jawbone UP 24	2.6	Biofeedback

Description of Monitor-OA (Li et al, 2018)

Description of content	Taxonomy coding	Code description
Standard education about PA Benefits of an active lifestyle Detrimental effect of sedentary behaviour Ways to be active without aggravating OA symptoms	4.1 5.1 5.1 13.3 1.2	Instruction on how to perform a behaviour. Info about health consequences Info about health consequences Incompatible beliefs Problem solving
Motivational interviewing (face-to-face)		
Brief Action Planning Including goal setting, action planning, Identify barriers and solutions SMART goal setting	1.4 1.1 13.3 1.1	Action planning Goal setting (behaviour) Incompatible beliefs Goal setting
Confidence rating – of goals	1.5	Review behaviour goal(s)
Self-monitoring	2.3	Self-monitoring of behaviour
Feedback from team / update goals/plan etc. – bi-weekly 20 min phone calls with team.	2.2	Feedback on behaviour
Fitbit flex	2.6	Biofeedback

Description of IBET (Allen et al, 2018)

Description of content	Taxonomy coding	Code description
Tailored exercise	1.4	Action planning
Progressive exercise plan, graded exercise.	1.4 8.7	Action planning Graded tasks
Online logs – to self-monitor progress	2.3 1.5	Self-monitoring of behaviour Review behavioural goal
Prescription of exercise /goal setting	1.1 1.4	Goal setting Action planning
Videos/images of exercise	4.1	Instruction on how to perform the behaviour
Automated reminders	2.2	Feedback on behaviour
Progress tracking	2.3 2.4	Self-monitoring of behaviour Self-monitoring of outcome(s) of behaviour
Graphs of pain, function, exercise over time	2.3	Self-monitoring
Educational information – OA risk factors, pathogenesis, advice about symptom management	5.1 4.1	Information about health consequences Instruction on how to perform a behaviour

Appendix B1: MPAM-R

The Scale

Motives for Physical Activities Measure – Revised (MPAM-R)

The following is a list of reasons why people engage in physical activities, sports and exercise. Keeping in mind your primary physical activity/sport, respond to each question (using the scale given), on the basis of how true that response is for you.

1	2	3	4	5	6	7
not at all true for me						very true for me

___ 1. Because I want to be physically fit.

___ 2. Because it's fun.

___ 3. Because I like engaging in activities which physically challenge me.

___ 4. Because I want to obtain new skills.

___ 5. Because I want to look or maintain weight so I look better.

___ 6. Because I want to be with my friends.

___ 7. Because I like to do this activity.

___ 8. Because I want to improve existing skills.

___ 9. Because I like the challenge.

___ 10. Because I want to define my muscles so I look better.

___ 11. Because it makes me happy.

___ 12. Because I want to keep up my current skill level.

___ 13. Because I want to have more energy

___ 14. Because I like activities which are physically challenging.

___ 15. Because I like to be with others who are interested in this activity.

___ 16. Because I want to improve my cardiovascular fitness.

___ 17. Because I want to improve my appearance.

___ 18. Because I think it's interesting.

___ 19. Because I want to maintain my physical strength to live a healthy life.

___ 20. Because I want to be attractive to others.

___ 21. Because I want to meet new people.

___ 22. Because I enjoy this activity.

___ 23. Because I want to maintain my physical health and well-being.

___ 24. Because I want to improve my body shape.

___ 25. Because I want to get better at my activity.

___ 26. Because I find this activity stimulating.

___ 27. Because I will feel physically unattractive if I don't.

___ 28. Because my friends want me to.

___ 29. Because I like the excitement of participation.

___ 30. Because I enjoy spending time with others doing this activity.

Scoring Information

Interest/Enjoyment: 2, 7, 11, 18, 22, 26, 29
Competence: 3, 4, 8, 9, 12, 14, 25
Appearance: 5, 10, 17, 20, 24, 27
Fitness: 1, 13, 16, 19, 23
Social: 6, 15, 21, 28, 30

Appendix B2: EMI-2

The Exercise Motivations Inventory - 2 (EMI-2)

On the following pages are a number of statements concerning the reasons people often give when asked why they exercise. *Whether you currently exercise regularly or not,* please read each statement carefully and indicate, by circling the appropriate number, whether or not each statement *is true* for you personally, *or would be true* for you personally if you did exercise. If you do not consider a statement to be true for you at all, circle the '0'. If you think that a statement is very true for you indeed, circle the '5'. If you think that a statement is partly true for you, then circle the '1', '2', '3' or '4', according to how strongly you feel that it reflects why you exercise or might exercise.

Remember, we want to know why *you personally* choose to exercise or might choose to exercise, not whether you think the statements are good reasons for *anybody* to exercise.

It helps us to have basic personal information about those who complete this questionnaire. We would be grateful for the following information:

Your age ..... years **Your gender ..... male/female**

		Not at all true for me					Very true for me
Personally, I exercise (or might exercise) ...							
1	To stay slim	0	1	2	3	4	5
2	To avoid ill-health	0	1	2	3	4	5
3	Because it makes me feel good	0	1	2	3	4	5
4	To help me look younger	0	1	2	3	4	5
5	To show my worth to others	0	1	2	3	4	5
6	To give me space to think	0	1	2	3	4	5

Personally, I exercise (or might exercise) …	Not at all true for me					Very true for me
7 To have a healthy body	0	1	2	3	4	5
8 To build up my strength	0	1	2	3	4	5
9 Because I enjoy the feeling of exerting myself	0	1	2	3	4	5
10 To spend time with friends	0	1	2	3	4	5
11 Because my doctor advised me to exercise	0	1	2	3	4	5
12 Because I like trying to win in physical activities	0	1	2	3	4	5
13 To stay/become more agile	0	1	2	3	4	5
14 To give me goals to work towards	0	1	2	3	4	5
15 To lose weight	0	1	2	3	4	5
16 To prevent health problems	0	1	2	3	4	5
17 Because I find exercise invigorating	0	1	2	3	4	5
18 To have a good body	0	1	2	3	4	5
19 To compare my abilities with other peoples'	0	1	2	3	4	5
20 Because it helps to reduce tension	0	1	2	3	4	5
21 Because I want to maintain good health	0	1	2	3	4	5
22 To increase my endurance	0	1	2	3	4	5
23 Because I find exercising satisfying in and of itself	0	1	2	3	4	5

		Not at all true for me					Very true for me
Personally, I exercise (or might exercise) …							
24	To enjoy the social aspects of exercising	0	1	2	3	4	5
25	To help prevent an illness that runs in my family	0	1	2	3	4	5
26	Because I enjoy competing	0	1	2	3	4	5
27	To maintain flexibility	0	1	2	3	4	5
28	To give me personal challenges to face	0	1	2	3	4	5
29	To help control my weight	0	1	2	3	4	5
30	To avoid heart disease	0	1	2	3	4	5
31	To recharge my batteries	0	1	2	3	4	5
32	To improve my appearance	0	1	2	3	4	5
33	To gain recognition for my accomplishments	0	1	2	3	4	5
34	To help manage stress	0	1	2	3	4	5
35	To feel more healthy	0	1	2	3	4	5
36	To get stronger	0	1	2	3	4	5
37	For enjoyment of the experience of exercising	0	1	2	3	4	5
38	To have fun being active with other people	0	1	2	3	4	5

Please Turn Over

	Not at all true for me					Very true for me
Personally, I exercise (or might exercise) …						
39 To help recover from an illness/injury	0	1	2	3	4	5
40 Because I enjoy physical competition	0	1	2	3	4	5
41 To stay/become flexible	0	1	2	3	4	5
42 To develop personal skills	0	1	2	3	4	5
43 Because exercise helps me to burn calories	0	1	2	3	4	5
44 To look more attractive	0	1	2	3	4	5
45 To accomplish things that others are incapable of	0	1	2	3	4	5
46 To release tension	0	1	2	3	4	5
47 To develop my muscles	0	1	2	3	4	5
48 Because I feel at my best when exercising	0	1	2	3	4	5
49 To make new friends	0	1	2	3	4	5
50 Because I find physical activities fun, especially when competition is involved	0	1	2	3	4	5
51 To measure myself against personal standards	0	1	2	3	4	5

Thank you for completing this questionnaire

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January 1997

Appendix B3: EMGI Questionnaire

EMGI layout 1

(Motives Section)

What Are Your Reasons for Exercising?

On the following pages are a number of statements concerning the reasons people often give when asked why they exercise. *Whether you currently exercise regularly or not,* please read each statement carefully and indicate, by circling the appropriate number, whether or not each statement *is true* for you personally, *or would be true* for you personally if you did exercise. If you do not consider a statement to be true for you at all, circle the '0'. If you think that a statement is very true for you indeed, circle the '5'. If you think that a statement is partly true for you, then circle the '1', '2', '3' or '4', according to how strongly you feel that it reflects why you exercise or might exercise.

Remember, we want to know why *you personally* choose to exercise or might choose to exercise, not whether you think the statements are good reasons for *anybody* to exercise.

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
1.	To stay slim	0	1	2	3	4
2.	To avoid ill-health	0	1	2	3	4
3.	Because it makes me feel good	0	1	2	3	4
4.	To help me look younger	0	1	2	3	4
5.	To show my worth to others	0	1	2	3	4
6.	To give me space to think	0	1	2	3	4
7.	To have a healthy body	0	1	2	3	4
8.	To build up my strength	0	1	2	3	4
9.	Because I enjoy the feeling of exerting myself	0	1	2	3	4
10.	To spend time with friends	0	1	2	3	4
11.	Because my doctor advised me to exercise	0	1	2	3	4
12.	Because I like trying to win in physical activities	0	1	2	3	4
13.	To stay/become more agile	0	1	2	3	4
14.	To give me goals to work towards	0	1	2	3	4
15.	To lose weight	0	1	2	3	4
16.	To prevent health problems	0	1	2	3	4
17.	Because I find exercise invigorating	0	1	2	3	4
18.	To have a good body	0	1	2	3	4
19.	To compare my abilities with other peoples'	0	1	2	3	4
20.	Because it helps to reduce tension	0	1	2	3	4
21.	Because I want to maintain good health	0	1	2	3	4
22.	To increase my endurance	0	1	2	3	4
23.	Because I find exercising satisfying in and of itself	0	1	2	3	4

EMGI layout 2

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
24.	To enjoy the social aspects of exercising	0	1	2	3	4
25.	To help prevent an illness that runs in my family	0	1	2	3	4
26.	Because I enjoy competing	0	1	2	3	4
27.	To maintain flexibility	0	1	2	3	4
28.	To give me personal challenges to face	0	1	2	3	4
29.	To help control my weight	0	1	2	3	4
30.	To avoid heart disease	0	1	2	3	4
31.	To recharge my batteries	0	1	2	3	4
32.	To improve my appearance	0	1	2	3	4
33.	To gain recognition for my accomplishments	0	1	2	3	4
34.	To help manage stress	0	1	2	3	4
35.	To feel more healthy	0	1	2	3	4
36.	To get stronger	0	1	2	3	4
37.	For enjoyment of the experience of exercising	0	1	2	3	4
38.	To have fun being active with other people	0	1	2	3	4
39.	To help recover from an illness/injury	0	1	2	3	4
40.	Because I enjoy physical competition	0	1	2	3	4
41.	To stay/become flexible	0	1	2	3	4
42.	To develop personal skills	0	1	2	3	4
43.	Because exercise helps me to burn calories	0	1	2	3	4
44.	To look more attractive	0	1	2	3	4
45.	To accomplish things that others are incapable of	0	1	2	3	4
46.	To release tension	0	1	2	3	4
47.	To develop my muscles	0	1	2	3	4
48.	Because I feel at my best when exercising	0	1	2	3	4
49.	To make new friends	0	1	2	3	4
50.	Because I find physical activities fun, especially when competition is involved	0	1	2	3	4
51.	To measure myself against personal standards	0	1	2	3	4

EMGI layout 3

A filler (questionnaire, interview, other activity, passage of time) should be included between the motives and gains sections.

EMGI layout 4

(Gains Section)

What Have You Actually Gained From Exercise?

This section of the questionnaire can only be completed by people who have some current or recent experience of exercise. So if you have not exercised within the last twelve months, please just put a cross here and skip this section ☐

The questions are about what you have actually gained from exercise. This may be the same or different from what you originally wanted or hoped to gain. Please tell us your personal experience of exercise using the following scale:

0 = Not at all true for me
2 = Somewhat true for me
4 = Very true for me

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
1.	I have lost weight through exercising	0	1	2	3	4
2.	I have found the experience of exercising enjoyable	0	1	2	3	4
3.	I have been able to develop personal skills	0	1	2	3	4
4.	I have found exercising satisfying in and of itself	0	1	2	3	4
5.	I have stayed/become more agile through exercise	0	1	2	3	4
6.	It has allowed me to accomplish things that others are incapable of	0	1	2	3	4
7.	It has helped me to maintain flexibility	0	1	2	3	4
8.	I have found physical activities fun, especially when competition was involved	0	1	2	3	4
9.	I have made new friends through exercise	0	1	2	3	4
10.	It has helped me to have a better body	0	1	2	3	4
11.	It has helped me to get stronger	0	1	2	3	4
12.	It has enabled me to stay slim	0	1	2	3	4
13.	It has given me personal challenges to face	0	1	2	3	4
14.	I have felt at my best when exercising	0	1	2	3	4
15.	It has reduced my risk of heart disease	0	1	2	3	4
16.	It has helped me to reduce tension	0	1	2	3	4
17.	I have followed my doctor's advice by exercising	0	1	2	3	4
18.	I have been able to enjoy competing	0	1	2	3	4
19.	It has helped me to have a healthy body	0	1	2	3	4
20.	I have been able to develop my muscles	0	1	2	3	4
21.	I have been able to manage stress through exercising	0	1	2	3	4

EMGI layout 5

	My personal experience of exercise has been that ...	Not at all true for me				Very true for me
22.	I have increased my endurance	0	1	2	3	4
23.	I have been able to stay/become flexible	0	1	2	3	4
24.	I have been able to avoid ill-health	0	1	2	3	4
25.	It has allowed me to compare my abilities with other peoples'	0	1	2	3	4
26.	It has given me space to think	0	1	2	3	4
27.	It has allowed me to spend time with friends	0	1	2	3	4
28.	It has helped me to look more attractive	0	1	2	3	4
29.	It has given me goals to work towards	0	1	2	3	4
30.	I have built up my strength through exercising	0	1	2	3	4
31.	It has allowed me to measure myself against personal standards	0	1	2	3	4
32.	I have been able to enjoy physical competition	0	1	2	3	4
33.	It has helped me to maintain good health	0	1	2	3	4
34.	I have been able to prevent health problems	0	1	2	3	4
35.	I have liked trying to win in physical activities	0	1	2	3	4
36.	It has helped control my weight	0	1	2	3	4
37.	It has helped me to recharge my batteries	0	1	2	3	4
38.	It has helped me to recover from an illness/injury	0	1	2	3	4
39.	I have felt more healthy	0	1	2	3	4
40.	I have had fun being active with other people	0	1	2	3	4
41.	I have gained recognition for my accomplishments	0	1	2	3	4
42.	I have been able to improve my appearance	0	1	2	3	4
43.	I have been able to show my worth to others	0	1	2	3	4
44.	I have released tension by exercising	0	1	2	3	4
45.	I have felt good through exercising	0	1	2	3	4
46.	It has helped me to burn calories	0	1	2	3	4
47.	I have enjoyed the feeling of exerting myself	0	1	2	3	4
48.	It has helped me to look younger	0	1	2	3	4
49.	It has helped reduce the risk of an illness that runs in my family	0	1	2	3	4
50.	I have found exercise invigorating	0	1	2	3	4
51.	I have enjoyed the social aspects of exercising	0	1	2	3	4

Appendix B4: Arthritis Self-Efficacy Scale

STANFORD
PATIENT EDUCATION
RESEARCH CENTER

Arthritis Self-Efficacy

For each of the following questions, please circle the number that corresponds to how certain you are that you can do the following tasks regularly at the present time.

Self-Efficacy Pain Scale (may be combined with Other Symptoms Scale)

1. How certain are you that you can decrease your pain **quite a bit**?

2. How certain are you that you can continue most of your daily activities?

3. How certain are you that you can keep arthritis pain from interfering with your sleep?

4. How certain are you that you can that you can make a **small-to-moderate** reduction in your arthritis pain by using methods other than taking extra medication?

5. How certain are you that you can make a **large** reduction in your arthritis pain by using methods other than taking extra medication?

very uncertain	1	2	3	4	5	6	7	8	9	10 very certain

Self-Efficacy Function Scale

1. How certain are you that you can walk 100 feet on flat ground in 20 seconds?

2. How certain are you that you can that you can walk 10 steps downstairs in 7 seconds?

3. How certain are you that you can get out of an armless chair quickly, without using your hands for support?

4. How certain are you that you can

very uncertain	1	2	3	4	5	6	7	8	9	10 very certain

1

button and unbutton 3 medium-size buttons in a row in 12 seconds?

uncertain 1 2 3 4 5 6 7 8 9 10 certain

5. How certain are you that you can cut 2 bite-size pieces of meat with a knife and fork in 8 seconds?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

6. How certain are you that you can turn an outdoor faucet all the way on and all the way off?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

7. How certain are you that you can scratch your upper back with both your right and left hands?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

8. How certain are you that you can get in and out of the passenger side of a car without assistance from another person and without physical aids?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

9. How certain are you that you can put on a long-sleeve front-opening shirt or blouse (without buttoning) in 8 seconds?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

Self-Efficacy Other Symptoms Scale (may be combined with Pain Scale)

1. How certain are you that you can control your fatigue?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

2. How certain are you that you can regulate your activity so as to be active without aggravating your arthritis?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

3. How certain are you that you can do something to help yourself feel better if you are feeling blue?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

4. As compared with other people with arthritis like yours, how certain are you that you can manage arthritis pain during your daily activities?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

5. How certain are you that you can manage your arthritis symptoms so that you can do the things you enjoy doing?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

6. How certain are you that you can deal with the frustration of arthritis?

very uncertain 1 2 3 4 5 6 7 8 9 10 very certain

2

Appendix B5: ESE Questionnaire

For each statement below, circle the statement that most accurately reflects your opinion.

1. Self-Efficacy for Exercise

If I want to exercise, I know I can do it	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
I'm not sure I could exercise regularly, even if I wanted to	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
I feel unsure about my ability to exercise	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
A person with medical problems like mine cannot exercise regularly	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

2. Barriers to Exercise

Exercise takes too much time	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is a waste of time	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Exercise is boring	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

3. Benefits of Exercise

Exercise helps people feel more attractive	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise makes people feel good physically and emotionally	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Exercise can help lift one's spirits	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise gives a person more energy	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise helps people manage their problems better	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

4. The impact of exercise on arthritis

Regular exercise will probably make my arthritis worse in the future	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis who exercise will remain more independent	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis should be encouraged to exercise regularly	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is dangerous for people with arthritis	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise causes too much pain to be helpful	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise causes arthritis flare-ups	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis who exercise are healthier	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is a way to lessen the impact of arthritis	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Appendix B6: ESE Scoring Key

Exercise self-efficacy scale

For each statement below, circle the statement that most accurately reflects your opinion

1. Self-Efficacy for Exercise

If I want to exercise, I know I can do it	**1**	**2**	**3**	**4**	**5**
I'm not sure I could exercise regularly, even if I wanted to	**5**	**4**	**3**	**2**	**1**
I feel unsure about my ability to exercise	**5**	**4**	**3**	**2**	**1**
A person with medical problems like mine cannot exercise regularly	**5**	**4**	**3**	**2**	**1**

2. Barriers to Exercise

Exercise takes too much time	**5**	**4**	**3**	**2**	**1**
Exercise is a waste of time	**5**	**4**	**3**	**2**	**1**
Exercise is boring	**5**	**4**	**3**	**2**	**1**

3. Benefits of Exercise

Exercise helps people feel more attractive	**1**	**2**	**3**	**4**	**5**
Exercise makes people feel good physically and emotionally	**1**	**2**	**3**	**4**	**5**

Exercise can help lift one's spirits	**1**	**2**	**3**	**4**	**5**
Exercise gives a person more energy	**1**	**2**	**3**	**4**	**5**
Exercise helps people manage their problems better	**1**	**2**	**3**	**4**	**5**

4. The impact of exercise on arthritis

Regular exercise will probably make my arthritis worse in the future	**5**	**4**	**3**	**2**	**1**
People with arthritis who exercise will remain more independent	**1**	**2**	**3**	**4**	**5**
People with arthritis should be encouraged to exercise regularly	**1**	**2**	**3**	**4**	**5**
Exercise is dangerous for people with arthritis	**5**	**4**	**3**	**2**	**1**
Exercise causes too much pain to be helpful	**5**	**4**	**3**	**2**	**1**
Exercise causes arthritis flare-ups	**5**	**4**	**3**	**2**	**1**
People with arthritis who exercise are healthier	**1**	**2**	**3**	**4**	**5**
Exercise is a way to lessen the impact of arthritis	**1**	**2**	**3**	**4**	**5**

Appendix B7: Invitation Letter

University of the West of England
BRISTOL

RESEARCH STUDY

What motivates people with osteoarthritis to do exercise?

Invitation Letter

Dear Sir/Madam,

We are writing to invite you to take part in a research study. You previously gave your consent to be contacted about future research, following your participation in the Facilitating Activity and Self-management in Arthritis (FASA) Study run by Dr. Nicola Walsh here at the University of the West of England.

We are investigating what motivates people with osteoarthritis to take part in physical activity and exercise. This study will only involve the completion of a questionnaire.

You will find more information about this study in the enclosed Patient Information Sheet. If you decide that you would be happy to take part, simply complete the questionnaire and return it to us in the enclosed pre-paid envelope. If you are unwilling or unable to participate then we apologise for any inconvenience, and will not contact you again regarding this study.

We ask that you return the questionnaire to us within the next 2-3 weeks if possible.

If you have any questions about taking part, or any other queries about why you have received this letter, please feel free to contact me: Alice Berry on 0117 3288796.

Thank you for your consideration,

Alice Berry
PhD Student
(Supervisors: Professor Candy McCabe,
Dr. Nicola Walsh, Dr. Sarah Muir)
Faculty of Health and Applied Sciences
University of the West of England
Glenside Campus, Blackberry Hill,
Bristol, BS16 1DD
Telephone: 0117 3288796 / Email: alice.berry@uwe.ac.uk

Appendix B8: Participant Information Sheet

University of the West of England
BRISTOL

RESEARCH STUDY

What motivates people with osteoarthritis to do exercise?

Participant Information Sheet

We would like to invite you to take part in a research study which is being conducted by the University of the West of England in Bristol. Before you decide to take part, we would like to explain why we are carrying out this study, and what it involves.

Please take some time to read this information sheet carefully and discuss it with other people if you wish.

Thank you for reading this information.

If you would like more information, or for any queries please contact:
Alice Berry on 0117 3288796 / alice.berry@uwe.ac.uk

What is the purpose of the study?

The purpose of this study is to find out more about what motivates people with osteoarthritis to take part in physical activity and exercise. We know that physical activity can help to ease some of the symptoms associated with osteoarthritis such as pain and stiffness, yet many people with osteoarthritis are not physically active. We want to find out more about what factors influence whether or not people with osteoarthritis are physically active.

Why have I been invited?

We are asking people who have osteoarthritis to take part in this study. You have been invited because you took part in a previous study led by Dr. Nicola Walsh - Facilitating Activity and Self-management in Arthritis (FASA) conducted here at the University of the West of England. At that time you agreed that we could contact you about any future research projects.

Do I have to take part?

It is entirely up to you if you would like to take part in the study. You do not have to take part, and we will not contact you further about this project if you do not return this questionnaire.

Once a completed questionnaire is returned the information can no longer be withdrawn, as there will be no identifiable data linking personal details to data.

What is involved if I decide to take part?

We will ask you to complete a questionnaire (included in this pack) about being physically active and the factors that affect whether or not you are active. The questionnaire is designed to be completed whether you are currently active or not, so it does not matter if you are currently inactive.

The questionnaire asks about the reasons why you may or may not be physically active. It also asks about your beliefs and opinions about physical activity, and how being physically active might affect your osteoarthritis. There are further instructions within the questionnaire, explaining which parts to complete depending on if you are currently active or not.

It is expected that the questionnaire will take around 15-20 minutes to complete.

Will my personal details be kept safe?

Yes. All of the information collected in the questionnaire will be kept completely confidential at all times. All information will be held securely on University computers. Data will be anonymised and no personal details will be included in any reports or presentations about the study.

Are there any benefits or disadvantages in taking part?

The benefit of taking part is that you will help us to gain knowledge about the different factors that affect levels of physical activity in people with osteoarthritis. The findings will help us to gain a greater understanding of this area, guiding both clinicians and researchers towards better management for osteoarthritis.

The only disadvantage to this study is the time it will take to complete the questionnaire. We anticipate, however, that the questionnaire should not take more than 20 minutes to complete.

What will happen to the results of the study?

At the end of the study the results will be published in appropriate scientific journals and presented at conferences. You will not be identified in any publication or presentation.

This study is the first phase of a larger project being completed as part of a PhD award at the University of the West of England. The second phase of the project will involve the design and testing of an internet-based programme for people with osteoarthritis to help them to remain physically active in the long-term. Data gathered from the questionnaires will go on to inform the second phase of the study.

Who is organising and funding this research study?

This research study is being organised and funded by the University of the West of England as part of a PhD project. The quality of this project has been reviewed and approved by the Faculty's Research Degree Committee at the University of the West of England.

What happens next?

If you have read all of the above information and you would like to take part, simply complete the questionnaire which is enclosed in this pack. You will also find a pre-paid envelope which you can use to return the questionnaire to us.

STUDY OVERVIEW

PURPOSE

To find out more about what motivates people to do exercise when they have osteoarthritis.

WHAT DOES IT INVOLVE?

Completion of the enclosed questionnaire, and return using the pre-paid envelope.

If you would like more information, or for any queries please contact either:

Alice Berry on 0117 3288796 / alice.berry@uwe.ac.uk

(Blue Lodge, University of the West of England, Glenside Campus, Blackberry Hill, Bristol, BS16 1DD)

Thank you for taking the time to read this information sheet

Appendix B9: Study Questionnaire

University of the West of England
BRISTOL

RESEARCH STUDY

What motivates people with osteoarthritis to do exercise?

Questionnaire

TODAY'S DATE:_____ (dd/mm/yyyy)

INFORMED CONSENT: Please INITIAL each box to confirm you are happy to take part in the study.

Please INITIAL box

1. I confirm that I have read and understand the information sheet (V4 23-07-15) for the above study and have had the opportunity to ask questions and these have been answered to my satisfaction. ☐

2. I understand that my participation in this study is voluntary. ☐

3. I agree to participate in this study. ☐

1998 Data Protection Act, Consent to Process Personal Information

The personal information collected on this questionnaire will be processed by the University in accordance with the terms and conditions of the 1998 Data Protection Act.

We will hold your data securely and not make it available to any third party unless permitted or required to do so by law.

Any data produced from the questionnaire will be completely anonymous. All data will be analysed and downloaded on a password protected computer at the University of the West of England. Back-up copies of electronic data will be made regularly onto a password protected CD. All source documents will be retained for a period of 5 years following the end of the study.

I agree to the University processing my personal data as described above

☐ *Please tick box*

About you:

1) Are you (please circle)	Male	Female

2) What is your date of birth?							

3) What is your postcode?							

4) Are you (please circle)	Single Married/partner Divorced/separated Widowed Other

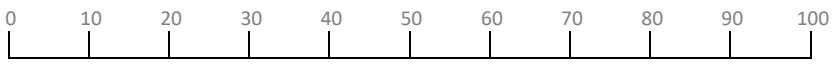
5) What is the highest level of education you have completed? (please circle)	GCSEs or equivalent College diploma or equivalent University degree or equivalent Post-graduate qualification None

5) Do you suffer from any of the following conditions? (please circle)	Diabetes Heart disease Hypertension Lung disease Mental health condition Other _____

6) How long have you had osteoarthritis?	_____ (years)

7) How would you rate your osteoarthritis? (Please draw a line on the scale below)

Mild Severe



What is physical activity? - For the purposes of this questionnaire we use the following definition to cover both terms 'physical activity' and 'exercise':

Physical activity includes all forms of activity, such as everyday walking or cycling to get from A to B, work-related activity, active recreational activities (such as going to the gym), dancing, gardening or playing active games, as well as organised and competitive sport.

Examples: Swimming, brisk walking, range of motion exercises, exercise classes, cycling, dancing, tai chi, or gardening.

Note: This can include any exercises you may have been given to do by a healthcare professional.

What Are Your Reasons for Exercising?

On the following pages are a number of statements concerning the reasons people often give when asked why they exercise. ***Whether you currently exercise regularly or not,*** please read each statement carefully and indicate, by circling the appropriate number, whether or not each statement ***is true*** for you personally, ***or would be true*** for you personally if you did exercise. If you do not consider a statement to be true for you at all, circle the '0'. If you think that a statement is very true for you indeed, circle the '5'. If you think that a statement is partly true for you, then circle the '1', '2', '3' or '4', according to how strongly you feel that it reflects why you exercise or might exercise.

Remember, we want to know why ***you personally*** choose to exercise or might choose to exercise, not whether you think the statements are good reasons for *anybody* to exercise.

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
1.	To stay slim	0	1	2	3	4
2.	To avoid ill-health	0	1	2	3	4
3.	Because it makes me feel good	0	1	2	3	4
4.	To help me look younger	0	1	2	3	4
5.	To show my worth to others	0	1	2	3	4
6.	To give me space to think	0	1	2	3	4
7.	To have a healthy body	0	1	2	3	4
8.	To build up my strength	0	1	2	3	4

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
9.	Because I enjoy the feeling of exerting myself	0	1	2	3	4
10.	To spend time with friends	0	1	2	3	4
11.	Because my doctor advised me to exercise	0	1	2	3	4
12.	Because I like trying to win in physical activities	0	1	2	3	4
13.	To stay/become more agile	0	1	2	3	4
14.	To give me goals to work towards	0	1	2	3	4
15.	To lose weight	0	1	2	3	4
16.	To prevent health problems	0	1	2	3	4
17.	Because I find exercise invigorating	0	1	2	3	4
18.	To have a good body	0	1	2	3	4
19.	To compare my abilities with other peoples'	0	1	2	3	4
20.	Because it helps to reduce tension	0	1	2	3	4

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
21.	Because I want to maintain good health	0	1	2	3	4
22.	To increase my endurance	0	1	2	3	4
23.	Because I find exercising satisfying in and of itself	0	1	2	3	4
24.	To enjoy the social aspects of exercising	0	1	2	3	4
25.	To help prevent an illness that runs in my family	0	1	2	3	4
26.	Because I enjoy competing	0	1	2	3	4
27.	To maintain flexibility	0	1	2	3	4
28.	To give me personal challenges to face	0	1	2	3	4
29.	To help control my weight	0	1	2	3	4
30.	To avoid heart disease	0	1	2	3	4
31.	To recharge my batteries	0	1	2	3	4
32.	To improve my appearance	0	1	2	3	4

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
33.	To gain recognition for my accomplishments	0	1	2	3	4
34.	To help manage stress	0	1	2	3	4
35.	To feel more healthy	0	1	2	3	4
36.	To get stronger	0	1	2	3	4
37.	For enjoyment of the experience of exercising	0	1	2	3	4
38.	To have fun being active with other people	0	1	2	3	4
39.	To help recover from an illness/injury	0	1	2	3	4
40.	Because I enjoy physical competition	0	1	2	3	4
41.	To stay/become flexible	0	1	2	3	4
42.	To develop personal skills	0	1	2	3	4
43.	Because exercise helps me to burn calories	0	1	2	3	4
44.	To look more attractive	0	1	2	3	4

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
45.	To accomplish things that others are incapable of	0	1	2	3	4
46.	To release tension	0	1	2	3	4
47.	To develop my muscles	0	1	2	3	4
48.	Because I feel at my best when exercising	0	1	2	3	4
49.	To make new friends	0	1	2	3	4
50.	Because I find physical activities fun, especially when competition is involved	0	1	2	3	4
51.	To measure myself against personal standards	0	1	2	3	4

If you **DO NOT** currently participate in physical activity, please answer the following question:

How long has it been since you did ***regular*** physical activity or exercise? (please circle)

h) Less than 6 months
i) More than 6 months but less than 1 year
j) More than 1 year but less than 2 years
k) More than 2 years but less than 5 years
l) More than 5 years but less than 10 years
m) More than 10 years
n) I have never been regularly physically active

If you **DO** currently participate in physical activity, answer the following questions:

5) How many days per week are you physically active? (circle/days) 1 2 3 4 5 6 7
6) Approximately how long each day (minutes)? _____ mins
7) How long have you been physically active at this level? (please circle)
    g) Less than 6 months
    h) More than 6 months but less than 1 year
    i) More than 1 year but less than 2 years
    j) More than 2 years but less than 5 years
    k) More than 5 years but less than 10 years
    l) More than 10 years

8) What activities do you do? (please circle all that apply)
    k) Walking
    l) Swimming
    m) Cycling
    n) Gym
    o) Exercise classes
    p) Dancing
    q) Gardening
    r) Tai Chi
    s) Exercises from a healthcare professional
    t) Other (please state)
    _____

For each statement below, circle the statement that most accurately reflects your opinion.

Self-Efficacy for Exercise

If I want to exercise, I know I can do it	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
I'm not sure I could exercise regularly, even if I wanted to	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
I feel unsure about my ability to exercise	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
A person with medical problems like mine cannot exercise regularly	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Barriers to Exercise

Exercise takes too much time	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is a waste of time	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is boring	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Benefits of Exercise

Exercise helps people feel more attractive	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise makes people feel good physically and emotionally	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise can help lift one's spirits	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Exercise gives a person more energy	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise helps people manage their problems better	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

The impact of exercise on arthritis

Regular exercise will probably make my arthritis worse in the future	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis who exercise will remain more independent	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis should be encouraged to exercise regularly	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is dangerous for people with arthritis	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise causes too much pain to be helpful	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise causes arthritis flare-ups	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis who exercise are healthier	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is a way to lessen the impact of arthritis	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

(continues on next page)

What Have You Actually Gained From Exercise?

This section of the questionnaire can only be completed by people who have some current or recent experience of exercise. So if you have not exercised within the last twelve months, please just put a cross here and skip this section ☐

The questions are about what you have actually gained from exercise. This may be the same or different from what you originally wanted or hoped to gain. Please tell us your personal experience of exercise using the following scale:

0 = Not at all true for me, 2 = Somewhat true for me, 4 = Very true for me

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
1.	I have lost weight through exercising	0	1	2	3	4
2.	I have found the experience of exercising enjoyable	0	1	2	3	4
3.	I have been able to develop personal skills	0	1	2	3	4
4.	I have found exercising satisfying in and of itself	0	1	2	3	4
5.	I have stayed/become more agile through exercise	0	1	2	3	4
6.	It has allowed me to accomplish things that others are incapable of	0	1	2	3	4
7.	It has helped me to maintain flexibility	0	1	2	3	4
8.	I have found physical activities fun, especially when competition was involved	0	1	2	3	4

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
9.	I have made new friends through exercise	0	1	2	3	4
10.	It has helped me to have a better body	0	1	2	3	4
11.	It has helped me to get stronger	0	1	2	3	4
12.	It has enabled me to stay slim	0	1	2	3	4
13.	It has given me personal challenges to face	0	1	2	3	4
14.	I have felt at my best when exercising	0	1	2	3	4
15.	It has reduced my risk of heart disease	0	1	2	3	4
16.	It has helped me to reduce tension	0	1	2	3	4
17.	I have followed my doctor's advice by exercising	0	1	2	3	4
18.	I have been able to enjoy competing	0	1	2	3	4
19.	It has helped me to have a healthy body	0	1	2	3	4
20.	I have been able to develop my muscles	0	1	2	3	4

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
21.	I have been able to manage stress through exercising	0	1	2	3	4
22.	I have increased my endurance	0	1	2	3	4
23.	I have been able to stay/become flexible	0	1	2	3	4
24.	I have been able to avoid ill-health	0	1	2	3	4
25.	It has allowed me to compare my abilities with other peoples'	0	1	2	3	4
26.	It has given me space to think	0	1	2	3	4
27.	It has allowed me to spend time with friends	0	1	2	3	4
28.	It has helped me to look more attractive	0	1	2	3	4
29.	It has given me goals to work towards	0	1	2	3	4
30.	I have built up my strength through exercising	0	1	2	3	4
31.	It has allowed me to measure myself against personal standards	0	1	2	3	4
32.	I have been able to enjoy physical competition	0	1	2	3	4

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
33.	It has helped me to maintain good health	0	1	2	3	4
34.	I have been able to prevent health problems	0	1	2	3	4
35.	I have liked trying to win in physical activities	0	1	2	3	4
36.	It has helped control my weight	0	1	2	3	4
37.	It has helped me to recharge my batteries	0	1	2	3	4
38.	It has helped me to recover from an illness/injury	0	1	2	3	4
39.	I have felt more healthy	0	1	2	3	4
40.	I have had fun being active with other people	0	1	2	3	4
41.	I have gained recognition for my accomplishments	0	1	2	3	4
42.	I have been able to improve my appearance	0	1	2	3	4
43.	I have been able to show my worth to others	0	1	2	3	4
44.	I have released tension by exercising	0	1	2	3	4

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
45.	I have felt good through exercising	0	1	2	3	4
46.	It has helped me to burn calories	0	1	2	3	4
47.	I have enjoyed the feeling of exerting myself	0	1	2	3	4
48.	It has helped me to look younger	0	1	2	3	4
49.	It has helped reduce the risk of an illness that runs in my family	0	1	2	3	4
50.	I have found exercise invigorating	0	1	2	3	4
51.	I have enjoyed the social aspects of exercising	0	1	2	3	4

Thank you

THIS IS THE END OF THE QUESTIONNAIRE

We would like to contact you again to see if you would like to take part in future stages of this project. If you are happy to be contacted by a member of the research team, please fill in your details below **(Please note: this is optional).**

Name: _____

Address:

_____

_____

_____

Email address:

_____

Please RETURN this completed questionnaire to us in the pre-paid envelope

Appendix B10: Online Advert

Appendix B11: EMGI Scoring

EMGI motive and gain items 1

Concept	Motive items	Gain items
Affiliation	10. To spend time with friends	27. It has allowed me to spend time with friends
	24. To enjoy the social aspects of exercising	51. I have enjoyed the social aspects of exercising
	38. To have fun being active with other people	40. I have had fun being active with other people
	49. To make new friends	9. I have made new friends through exercise
Appearance	4. To help me look younger	48. It has helped me to look younger
	18. To have a good body	10. It has helped me to have a better body
	32. To improve my appearance	42. I have been able to improve my appearance
	44. To look more attractive	28. It has helped me to look more attractive
Challenge	14. To give me goals to work towards	29. It has given me goals to work towards
	28. To give me personal challenges to face	13. It has given me personal challenges to face
	42. To develop personal skills	3. I have been able to develop personal skills
	51. To measure myself against personal standards	31. It has allowed me to measure myself against personal standards
Competition	12. Because I like trying to win in physical activities	35. I have liked trying to win in physical activities
	26. Because I enjoy competing	18. I have been able to enjoy competing
	40. Because I enjoy physical competition	32. I have been able to enjoy physical competition
	50. Because I find physical activities fun, especially when competition is involved	8. I have found physical activities fun, especially when competition was involved
Enjoyment	9. Because I enjoy the feeling of exerting myself	47. I have enjoyed the feeling of exerting myself
	23. Because I find exercising satisfying in and of itself	4. I have found exercising satisfying in and of itself
	37. For enjoyment of the experience of exercising	2. I have found the experience of exercising enjoyable
	48. Because I feel at my best when exercising	14. I have felt at my best when exercising

EMGI motive and gain items 2

Concept	Motive items	Gain items
Health Pressures	11. Because my doctor advised me to exercise	17. I have followed my doctor's advice by exercising
	25. To help prevent an illness that runs in my family	49. It has helped reduce the risk of an illness that runs in my family
	39. To help recover from an illness/injury	38. It has helped me to recover from an illness/injury
Ill Health Avoidance	2. To avoid ill-health	24. I have been able to avoid ill-health
	16. To prevent health problems	34. I have been able to prevent health problems
	30. To avoid heart disease	15. It has reduced my risk of heart disease
Nimbleness	13. To stay/become more agile	5. I have stayed/become more agile through exercise.
	27. To maintain flexibility	7. It has helped me to maintain flexibility
	41. To stay/become flexible	23. I have been able to stay/become flexible
Positive Health	7. To have a healthy body	19. It has helped me to have a healthy body
	21. Because I want to maintain good health	33. It has helped me to maintain good health
	35. To feel more healthy	39. I have felt more healthy
Revitalisation	3. Because it makes me feel good	45. I have felt good through exercising
	17. Because I find exercise invigorating	50. I have found exercise invigorating
	31. To recharge my batteries	37. It has helped me to recharge my batteries
Stress Management	6. To give me space to think	26. It has given me space to think
	20. Because it helps to reduce tension	16. It has helped me to reduce tension
	34. To help manage stress	21. I have been able to manage stress through exercising
	46. To release tension	44. I have released tension by exercising
Social Recognition	5. To show my worth to others	43. I have been able to show my worth to others
	19. To compare my abilities with other peoples'	25. It has allowed me to compare my abilities with other peoples'

EMGI motive and gain items 3

Concept	Motive items	Gain items
	33. To gain recognition for my accomplishments	41. I have gained recognition for my accomplishments
	45. To accomplish things that others are incapable of	6. It has allowed me to accomplish things that others are incapable of
Strength and Endurance	8. To build up my strength	30. I have built up my strength through exercising
	22. To increase my endurance	22. I have increased my endurance
	36. To get stronger	11. It has helped me to get stronger
	47. To develop my muscles	20. I have been able to develop my muscles
Weight Management	1. To stay slim	12. It has enabled me to stay slim
	15. To lose weight	1. I have lost weight through exercising
	29. To help control my weight	36. It has helped control my weight
	43. Because exercise helps me to burn calories	46. It has helped me to burn calories

Appendix B12: Completion rates of study questionnaire

Completion of Questionnaire

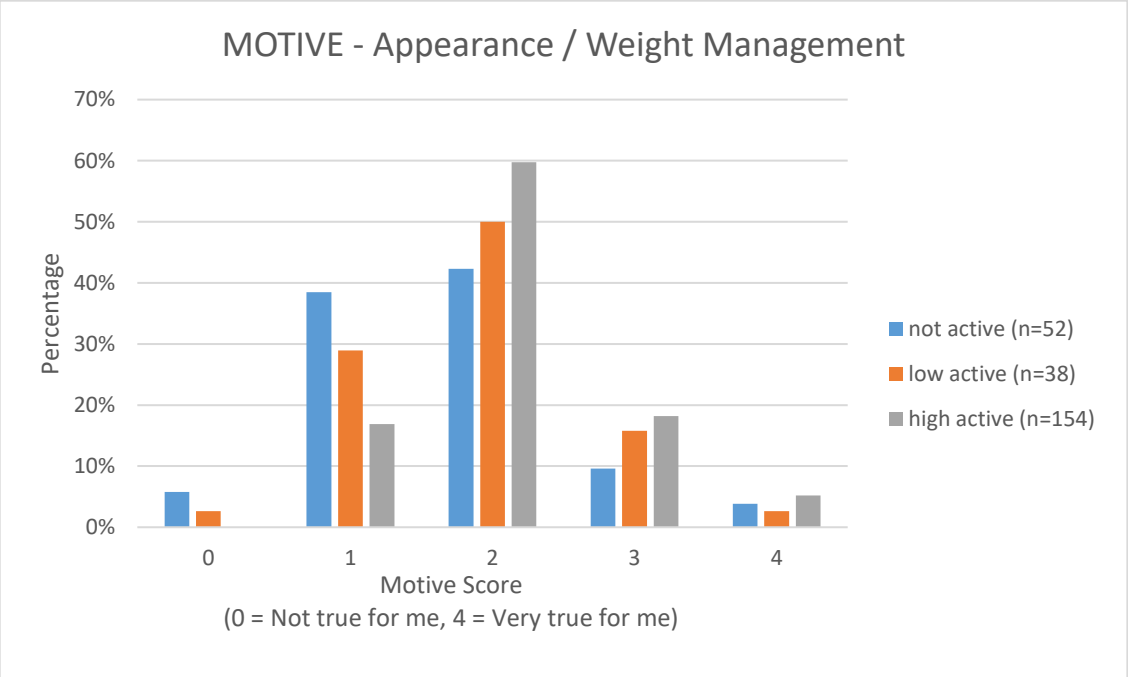
Sections of the questionnaire included: demographics, motives for physical activity, physical activity history, exercise self-efficacy scale, and gains from physical activity.

Appendix B13: Comorbidities

Antiphospholipid Syndrome
Arthritis of blood
Asthma
Atrial Fibrillation
Bowel cancer
Coeliac disease
Crohns disease
Depression/stress
Diverticulitis
Epilepsy
Fibromyalgia
Gilbert's syndrome
Glaucoma / loss of sight
Gout
Hearing loss
Heart condition
High cholesterol
Hypermobility Syndrome
Inflammatory Arthritis
Low back pain
Lupus (SLE)
ME
Migraine
Non Hodgkin Lymphoma
Oedema
Osteoporosis
Parkinsons/dementia
Polymyalgia rheumatica
possible stroke
psoriasis
Psoriatic arthritis
Raynauds
Rheumatoid arthritis
S.A.D
Sciatica
Sjogren's Syndrome
Spastic diplegia
Spondylolisthesis
Thyroid problems

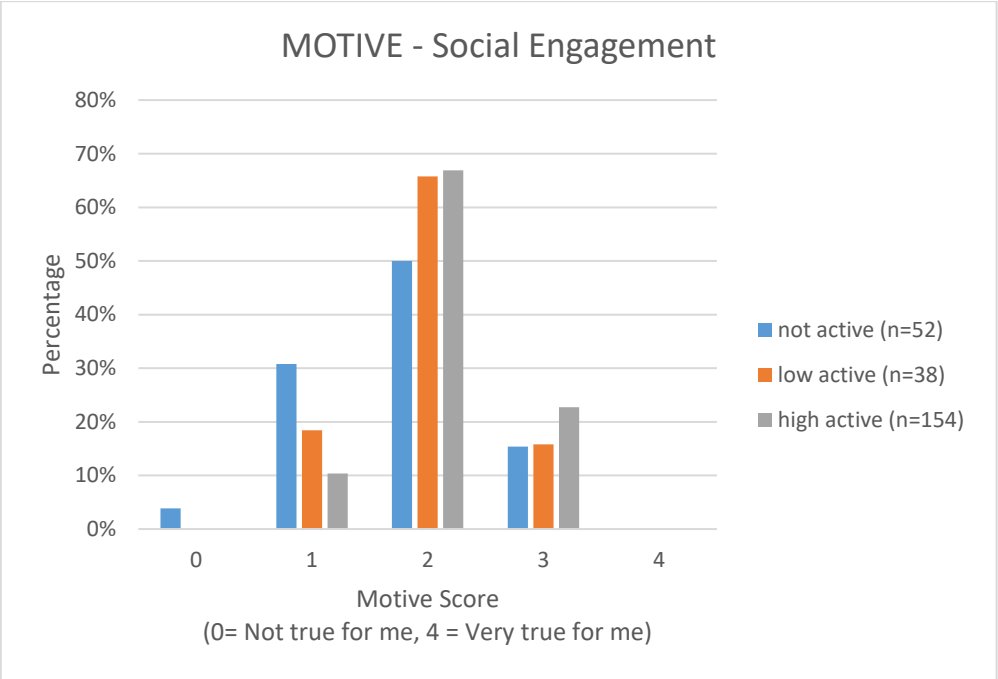
Appendix B14: Graph 5 and Graph 6

Graph 5 – Appearance / Weight Management Motive (EMGI)



Graph 5 shows how those who reported being more active, were most likely to have a motive score or 2. Those who were not active, were more likely to have a lower motive score in this category.

Graph 6 – Social Engagement Motive (EMGI)



Graph 6 shows that those who were more active, were more likely to have a higher motive score for social engagement. Those who were not active, tended to have a lower motive score.

Appendix C1: Bandura's Self-Efficacy Scale (Exercise)

Self-Efficacy to Regulate Exercise

A number of situations are described below that can make it hard to stick to an exercise routine. Please rate in each of the blanks in the column how certain you are that you can get yourself to perform your exercise routine regularly (three or more times a week).

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do				Highly certain can do	

	Confidence (0-100)
When I am feeling tired	____
When I am feeling under pressure from work	____
During bad weather	____
After recovering from an injury that caused me to stop exercising	____
During or after experiencing personal problems	____
When I am feeling depressed	____
When I am feeling anxious	____
After recovering from an illness that caused me to stop exercising	____
When I feel physical discomfort when I exercise	____
After a vacation	____
When I have too much work to do at home	____
When visitors are present	____
When there are other interesting things to do	____
If I don't reach my exercise goals	____
Without support from my family or friends	____
During a vacation	____
When I have other time commitments	____
After experiencing family problems	____

Appendix D1: Initial Design Documents

Table 1 – Initial Design Document for Knowledge/Skills Section of the Website

Performance Objective	Change objective codings	Change Objective	Possible Headings	Possible Practical applications	Corresponding BCTs
PO 1.1: Understand, and accept the benefits of PA for osteoarthritis.	CO1.1.1	Individual to have access to sufficient information so that they are able to understand how PA can help OA.	What is Osteoarthritis, and how is it affecting my joints? Your symptoms can improve. How can PA help my osteoarthritis?	Information from FASA and ARUK. Factual information. Possibly animations or videos about - what is OA.	5.1 information about health consequences. 13.3. incompatible beliefs, 13.2 framing/re-framing
	CO1.1.2	Individual to understand how others (from a physiological and emotional perspective) have benefited from PA.	How have others (with arthritis) benefited from being active? (from physiological perspective - i.e. reduced pain, increased strength - tangible changes etc) HEADINGS - How PA helped my OA - 'My symptoms improved when I became more active'.	Stories (text and videos) from ARUK - people with OA, benefits I have seen from being active etc.	6.2 Social comparison 12.6 body changes.

	CO1.1.3	Individual to receive persuasive prompts/advice? About...	Top tips from others who have become active.	Stories from others - tips/advice about how I became active.	15.1 Verbal persuasion about capability.
	Co1.1.4	PROCESS – Messages to be focused on understanding of emotional states/Mood.	How can PA help my OA? How can PA help my mood?	Stories from others - tips/advice about how PA helped my mood. Include stories about how PA can help mood.	5.1 information about health consequences, 16.3 vicarious consequences.
	CO1.1.5	See CO1.1.2			
	CO1.1.6	PROCESS - Individual to have choice about what information they receive about the benefits of PA for OA – I.E. more/less.	PROCESS: MORE/LESS options.	user to have option to view stories – OPTIONAL.	Unable to code CHOICE? In BCTTv1.
	CO1.1.7	See CO1.1.1	See CO1.1.1	See CO1.1.1	See CO1.1.1

PO 1.2: Understand how to select, and safely perform their chosen type of activity.	CO1.2.1	Individual to have access to sufficient information so that are able to select an appropriate activity, and carry it out safely.	WHAT IS PA? DEFINITION? What PA should I do when I have OA? - sections - day to day life?, strengthening/joint specific exercise, activities outside of the house/groups.	Factual information - NICE guidelines/ARUK/FASA - What activity should I do? How much? How hard should the activity be?	4.1 Information on how to perform the behaviour. 4.2 Information about antecedents.
	Co1.2.6	PROCESS – have choice for more/less information – i.e. guided exercise, or not.	PROCESS: MORE/LESS options		PROCESS
	CO1.2.7	Individual to have access to sufficient information so that are able to select an appropriate activity, and carry it out safely.	see co1.2.1	National guidelines - exercise/PA recommendations.	4.1, 4.2 (AS ABOVE)
PO 1.3: Understand that normal physiological	CO1.3.1	Individual to reflect on previous/current experiences of physiological responses	Think about how you've responded to pain in the past?	TASK option to complete/record information about times in the past.	12.6 body changes. 15.3 focus on past success.

responses can be experienced, and how to respond.		such as pain, and consider options for how to respond.			
	CO1.3.2	Individual to recognise that others with OA have experiences 'normal physiological responses' and how they have overcome such barriers.	How others (with OA) have overcome pain, and continued with PA.	Stories/videos/text from others.	16.3 vicarious consequences, 5.1 information about health consequences.
	CO1.3.4	see CO1.3.2			
	CO1.3.7	Individual to understand what a 'normal physiological response' might feel like.	What happens in the joint when I exercise? What if I experience pain? TAKE HOME MESSAGE: Exercise related discomfort does not mean your joints are being harmed.	Factual information (ARUK/FASA) about why a joint might initially be more painful after becoming active. Link to PACING/VIDEO LINKS TO 'FINDING THAT IS RIGHT FOR YOU' FASA?	5.1 information about health consequences.

Table 2 – Initial Design Document for Action Planning Section of the Website

Performance Objective	**Change objective codings**	**Change Objective**	**Content/headings**	**Practical applications/materials**	**Corresponding BCTs**
PO 2.1 Learn about, and set SMART Goals for PA, using pacing/graded tasks.	C02.1.2	Individual understands that others have benefited from setting SMART goals/and using pacing/graded tasks.	How have others benefited from setting goals?	Stories- video/text about how people have benefited from setting a goal.	16.3 Vicarious consequences.
	CO2.1.3	Verbal encouragement about the benefits of setting GOALS.	Why should I set a goal? What are the benefits? What is an ACTION PLAN.	Text/guidance about the benefits of setting goals - why set goals.	4.1 instruction on how to perform a behaviour (goal setting).
	CO2.1.4	Individual understands the benefits of using	What is pacing/graded tasks? Why should I use pacing? **INFO.**	Information from FASA etc - why is pacing important. Definition of Pacing. Infographic if available.	8.7 graded tasks

		pacing and graded tasks.			
	CO2.1.5	SEE CO2.1.2			
	CO2.1.6	Individual understand what a SMART goal is, and has the ability to choose own SMART goals. **PROCESS** - choice to decide how many goals etc.	What is a SMART goal? (Specific, Measurable, achievable, relevant, time-bound/tangiable). INCLUDE EXAMPLES. Define stretching/strengthening, and cardio activity. Key point - Find something that you ENJOY!	Factual information - what is a SMART goals, why set SMART goals. Factual information - FASA/ARUK etc - definitions: what is stretching/strengthening exercises/PA, what is cardio exercise? Also information/options to FIND ACTIVITIES in my area. Option for interactive 'mock-up' map of my area? List types of exercise - possibly home-based and structured - short overview of each activity, and how it can be beneficial for OA (ARUK etc).	1.1 goal setting (behaviour).
	CO2.1.7	Individual confident to select appropriate goals/pacing/graded	I'm ready to set some goals.	Optional TASK - complete information/set a goal - enter detail - i.e. SMART. Optional. -	1.1 goal setting, 8.7 graded tasks.

		tasks for current level of PA.		Option to CLICK MORE - if not confident that they can set a goal.	
PO 2.2 Learn about self-monitoring and updating goals.	CO2.2.1	Individual accepts the benefits of self-monitoring, and is confident to make a plan. Knows when to review and update goals.	What are the benefits of self-monitoring? How often should I review my goals?	POSSIBLE WORDING FROM FASA - CELEBRATE, REVIEW, SET NEW GOALS. Information about Why Self-monitor? Possible option to reflect on goals when reviewing - how well did it go? Traffic light system?Guidance on how to adjust goals, and set new goals etc.	1.1 goal setting (behaviour). 1.4 action planning, 1.5 review behaviour goal.
	CO2.2.2	Examples of others who have set up goals. How and when, have self-monitored their behaviour – i.e. different monitoring methods.	How do others (with OA) monitor their goals/activity?	Stories - video/text from others - How do other people with OA monitor their goals?	6.2 social comparison, 16.3 vicarious consequences.

	CO2.2.3	Social encouragement from others, you can succeed at your goals – sharing of goals?	How can others help me to achieve my goals.	Optional TASK - Would you like to buddy-up, other social support options. Links to social support. Links to develop networks etc. Information (text) about the benefits of being active with others. Elements/guidance from self-determination theory here.	3.2 social support (practical) 3.3 social support (emotional).
	CO2.2.4	Understand the emotional benefits of self-monitoring your goals. Stories?	How can monitoring my goals help me emotionally / my mood? **INFO SEE CO 2.2.1.**	See CO2.2.1.	5.4 monitoring of emotional consequences.
	CO2.2.5	See CO 2.2.2		See CO 2.2.2	
	CO2.2.6	Individual chooses how they monitor PA, and how often they receive prompts.	I'm ready to decide (and record) how I will monitor and review my goals **TASK.**	OPTIONAL TASK - Set a date/make a plan on how each goal will be monitored. Do you want to receive text/email etc. how often/when.	PROCESS – CHOICE.
	CO2.2.7	(SEE CO2.2.1)			

PO 2.3 Acknowledgement of past successes of PA (RECORD OF ACHIEVEMENT).	CO2.3.2	Individual to recognise the benefits of others who have explored their previous successes.	How have others (with OA) benefited from recording their achievements?	Stories (video/text) examples from others - how have others benefited from monitoring their goals, how has this helped them to achieve their goals?	6.2 social comparison, 16.3 vicarious consequences.
	CO2.3.3	Verbal encouragement about the benefits of exploring, and recording past success	The benefits of exploring, and recording your achievements/past successes (positive effect on mood etc).	Advice (Text? Videos?) about the benefits of monitoring goals.	1.4 Action planning.
	CO2.3.4	Individual to accept that exploring previous success can have a positive effect on emotional / somatic states.	see CO2.3.4.	Prompt - think about past successes.	13.4 valued self-identity, 15.3 focus on past success.
	CO2.3.5	(SEE CO2.4.2)			
	CO2.3.6	PROCESS - Individual to have a choice to	PROCESS - Free choice to complete or not.	Optional TASK - Record past achievements.	PROCESS – CHOICE.

		record previous successes/or not.			
	CO2.3.7	Individual to explore and recognise the value of previous personal successes.	I'm ready to think about (and record) my own past achievements.	Optional TASK - Record past successes.	13.4 valued self-identity.
PO 2.4 Planning for challenging times, including recognition of how others have overcome barriers.	CO 2.4.1	Individual to explore (and record) previous (and current) barriers, and how they were(and might be) overcome.	I'm ready to think about previous barriers, and how I overcame them. **TASK** I'm ready to plan for current and future challenging times **TASK.**	Optional TASK - **MY PLAN TO OVERCOME MY BARRIERS** - make choices for - WHAT CHALLENGES MIGHT I ENCOUNTER? Possibly in a form. List of potential barriers - and advice/tips on how to overcome each one. Reflect on what might be barriers for you.	1.2 problem solving.
	CO2.4.2	Accept that others have successfully overcome barriers, and learn about how they have done this	How have others overcome barriers.	STORIES/ VIDEOS - ARUK Stories about how others have overcome barriers.	6.2 social comparison. 11.2 Reduce negative emotions.

	CO2.4.3	Advice from others, (verbal encouragement) about how others have successfully overcome barriers – tools and advice.	How have others overcome challenging times SEE CO2.4.3.	SHORT QUOTES/TIPS FROM ARUK WEBSITE? Other online videos?	16.3 vicarious consequences.
	CO2.4.4	Individual to understand how to overcome emotional and somatic responses/barriers to PA (Mood etc).	How others have overcome emotional/physical barriers.	SHORT QUOTES/TIPS FROM ARUK WEBSITE? Other online videos?	1.2 problem solving.
	CO2.4.5	see CO2.4.2			
	CO2.5.7	Individual to understand and accept that barriers to PA can be overcome.	Barriers can be overcome.	reinforcement - MESSAGE - 'barriers can be overcome'.	1.2 problem solving.

Table 3 – Initial Design Document for Social Support Section of the Website

Performance Objective	**Change objective codings**	**Change Objective**	**Content/headings**	**Practical applications/materials**	**Corresponding BCTs**
PO 3.1 Accept (and plan for) the emotional and practical benefits of a social network of support	CO3.2.1	Individual to plan for how social support might help with practical issues of PA.	Thinking about how social support might help you to become active (LINK: to challenging times?). **WHAT SUPPORT WOULD BENEFIT YOU THE MOST? - OPTIONS -** emotional/practical /both.	Advice/stories/videos - CHOICE - thinking about what type of support you might need/like. Information about the benefits of social support. Why does it help to be active with others.	3.2 social support (practical). 3.3 social support.
	CO3.2.3	Individual to accept the benefits that practical support from others can have on becoming more active.	How social support helped me to become active (practically).	videos/stories - how support from others helped me to become active. How support from others helped me to stay active.	6.2 social comparison, 16.3 vicarious consequences.
	CO3.2.4	Recognise the positive effects that a social network can have on an	How social support has helped me emotionally.	Stories from others - how being active with others helped my mood.	5.6 information about emotional consequences.

		individual's emotional responses.			
	CO3.2.6	PROCESS – Individual to make own plan about how a social network might support them.	Tools to help you make a plan?	Optional LINKS - to social groups/local activities/what activities are going on in my area?	PROCESS - CHOICE
	CO3.2.7	Individual to accept the benefits of developing a social network.	How can a social network help you to be active? SEE CO3.2.1	see CO3.2.1	3.1 Social support (unspecified).
PO 3.2: Identify new social network links – friends/family/active others with OA.	CO3.3.1	Individual to be confident in identifying and contacting friends and family/others with OA	Thinking about who can help? Identify family/friends/others with OA, and how they might support you to become active.	Optional - TASK - Complete task with details of family/friends who could support my activity.	12.2 restructuring the social environment.
	CO3.3.2	Individual to learn how others have benefited from support from family/ friends/others with OA.	How support from my family/friend/OA buddy? Helped me to become active? SEE CO3.2.3.	see CO 3.2.3	
	CO3.3.3	see co3.2.3		see CO 3.2.3	
	CO3.3.4	see co3.2.4		see CO 3.2.4	

	CO3.3.5	Individual to learn how others have identified, and started new activities with others with OA.	Where do you start? How I developed a social support system STORIES.	Videos/text story from others - how did I find my social support? How did I develop my social support? Where to go?	6.1 demonstration of the behaviour (Modelling) 6.2 Social comparison .
	CO3.3.6	PROCESS – Individual to make own plan about how a social network might support them.	see co3.2.6	see co3.2.6	PROCESS - CHOICE
	CO3.3.7	see co3.3.1	see co3.3.1	see co3.3.1	
PO 3.3: Accept that one's own behaviour can be an example for others to help them to be physically active.	CO3.5.1	Individual to identify positive personal outcomes that could help others with OA to become active.	Thinking about stories you could share, Link back to record of achievement, and tips/advice for others.	Optional TASK - Can you help others? Your story can help others. Share your TIPS AND ADVICE	13.1 identification of self as role model.
	CO3.5.2	Individual to learn about how shared experiences can help people to become active.	How hearing other people's stories helped me to become active (SEE 3.2.3).	Video/text - storied about the benefits of helping others to stay active.	13.4 valued self-identity.
	CO3.5.3	Encouragement from others, to share success stories.	see co3.5.2	see co3.5.2	

	CO3.5.4	Individual to accept the emotional benefits of helping others to be active.	see co3.5.1	see co3.5.1	
	CO3.5.5	Recognise that one's own behaviour can help others to succeed.	see 3.5.1	see 3.5.1	
	CO3.5.6	PROCESS – Option to share own personal experiences to help other.	OPTIONAL - TOOLs to help you submit a story.	Optional TASK - Record tips/advice - for others.	PROCESS - CHOICE
	CO3.5.6	Individual to identify positive personal outcomes that could help others with OA to become active.	see co3.5.1	see co3.5.1	

Appendix D2: Final ELLA webpages

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

Knowledge and Skills - What is Osteoarthritis?

1 What is Osteoarthritis? 6

Your symptoms can improve 2

How can physical activity help my arthritis? 3

What if I experience pain? 4

Which activities should I do?

Osteoarthritis is a common condition that affects your joints.

8.75 million people aged 45 and over in the UK have sought treatment for osteoarthritis (ARUK, 2017).

How does it affect my joints?

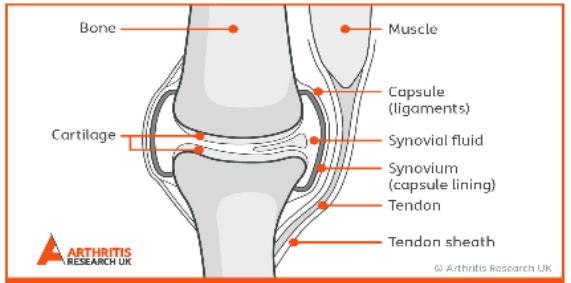
Surfaces of your joints become damaged so it doesn't move smoothly.

Cartilage covering the ends of the bones roughens and becomes thin.

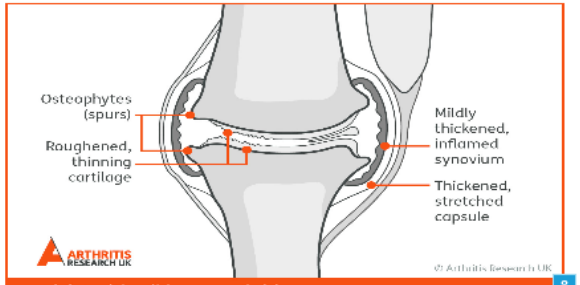
Bone at the edge of your joint grows outwards, forming bony spurs called osteophytes.

The joint capsule may thicken and make extra fluid, causing your joint to swell.

Ligaments (tough bands that hold the joint together) slowly thicken and contract as if they were trying to make your joint more stable.



A normal joint (front view)



A joint with mild osteoarthritis

8

NEXT →

Knowledge and Skills - Your symptoms can improve!

1 What is Osteoarthritis?

7 Your symptoms can improve!

2 How can physical activity help my arthritis?

3 What if I experience pain?

4 Which activities should I do?

8 BACK

Many people think osteoarthritis is untreatable.

This is not correct.

There is no cure for the dengenerative changes seen in the joints, but this does not mean there is nothing that can be done to help the problem.

There is a lot you can do to reduce pain and maximise your ability to do what you want.

Having a healthly lifestyle, which includes ***remaining active***, and ***keeping your weight controlled***, can make a significant difference.

You can still lead a ***healthy, active life*** if you have arthritis.

Symptoms can include:

- Pain
- Stiffness
- Swelling
- Grinding sensation when the joint moves

6 NEXT →

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

Knowledge and Skills - How can physical activity help my arthritis?

4 What is Osteoarthritis?

8 Your symptoms can improve!

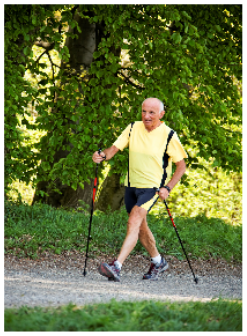
5 How can physical activity help my arthritis?

6 What if I experience pain?

7 Which activities should I do?

If you have arthritis, regular physical activity has special benefits above and beyond the general benefits of improved health, including:

- ***Reduced joint pain*** and ***stiffness***
- ***Improved joint circulation*** and ***decreased swelling***
- ***Better balance***, and greater comfort doing daily activities.
- ***Stronger muscles*** to protect joints by improving stability and absorbing shock
- ***Higher energy levels,*** and ***improved mood***,



CLICK HERE 1
to watch a video about how other people wth arthritis keep active

(from healthtalkonline.com)

KEEP MOVING

This approach can help you to feel in control, and to manage symptoms better in the long-term.

It doesn't matter how old you are, or how long it is since your last exercised.

Physical Activity will help to maintain your joints and make you fitter and healthier.

MEL'S STORY (Source: ArthritisResearchUK)

'My Symptoms Improved when I Became Active'

'I decided to exercise to keep mobile, to sleep better and stay positive. Shane, a personal trainer at the gym, knew about my arthritis and created a programme of weights, stretching and resistance training I could do without hurting my knees. I started slowly doing a little each time, stopping if anything hurt. Within weeks I was able to walk upstairs without pain.

9 BACK

NEXT → 3


ELLA Enjoying Life & Living with Arthritis
Knowledge and Skills
Action Planning
Social Support
MY PLAN
Knowledge and Skills - What if I experience pain when exercising?
4
What is Osteoarthritis?
8
Your symptoms can improve!
5
How can physical activity help my arthritis?
6
What if I experience pain?
7
Which activities should I do?
You may experience discomfort when you are exercising, or for a day or two afterwards, especially if you are trying something new, or if it's something you haven't done for a long time.
Don't worry, this does not mean you have harmed your joints, or that you should stop the activity.
It is inevitable that with long-term joint conditions you will sometimes experience aches and pains during exercise or activity.
What is important, is that you recognise the need to keep your joints moving, without overdoing it. You will gradually learn what level is right for you.
1
CLICK HERE to find out more about how others have overcome pain to STAY ACTIVE
You will learn more about how to use PACING techniques, in the next section of this website.
9
BACK
3
NEXT

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

Knowledge and Skills - What sort of Physical Activity should I do?

2 What is Osteoarthritis?

6 Your symptoms can improve!

3 How can physical activity help my arthritis?

4 What if I experience pain?

5 Which activities should I do?

What are the guidelines?

How Long?	30 minutes Short bouts or in one go
How Often?	Most days
How much effort?	Feeling slightly warm Heart beating a little faster Able to talk
What?	Anything that you enjoy! Part of a daily routine

7 BACK

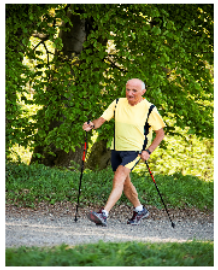
Try to find the right balance between rest and exercise. Little and often is usually the best approach.

Stretching exercises can relieve stiffness and improve the range of movement in your joints.

Strengthening exercises help to build stronger muscles, providing joints with greater stability, and help to improve balance.

Aerobic (or cardiovascular) exercise is any exercise that increases your pulse rate and makes you a bit short of breath (for example, a brisk walk or swimming).

This type of exercise can improve your general health and well-being, as well as reduce pain (aerobic exercise raises the levels of pain-relieving hormones called endorphins).



1 NEXT (ACTION PLANNING)

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

ACTION PLANNING - Setting GOALS

- Setting Goals
- Why is Pacing important?
- Past Successes
- My Activities
- How and Where
- Stumbling Blocks
- Self-monitoring

It's much easier to become more active if you set yourself a goal. Setting a long-term goal however may seem scary, so consider the smaller steps that lead to what you ultimately want to acheive.

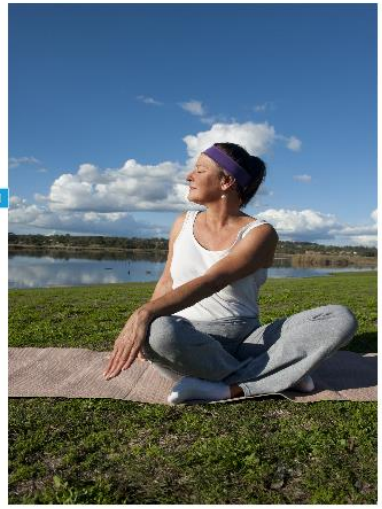
An 'Action Plan' is a record of what you want to achieve, and how you will go about it. It will help you to reach your long-term goal by breaking it down into achievable, short-term aims. It will also allow you to monitor your progress, and help you to decide whether to set a new, slightly harder goal.

TASK
Do you have an overall aim, something that you would like to achieve? If so, write it here

CLICK HERE

To watch a video about how other people have set goals

(healthtalk.org)



Think about goals that are CHALLENGING but REALISTIC

NORA'S STORY

Making small changes has helped Nora feel in control
(Source: Arthritis Research UK website)

After taking advice from healthcare professionals and doing online research, Nora started an exercise routine that worked for her, incorporating Pilates, low-impact exercise on a cross-trainer or a bike and swimming.

NEXT →

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

ACTION PLANNING - Why is Pacing important?

- 4 Setting Goals
- 5 Why is Pacing important?
- 10 Past Successes
- 6 My Activities
- 7 How and Where
- 8 Stumbling Blocks
- 9 Self-monitoring

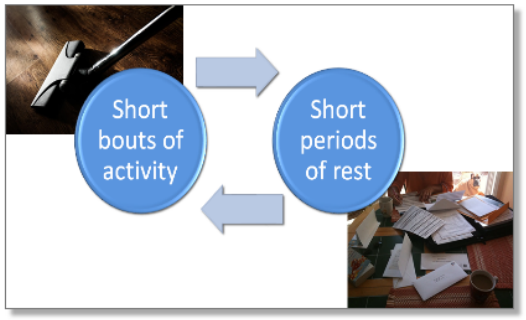
REMEMBER - It is generally not the activity that causes pain, but the intensity at which the activity is performed.

'PACING' encourages you to adopt a different approach to activity - alternating periods of activity with rest to reduce pain and associated anxiety.

Think about an activity that you do on a regular basis but find uncomfortable. Think about how you perform this task.

Most people recognise a pattern of experiencing pain after a relatively short period of time, but continue until the task is completed, and then rest.

Think about a time period when you start to feel slightly tired, prior to experiencing pain or discomfort, and have a short rest at this stage.



1 CLICK HERE to watch some videos about how PACING has helped other people to achieve their goals

TASK: Write down an activity that you do regularly. How might you PACE yourself the next time you do it?

2

11 BACK

12 NEXT →

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

ACTION PLANNING - Past Successes

- Setting Goals
- Why is Pacing important?
- Past Successes
- My Activities
- How and Where
- Stumbling Blocks
- Self-monitoring

TASK

What activity did you do in the past?

Did you enjoy it?

Can you remember how it made you feel?

Did anything get in the way? How did you overcome these barriers?

BACK

NEXT

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

ACTION PLANNING - My Activities

- Setting Goals
- Why is Pacing important?
- Past Successes
- My Activities
- How and Where
- Stumbling Blocks
- Self-monitoring

Think about activities that you find enjoyable. You are more likely to continue doing an activity over the long-term, if you ***ENJOY*** it.

Think about the different types of activities that you could include in your goals:

EVERYDAY LIVING ACTIVITIES - Things that you do regularly, like walking to the local shop, housework, or gardening. This could also include sets of arthritis specific exercises that you can do at home.

STRUCTURED ACTIVITIES - Things that you would outside of the home, in a more organised environment, like going to a yoga class, or swimming.

- **Choose a mixture of stretching/strengthening and aerobic activities.**
- **Include an activity that involves some interaction with others. Exercising with others can be more enjoyable.**
- **Be realistic. Think about how your joints are feeling today. Remember that activity can help your joints, reduce pain, and improve mood.**

TASK

Click on the activities below for more information. Write down some goals, choosing an activity from the lists, or your own.

Everyday Living Activities

TIP: Think about how you might add activity into your daily routine

Walking	Gardening
General exercises for arthritis	Exercises for knee pain
Exercises for back pain	Exercises for neck pain
Exercises for shoulder pain	Exercises for hip pain
Other?	

My EVERYDAY GOAL IS:

Structured Activities

TIP: Choose activities that you think you might ENJOY

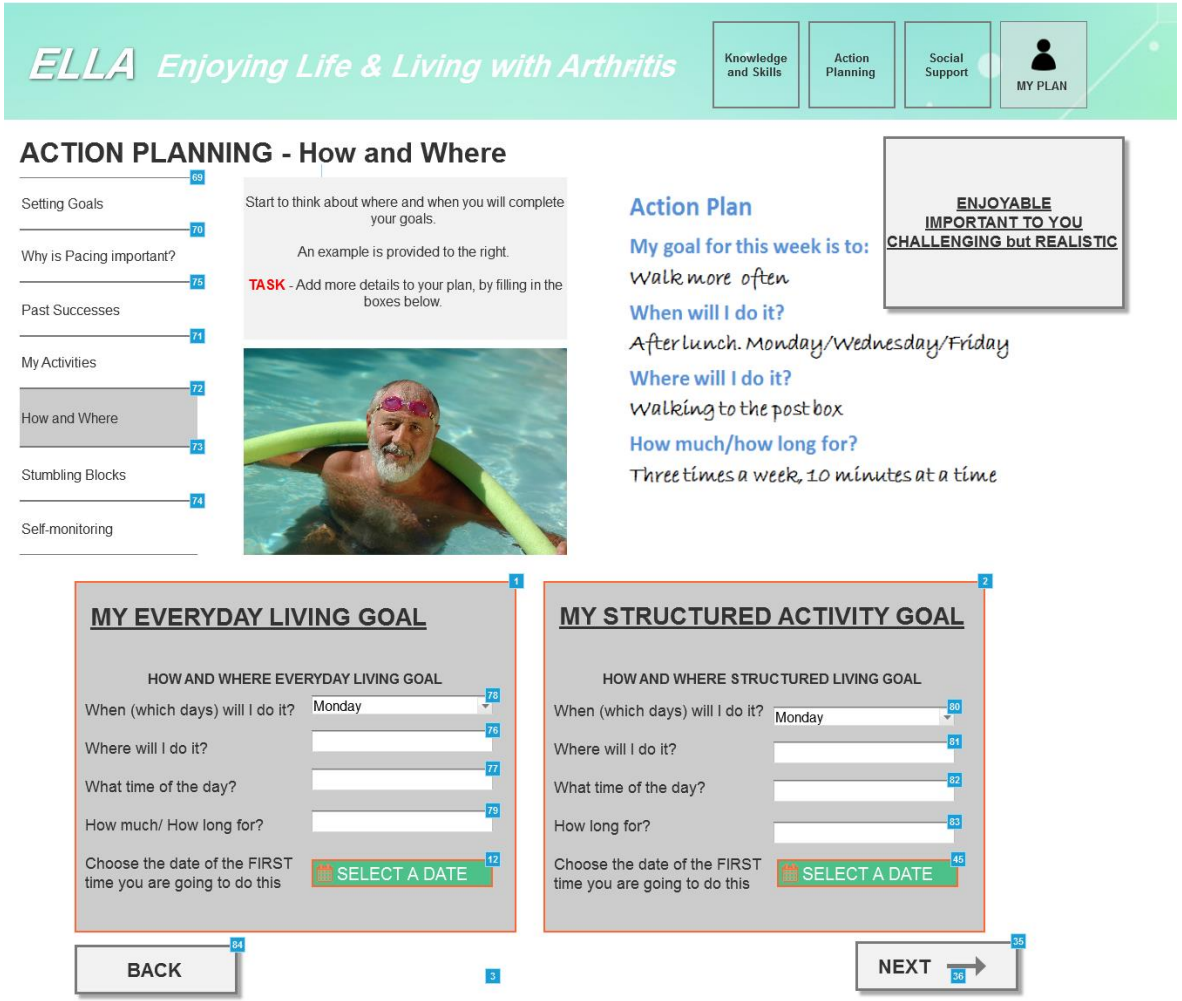
Walking groups	Swimming
Yoga	Pilates
Tai-chi	Dancing
Cycling	Gym
Fitness classes	Other?

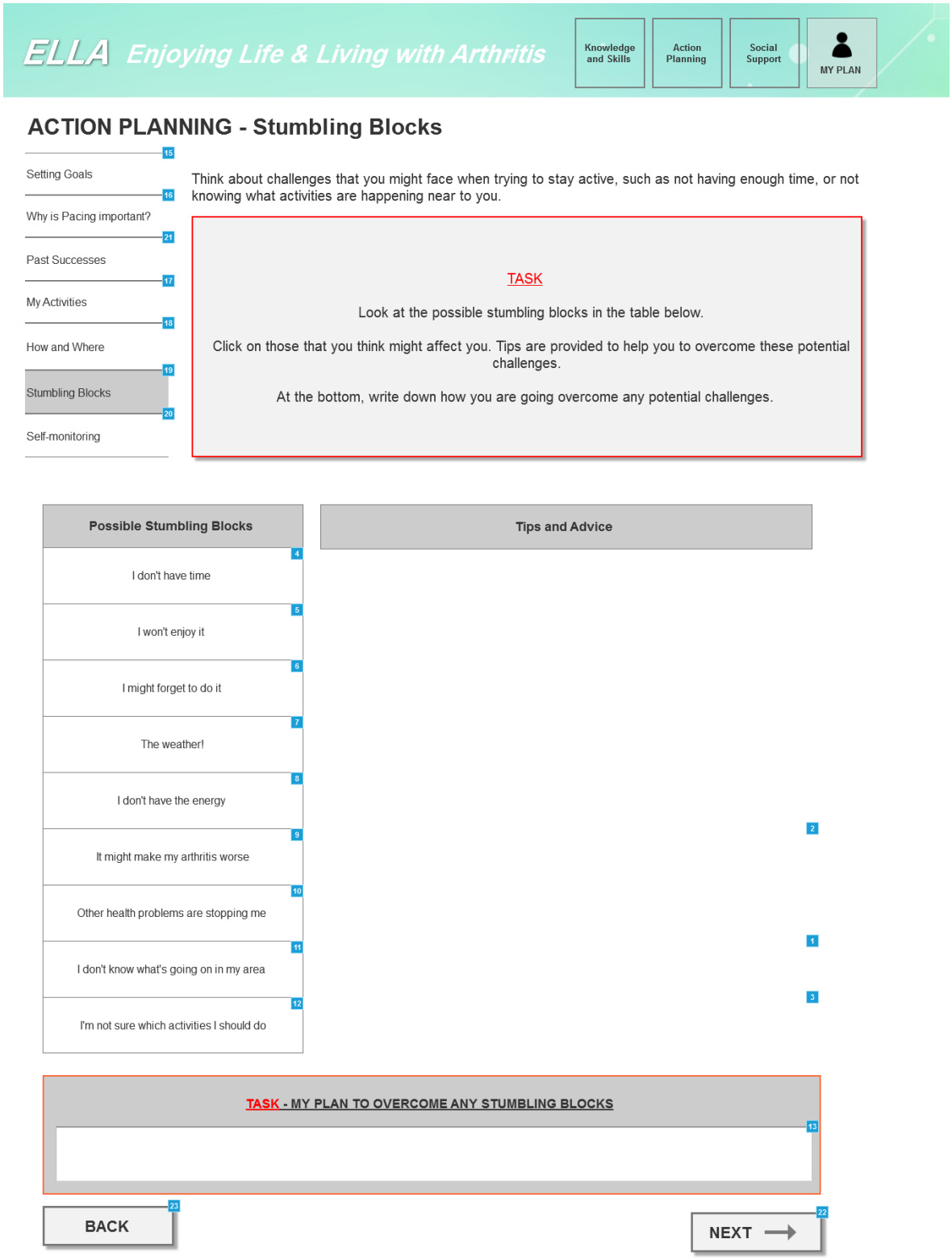
CLICK HERE TO SEE WHAT'S AVAILABLE IN YOUR LOCAL AREA

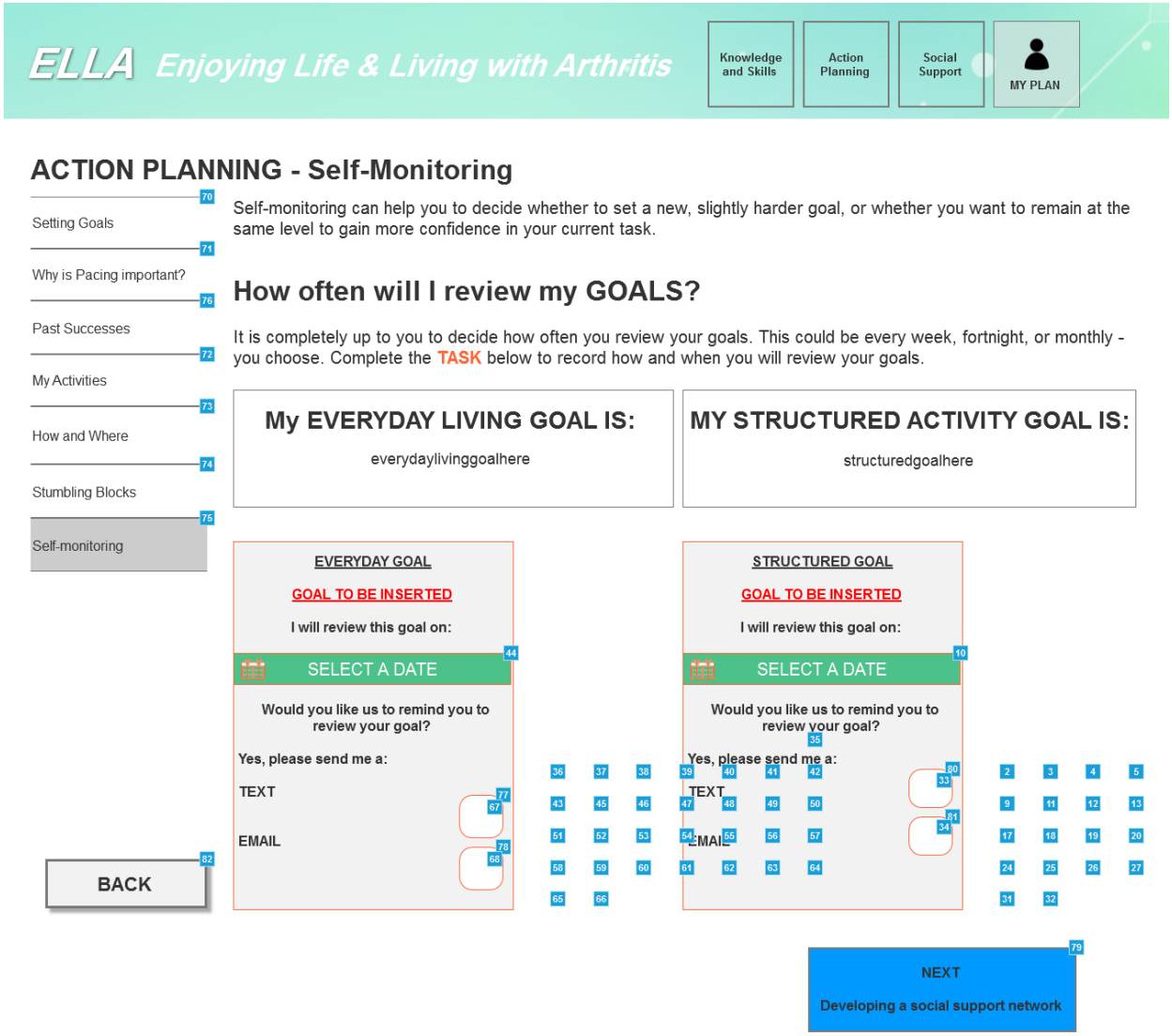
MY STRUCTURED GOAL IS:

BACK

NEXT


ELLA Enjoying Life & Living with Arthritis
Knowledge and Skills
Action Planning
Social Support
MY PLAN
ACTION PLANNING - How and Where
Setting Goals
Why is Pacing important?
Past Successes
My Activities
How and Where
Stumbling Blocks
Self-monitoring
Start to think about where and when you will complete your goals.
An example is provided to the right.
TASK - Add more details to your plan, by filling in the boxes below.
Action Plan
ENJOYABLE
IMPORTANT TO YOU
CHALLENGING but REALISTIC
My goal for this week is to:
Walk more often
When will I do it?
After lunch. Monday/Wednesday/Friday
Where will I do it?
Walking to the post box
How much/how long for?
Three times a week, 10 minutes at a time
MY EVERYDAY LIVING GOAL
HOW AND WHERE EVERYDAY LIVING GOAL
When (which days) will I do it?
Monday
Where will I do it?
What time of the day?
How much/ How long for?
Choose the date of the FIRST time you are going to do this
SELECT A DATE
MY STRUCTURED ACTIVITY GOAL
HOW AND WHERE STRUCTURED LIVING GOAL
When (which days) will I do it?
Monday
Where will I do it?
What time of the day?
How long for?
Choose the date of the FIRST time you are going to do this
SELECT A DATE
BACK
NEXT


ELLA Enjoying Life & Living with Arthritis
Knowledge and Skills
Action Planning
Social Support
MY PLAN
ACTION PLANNING - Stumbling Blocks
Setting Goals
Why is Pacing important?
Past Successes
My Activities
How and Where
Stumbling Blocks
Self-monitoring
Think about challenges that you might face when trying to stay active, such as not having enough time, or not knowing what activities are happening near to you.
TASK
Look at the possible stumbling blocks in the table below.
Click on those that you think might affect you. Tips are provided to help you to overcome these potential challenges.
At the bottom, write down how you are going overcome any potential challenges.
Possible Stumbling Blocks
Tips and Advice
I don't have time
I won't enjoy it
I might forget to do it
The weather!
I don't have the energy
It might make my arthritis worse
Other health problems are stopping me
I don't know what's going on in my area
I'm not sure which activities I should do
TASK - MY PLAN TO OVERCOME ANY STUMBLING BLOCKS
BACK
NEXT


ELLA Enjoying Life & Living with Arthritis
Knowledge and Skills
Action Planning
Social Support
MY PLAN
ACTION PLANNING - Self-Monitoring
Setting Goals
Why is Pacing important?
Past Successes
My Activities
How and Where
Stumbling Blocks
Self-monitoring
Self-monitoring can help you to decide whether to set a new, slightly harder goal, or whether you want to remain at the same level to gain more confidence in your current task.
How often will I review my GOALS?
It is completely up to you to decide how often you review your goals. This could be every week, fortnight, or monthly - you choose. Complete the TASK below to record how and when you will review your goals.
My EVERYDAY LIVING GOAL IS:
everydaylivinggoalhere
MY STRUCTURED ACTIVITY GOAL IS:
structuredgoalhere
EVERYDAY GOAL
GOAL TO BE INSERTED
I will review this goal on:
SELECT A DATE
Would you like us to remind you to review your goal?
Yes, please send me a:
TEXT
EMAIL
STRUCTURED GOAL
GOAL TO BE INSERTED
I will review this goal on:
SELECT A DATE
Would you like us to remind you to review your goal?
Yes, please send me a:
TEXT
EMAIL
BACK
NEXT
Developing a social support network

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

Social Support - How can a social network help me to be active?

- How can a social network help me to be active? (4)
- Develop my own social support plan (3)
- How can I help to support others? (2)

We all need supportive people to help us to meet our goals. Sometimes, getting the right kind of support can be challenging, or it can hard to know who to ask.

Choosing the right people to turn to

Support and encouragement from others can be great for helping us to meet our goals. Relationships that are good for you will support you, especially at times when you are struggling to reach your goals. Supportive others (eg friends and family) are the people that can remind you of your strengths, and join forces with you to fight the challenges that come your way.

Asking for Support

We might assume that people know how to be supportive, but this is not always the case. Those supporting you might need to know when and how they can help. Think about what type of support you would find most helpful. This might be somebody at the end of the telephone, to talk abut how you are feeling, and what challenges you are facing. Or you could be looking for more practical help, finding out about what activities your friends are doing, or arranging to meet up and take part in an activity together.

Ideas for Emotional Support

- Encouragement from friends or family (via email, phone call, text, face-to-face)
- Buddy-up system - link up with somebody else with similar symptoms to you, share your goals, challenges, and acheivements

Ideas for Practical Support

- Arranging to meet up with friends or family to exercise together
- Online interaction (e.g. forum/facebook group) with others to find suitable activities in your area
- Group/buddy-up system for local events

CLICK HERE (1)
to watch a video about a group of people being active (Arthritis Care.com)

NEXT (5)


ELLA Enjoying Life & Living with Arthritis
Knowledge and Skills
Action Planning
Social Support
MY PLAN
Social Support - Developing my own support plan
How can a social network help me to be active?
Develop my own social support plan
How can I help to support others?
Who can support me, and how?
• Who are the people that can help remind you of your strengths and join forces with you to meet your goals?
• Different people might help you to tackle different challenges, think about who might be the most suited to help you achieve your current goals.
• Complete the TASKs below, by writing down who might be able to support you emotionally and physcially.
NOTE: This information will not be shared, only you will be able to see it.
TASK - Support for Everyday Living Goal
everyday living goal here
Name of support:
What would you like them to do to be supportive of you?
What specifically could they do to help you out when challenges come up?
Would you like us to send them a copy of your PLAN?
Yes please, VIA email
TASK - Support for Structured Goal
structured goal here
Name of support:
What would you like them to do to be supportive of you?
What specifically could they do to help you out when challenges come up?
Would you like us to send them a copy of your PLAN?
Yes please, VIA email
BACK
NEXT

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

How can I help by supporting others?

1 How can a social network help me to be active?

3 Develop my own social support plan

2 How can I help to support others?

Hearing stories and getting advice from other people with arthritis can be really helpful, and make people feel like they are not alone.

Finding out about how others have become active, and how they overcame barriers, found local activities, and set goals can be very useful.

Think about tips or adivce that you could give to others, or recommendations of activities in your local area.

Would you be interested in adding your own tips/advice or stories to our website, about your experiences with physical activity?

yes

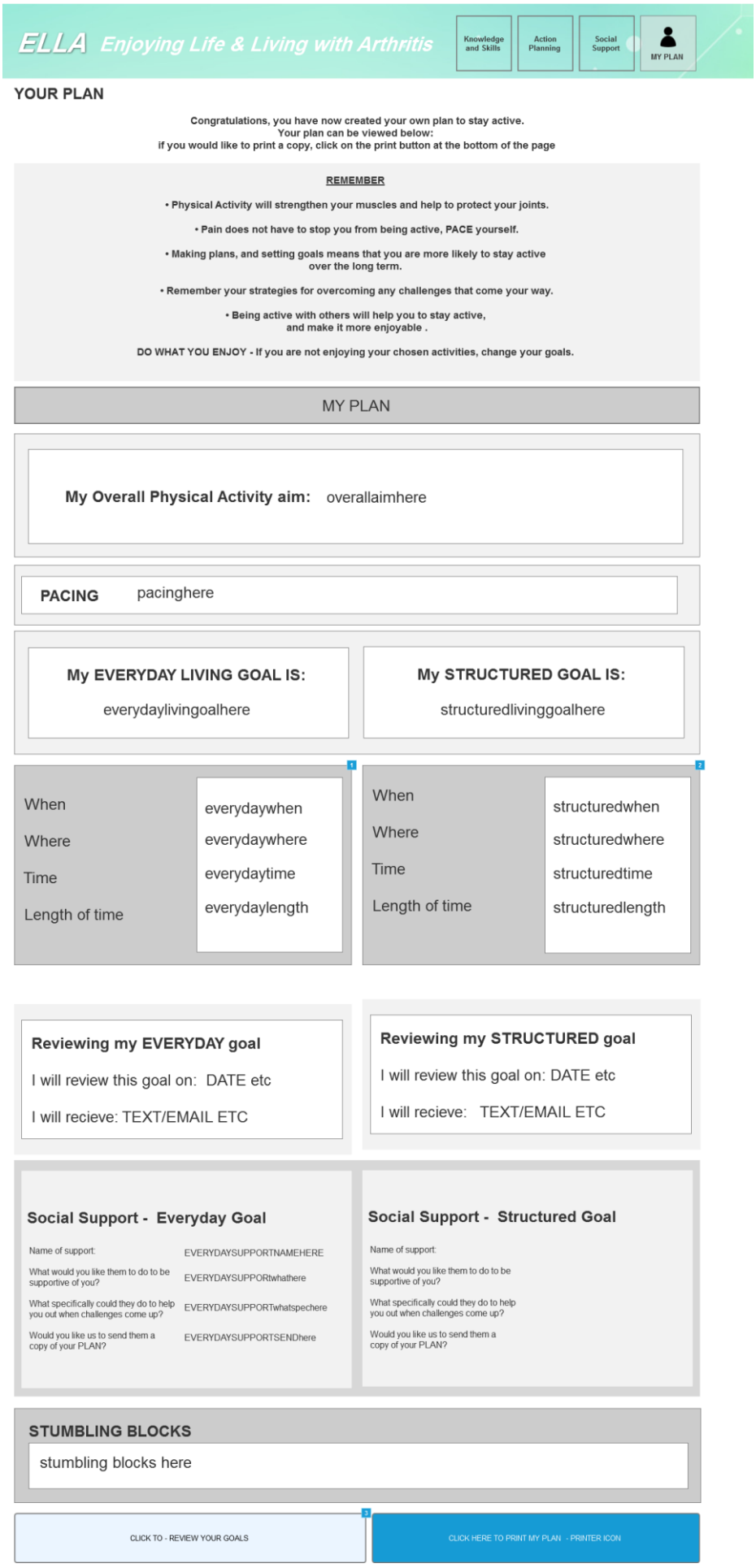
Would you be interested in joining an online group for people in your local area, to share advice about local activities?

yes

5 BACK

4 THIS IS THE END!

CLICK HERE TO SEE YOUR PLAN


ELLA Enjoying Life & Living with Arthritis
Knowledge and Skills
Action Planning
Social Support
MY PLAN
YOUR PLAN
Congratulations, you have now created your own plan to stay active.
Your plan can be viewed below:
if you would like to print a copy, click on the print button at the bottom of the page
REMEMBER
• Physical Activity will strengthen your muscles and help to protect your joints.
• Pain does not have to stop you from being active, PACE yourself.
• Making plans, and setting goals means that you are more likely to stay active over the long term.
• Remember your strategies for overcoming any challenges that come your way.
• Being active with others will help you to stay active, and make it more enjoyable .
DO WHAT YOU ENJOY - If you are not enjoying your chosen activities, change your goals.
MY PLAN
My Overall Physical Activity aim: overallaimhere
PACING pacinghere
My EVERYDAY LIVING GOAL IS:
everydaylivingoalhere
My STRUCTURED GOAL IS:
structuredlivinggoalhere
When everydaywhen
Where everydaywhere
Time everydaytime
Length of time everydaylength
When structuredwhen
Where structuredwhere
Time structuredtime
Length of time structuredlength
Reviewing my EVERYDAY goal
I will review this goal on: DATE etc
I will recieve: TEXT/EMAIL ETC
Reviewing my STRUCTURED goal
I will review this goal on: DATE etc
I will recieve: TEXT/EMAIL ETC
Social Support - Everyday Goal
Name of support: EVERYDAYSUPPORTNAMEHERE
What would you like them to do to be supportive of you? EVERYDAYSUPPORtwhathere
What specifically could they do to help you out when challenges come up? EVERYDAYSUPPORTwhatspechere
Would you like us to send them a copy of your PLAN? EVERYDAYSUPPORTSENDhere
Social Support - Structured Goal
Name of support:
What would you like them to do to be supportive of you?
What specifically could they do to help you out when challenges come up?
Would you like us to send them a copy of your PLAN?
STUMBLING BLOCKS
stumbling blocks here
CLICK TO - REVIEW YOUR GOALS
CLICK HERE TO PRINT MY PLAN - PRINTER ICON

ELLA *Enjoying Life & Living with Arthritis*

Knowledge and Skills | Action Planning | Social Support | MY PLAN

REVIEW YOUR GOALS

When you review your goals - it can be really helpful to reflect on how you/your joints felt after you have completed the activity/exercise.

When your goal becomes easy, you need to review your goals and set a new action for further success, so for example walk a little bit further.

Challenging, but achievable

If you aren't achieving your goals you may have set your sights too high initially, or your plan to achieve the goal may not have been specific enough. Modify your action plan, and be more specific on how you will work towards change

TASK - REVIEW YOUR GOALS

EVERYDAY LIVING GOAL	STRUCTURED GOAL
everydaylivingoalhere	structuredlivinggoalhere

	EVERYDAY LIVING GOAL		STRUCTURED GOAL
When	everydaywhen	When	structuredwhen
Where	everydaywhere	Where	structuredwhere
Time	everydaytime	Time	structuredtime
Length of time	everydaylength	Length of time	structuredlength

Click on the traffic lights to review your goals

Appendix E1: Study Interview Schedule

Acceptability and Usability of a Digital Intervention to facilitate sustained engagement in physical activity for people with osteoarthritis

Semi-structured Interview – topic guide/interview schedule

(Attitude/feelings)	What are your thoughts about the website, now that you've had a go at using it?
(Likes/Dislikes)	What did you like / dislike?
(Attitude)	How do you feel about using it in the future?
(Self-efficacy for int. use)	How confident are you that you can complete the TASKS on the website?
(Presentation)	How did you feel about how the information was presented? I.e. the text, and videos - would you have liked it to be presented in a different way? E.g. animations?
(Intervention Coherence)	Was it clear? Is there anything that could be clearer?
(Ethicality/value)	**T**he aims of the website are to: increase your knowledge, help you to set goals, and to develop a support network - How important are these things to you, if at all? Is it relevant to you?
(Perceived effectiveness)	How much do you think this website could help you to be active, or not?
	What about over the longer term?
(Burden/Intended use)	How do you feel about the amount of time and effort that was required to use the website?
	How often do you think you might use the website in your day to day life? Over the long-term?
	Would you use all elements of the website, or just some?
(Opportunity Costs)	Do the potential benefits of using the website, outweigh the amount of time and effort needed to use it? Is it worth it?
(Tailoring)	Would you have liked the information to be more personalised? Which bits?
	PROMPTS - Stories/videos/exercise options

(Self-Monitoring)	Do you think the website would help you to monitor your goals? – Or would you like additional tools to help you to monitor like – like linking up to your phone/pedometer/fitbit?
(Professional support)	Would you like the website to include professional support? (face to face, or online)
(Referral pathway)	How would you like to first access the website? GP/physio/directly online
(Missing elements)	Is there anything missing? What else would you like?

Closing: Thank you very much for taking part, do you have any other reflections about anything we have discussed, or any other questions at all?

Appendix E2: Participant Information Sheet

RESEARCH STUDY

How Acceptable and Usable is a Digital Intervention, for Helping People with Osteoarthritis to be Active

Participant Information Sheet

We would like to invite you to take part in a research study which is being conducted by the University of the West of England, in Bristol. Before you decide to take part, we would like to explain why we are doing this study, and what it involves. Please read this information sheet carefully and discuss it with other people if you wish.

For more information, or for any queries please contact:
alice.berry@uwe.ac.uk OR **0117 3288796**

What is the purpose of the study? The purpose of this study is to see what people think about a website that we have created.

We know that physical activity can help to ease some of the symptoms associated with osteoarthritis such as pain and stiffness, yet many people with osteoarthritis are not physically active. We have designed a website which aims to provide information and support for people to be active. It includes information about the benefits of physical activity, which activities are suitable for people with osteoarthritis, tools to set goals for becoming active, and help with developing a social network of support if desired.

We would really like to talk to people who are currently ***not active***, as well as those who are currently ***active.*** It is important that we talk to a range of people. This study is trying to find out what people think of our website, and how they might use it, in everyday life.

Why have I been invited? You might remember that you took part in a previous part of this project, in 2015. We asked you to complete some questionnaires about beliefs and

motivations for physical activity. At that time, you agreed to be contacted about future parts of the project.

RESULTS of the Previous Study: The results from the questionnaires showed us that those who did no physical activity had lower levels of confidence about their ability to be active. Those who did the most physical activity, tended to find the activities they took part in to be enjoyable and fun.

We have developed a website which focuses on helping people to become more confident about being active, and which also helps with setting goals, and finding suitable (and enjoyable) local activities.

Do I have to take part? It is entirely up to you if you would like to take part in the study. If you do not want to take part, you do not need to reply to this email, and we will not send you any further emails.

What is involved if I decide to take part? Below is an overview of what is involved:

> **1) QUESTIONNAIRE**: We will ask you to complete a questionnaire before we visit you in your home. This should take about 20 minutes, and can be completed online (or via post if preferred).
> **2) HOME VISIT**: We will arrange to visit you in your home to show you the website, using your own computer or tablet (NOTE: You will have to have an internet connection to take part).
> **Try the website**: You will have a look though the website, and we will ask you to talk out loud about your thoughts, as you click through each page.
> **Short interview**: We will then ask you about the website content; how relevant it is to you, and if you think it might motivate you to be active.

We would like to visit you in your home, because this is how we hope the website will be accessed in the future. This way, people can use it whenever they choose.

How long will the home visit take? We expect that the home visit will take around **1 to 1 ½ hours** to complete.

Will my personal details be kept safe? Yes. All of the information collected will be kept completely confidential at all times, and will be held securely on University computers. Data will be anonymised and no personal details will be included in any reports or presentations about the study.

Are there any benefits or disadvantages in taking part? There are no direct personal benefits for you. However, during the study visit, we hope that you may get some useful insight into the things that might help you to be active, such as setting goals, or how you may wish to develop a social network of support.

The benefit to us of you taking part is that you will help us to find out about how usable and acceptable our website is. The findings will help us to modify it, as needed. We hope that the website will then be able to be tested on a larger scale, to see how people use it over a longer period of time.

The only disadvantage to this study is the time it will take to complete the visit.

What will happen to the results of the study? At the end of the study the results will be published in appropriate scientific journals and presented at conferences. You will not be identified in any publication or presentation. Quotes from the interviews may be used in these publications, but these will be completely anonymous.

Who is organising and funding this research study? This research study is being organised and funded by the University of the West of England as part of a PhD project. The quality of this project has been reviewed and approved by the Faculty's Research Degree Committee at the University of the West of England.

What happens next? If you are interested in taking part, reply to this email, and we will be in touch to arrange a time for the home visit, over the next 2-4 weeks.

A project from the University of the West of England, Bristol, in collaboration with Bournemouth University.

Project Team

Alice Berry, PhD Candidate, University of the West of England (UWE), Bristol.

Professor Nicola Walsh, UWE, Bristol.

Professor Candy McCabe, UWE and Royal National Hospital for Rheumatic Diseases (RNHRD), Bath.

Dr Sarah Muir, University of Bournemouth, Bournemouth.

Jill Boreham and Don Jones (Patient Insight Partners, Bristol).

For more information, or for any queries please contact:
alice.berry@uwe.ac.uk OR **0117 3288796**

Thank you for taking the time to read this information sheet.

Appendix E3: Study Consent Form

RESEARCH STUDY

How Acceptable and Usable is a Digital Intervention, for Helping People with Osteoarthritis to be Active

Consent Form

Please read the statements below and circle your answer for each. Please then initial the box to the right, to confirm your response.

			Initials
I confirm that I have read the Participant Information Sheet (Participant Information Sheet Phase 3B V2 26-03-18 Acceptability and usability), understand the purpose of the study, and agree to take part.	*YES*	*NO*	
I agree to test the prototype digital intervention on my home computer, and understand that I will be video-recorded when doing this.	*YES*	*NO*	
I agree to take part in an interview, following the testing of the prototype (this will be audio recorded).	*YES*	*NO*	
I understand that my participation in this study is voluntary, and that I can ask for my information to be withdrawn at any time during the home visit.	*YES*	*NO*	

Appendix E4: Study Questionnaire

University of the West of England
BRISTOL

RESEARCH STUDY

How Acceptable and Usable is a Digital Intervention, for Helping People with Osteoarthritis to be Active

Questionnaire

TODAY'S DATE:

_____ (dd/mm/yyyy)

INFORMED CONSENT – Please circle yes OR no, AND initial each box to confirm that you are happy to take part in the study.

			Initials
I confirm that I have read the Participant Information Sheet (Participant Information Sheet Phase 3B V2 26-03-18 Acceptability and usability), understand the purpose of the study, and agree to complete the questionnaire.	*YES*	*NO*	
I agree to take part, and am happy to complete this questionnaire.	*YES*	*NO*	
I understand that my participation in this study is voluntary, and that I can ask for my information to be withdrawn at any time during the home visit.	*YES*	*NO*	

1998 Data Protection Act, Consent to Process Personal Information

The personal information collected on this questionnaire will be processed by the University in accordance with the terms and conditions of the 1998 Data Protection Act. We will hold your data securely and not make it available to any third party unless permitted or required to do so by law.

Any data produced from the online questionnaire will be completely anonymous. All data will be analysed and downloaded on a password protected computer at the University of the West of England. Back-up copies of electronic data will be made regularly onto a password protected CD. All source documents will be retained for a period of 5 years following the end of the study.

I agree to the University processing my personal data as described above

☐ *Please tick box*

About you:

Name: ……

Participant ID: (to be completed by research team) : ……

What is physical activity? - For the purposes of this questionnaire we use the following definition to cover both terms 'physical activity' and 'exercise':

Physical activity includes all forms of activity, such as everyday walking or cycling to get from A to B, work-related activity, active recreational activities (such as going to the gym), dancing, gardening or playing active games, as well as organised and competitive sport.

Examples: Swimming, brisk walking, range of motion exercises, exercise classes, cycling, dancing, tai chi, or gardening.

Note: This can include any exercises you may have been given to do by a healthcare professional.

What Are Your Reasons for Exercising?

On the following pages are a number of statements concerning the reasons people often give when asked why they exercise. ***Whether you currently exercise regularly or not,*** please read each statement carefully and indicate, by circling the appropriate number, whether or not each statement ***is true*** for you personally, ***or would be true*** for you personally if you did exercise. If you do not consider a statement to be true for you at all, circle the '0'. If you think that a statement is very true for you indeed, circle the '5'. If you think that a statement is partly true for you, then circle the '1', '2', '3' or '4', according to how strongly you feel that it reflects why you exercise or might exercise.

Remember, we want to know why ***you personally*** choose to exercise or might choose to exercise, not whether you think the statements are good reasons for *anybody* to exercise.

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
1.	To stay slim	0	1	2	3	4
2.	To avoid ill-health	0	1	2	3	4
3.	Because it makes me feel good	0	1	2	3	4
4.	To help me look younger	0	1	2	3	4
5.	To show my worth to others	0	1	2	3	4
6.	To give me space to think	0	1	2	3	4
7.	To have a healthy body	0	1	2	3	4
8.	To build up my strength	0	1	2	3	4
9.	Because I enjoy the feeling of exerting myself	0	1	2	3	4
10.	To spend time with friends	0	1	2	3	4
11.	Because my doctor advised me to exercise	0	1	2	3	4

		Not at all true for me				**Very true for me**
	Personally, I exercise (or might exercise) ...					
12.	Because I like trying to win in physical activities	0	1	2	3	4
13.	To stay/become more agile	0	1	2	3	4
14.	To give me goals to work towards	0	1	2	3	4
15.	To lose weight	0	1	2	3	4
16.	To prevent health problems	0	1	2	3	4
17.	Because I find exercise invigorating	0	1	2	3	4
18.	To have a good body	0	1	2	3	4
19.	To compare my abilities with other peoples'	0	1	2	3	4
20.	Because it helps to reduce tension	0	1	2	3	4
21.	Because I want to maintain good health	0	1	2	3	4
22.	To increase my endurance	0	1	2	3	4
23.	Because I find exercising satisfying in and of itself	0	1	2	3	4
24.	To enjoy the social aspects of exercising	0	1	2	3	4
25.	To help prevent an illness that runs in my family	0	1	2	3	4
26.	Because I enjoy competing	0	1	2	3	4
27.	To maintain flexibility	0	1	2	3	4
28.	To give me personal challenges to face	0	1	2	3	4
29.	To help control my weight	0	1	2	3	4
30.	To avoid heart disease	0	1	2	3	4
31.	To recharge my batteries	0	1	2	3	4
32.	To improve my appearance	0	1	2	3	4
33.	To gain recognition for my accomplishments	0	1	2	3	4

	Personally, I exercise (or might exercise) ...	**Not at all true for me**				**Very true for me**
34.	To help manage stress	0	1	2	3	4
35.	To feel more healthy	0	1	2	3	4
36.	To get stronger	0	1	2	3	4
37.	For enjoyment of the experience of exercising	0	1	2	3	4
38.	To have fun being active with other people	0	1	2	3	4
39.	To help recover from an illness/injury	0	1	2	3	4
40.	Because I enjoy physical competition	0	1	2	3	4
41.	To stay/become flexible	0	1	2	3	4
42.	To develop personal skills	0	1	2	3	4
43.	Because exercise helps me to burn calories	0	1	2	3	4
44.	To look more attractive	0	1	2	3	4
45.	To accomplish things that others are incapable of	0	1	2	3	4
46.	To release tension	0	1	2	3	4
47.	To develop my muscles	0	1	2	3	4
48.	Because I feel at my best when exercising	0	1	2	3	4
49.	To make new friends	0	1	2	3	4
50.	Because I find physical activities fun, especially when competition is involved	0	1	2	3	4
51.	To measure myself against personal standards	0	1	2	3	4

If you **DO NOT** currently participate in physical activity, please answer the following question:

How long has it been since you did ***regular*** physical activity or exercise? (please circle)

o) Less than 6 months
p) More than 6 months but less than 1 year
q) More than 1 year but less than 2 years
r) More than 2 years but less than 5 years
s) More than 5 years but less than 10 years
t) More than 10 years
u) I have never been regularly physically active

If you **DO** currently participate in physical activity, answer the following questions:

9) How many days per week are you physically active? (circle/days) 1 2 3 4 5 6 7
10) Approximately how long each day (minutes)? _____ mins
11) How long have you been physically active at this level? (please circle)
    m) Less than 6 months
    n) More than 6 months but less than 1 year
    o) More than 1 year but less than 2 years
    p) More than 2 years but less than 5 years
    q) More than 5 years but less than 10 years
    r) More than 10 years

12) What activities do you do? (please circle all that apply)
    u) Walking
    v) Swimming
    w) Cycling
    x) Gym
    y) Exercise classes

z) Dancing

aa) Gardening

bb) Tai Chi

cc) Exercises from a healthcare professional

dd) Other (please state)

For each statement below, circle the statement that most accurately reflects your opinion

Self-Efficacy for Exercise

If I want to exercise, I know I can do it	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
I'm not sure I could exercise regularly, even if I wanted to	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
I feel unsure about my ability to exercise	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
A person with medical problems like mine cannot exercise regularly	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Barriers to Exercise

Exercise takes too much time	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is a waste of time	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Exercise is boring	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Benefits of Exercise

Exercise helps people feel more attractive	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise makes people feel good physically and emotionally	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise can help lift one's spirits	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise gives a person more energy	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise helps people manage their problems better	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

The impact of exercise on arthritis

Regular exercise will probably make my arthritis worse in the future	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis who exercise will remain more independent	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis should be encouraged to exercise regularly	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise is dangerous for people with arthritis	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise causes too much pain to be helpful	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
Exercise causes arthritis flare-ups	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree
People with arthritis who exercise are healthier	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

Exercise is a way to lessen the impact of arthritis	Strongly disagree	Disagree	Don't agree or disagree	Agree	Strongly agree

(continues on next page)

What Have You Actually Gained From Exercise?

This section of the questionnaire can only be completed by people who have some current or recent experience of exercise. So if you have not exercised within the last twelve months, please just put a cross here and skip this section ☐

The questions are about what you have actually gained from exercise. This may be the same or different from what you originally wanted or hoped to gain. Please tell us your personal experience of exercise using the following scale:

0 = Not at all true for me
2 = Somewhat true for me
4 = Very true for me

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
1.	I have lost weight through exercising	0	1	2	3	4
2.	I have found the experience of exercising enjoyable	0	1	2	3	4
3.	I have been able to develop personal skills	0	1	2	3	4
4.	I have found exercising satisfying in and of itself	0	1	2	3	4
5.	I have stayed/become more agile through exercise	0	1	2	3	4
6.	It has allowed me to accomplish things that others are incapable of	0	1	2	3	4
7.	It has helped me to maintain flexibility	0	1	2	3	4
8.	I have found physical activities fun, especially when competition was involved	0	1	2	3	4
9.	I have made new friends through exercise	0	1	2	3	4

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
10.	It has helped me to have a better body	0	1	2	3	4
11.	It has helped me to get stronger	0	1	2	3	4
12.	It has enabled me to stay slim	0	1	2	3	4
13.	It has given me personal challenges to face	0	1	2	3	4
14.	I have felt at my best when exercising	0	1	2	3	4
15.	It has reduced my risk of heart disease	0	1	2	3	4
16.	It has helped me to reduce tension	0	1	2	3	4
17.	I have followed my doctor's advice by exercising	0	1	2	3	4
18.	I have been able to enjoy competing	0	1	2	3	4
19.	It has helped me to have a healthy body	0	1	2	3	4
20.	I have been able to develop my muscles	0	1	2	3	4
21.	I have been able to manage stress through exercising	0	1	2	3	4
22.	I have increased my endurance	0	1	2	3	4
23.	I have been able to stay/become flexible	0	1	2	3	4
24.	I have been able to avoid ill-health	0	1	2	3	4
25.	It has allowed me to compare my abilities with other peoples’	0	1	2	3	4
26.	It has given me space to think	0	1	2	3	4
27.	It has allowed me to spend time with friends	0	1	2	3	4
28.	It has helped me to look more attractive	0	1	2	3	4
29.	It has given me goals to work towards	0	1	2	3	4
30.	I have built up my strength through exercising	0	1	2	3	4

	My personal experience of exercise has been that ...	**Not at all true for me**				**Very true for me**
31.	It has allowed me to measure myself against personal standards	0	1	2	3	4
32.	I have been able to enjoy physical competition	0	1	2	3	4
33.	It has helped me to maintain good health	0	1	2	3	4
34.	I have been able to prevent health problems	0	1	2	3	4
35.	I have liked trying to win in physical activities	0	1	2	3	4
36.	It has helped control my weight	0	1	2	3	4
37.	It has helped me to recharge my batteries	0	1	2	3	4
38.	It has helped me to recover from an illness/injury	0	1	2	3	4
39.	I have felt more healthy	0	1	2	3	4
40.	I have had fun being active with other people	0	1	2	3	4
41.	I have gained recognition for my accomplishments	0	1	2	3	4
42.	I have been able to improve my appearance	0	1	2	3	4
43.	I have been able to show my worth to others	0	1	2	3	4
44.	I have released tension by exercising	0	1	2	3	4
45.	I have felt good through exercising	0	1	2	3	4
46.	It has helped me to burn calories	0	1	2	3	4
47.	I have enjoyed the feeling of exerting myself	0	1	2	3	4
48.	It has helped me to look younger	0	1	2	3	4
49.	It has helped reduce the risk of an illness that runs in my family	0	1	2	3	4
50.	I have found exercise invigorating	0	1	2	3	4

		Not at all true for me				**Very true for me**
	My personal experience of exercise has been that ...					
51.	I have enjoyed the social aspects of exercising	0	1	2	3	4

Thank you

THIS IS THE END OF THE QUESTIONNAIRE

Appendix E5: Ethical Approval Letter

Faculty of Health & Applied Sciences
Glenside Campus
Blackberry Hill
Stapleton
Bristol BS16 1DD

Tel: 0117 328 1170

UWE REC REF No: HAS.18.04.140

4th May 2018

Alice Berry
Blue Lodge
Glenside Campus
UWE
Bristol

Dear Alice

Application title: Acceptability and Usability of a Digital Intervention to facilitate sustained engagement in physical activity for people with osteoarthritis

I am writing to confirm that the Faculty Research Ethics Committee are satisfied that you have addressed all the conditions relating to our previous letter sent on 30th April 2018 and the study has been given ethical approval to proceed.

Please note that any information sheets and consent forms should have the UWE logo. Further guidance is available on the web: https://intranet.uwe.ac.uk/tasks-guides/Guide/writing-and-creating-documents-in-the-uwe-bristol-brand

The following standard conditions also apply to all research given ethical approval by a UWE Research Ethics Committee:

1. You must notify the relevant UWE Research Ethics Committee in advance if you wish to make significant amendments to the original application: these include any changes to the study protocol which have an ethical dimension. Please note that any changes approved by an external research ethics committee must also be communicated to the relevant UWE committee.
   http://www1.uwe.ac.uk/research/researchethics/applyingforapproval.aspx

2. You must notify the University Research Ethics Committee if you terminate your research before completion;

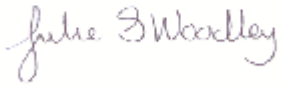
3. You must notify the University Research Ethics Committee if there are any serious events or developments in the research that have an ethical dimension.

Please note: The UREC is required to monitor and audit the ethical conduct of research involving human participants, data and tissue conducted by academic staff, students and researchers. Your project may be selected for audit from the research projects submitted to and approved by the UREC and its committees.

Please remember to populate the HAS Research Governance Record with your ethics outcome via the following link: https://teams.uwe.ac.uk/sites/HASgovernance.

We wish you well with your research.

Yours sincerely



Dr Julie Woodley
Chair
Faculty Research Ethics Committee

c.c. Nicola Walsh

Appendix E6: Sample of the Independent Coding Exercise (NW, CM, AB)

Key: AA = Affective Attitude, B = Burden/intended use, E = Ethicality/Value, IC = intervention coherence, OC = Opportunity costs, PE = Perceived effectiveness, SE= Self-efficacy

INTERVIEW P2	NW	CM	AB	Final Vote (and any reasoning)
INTERVIEW STARTS Thank you. It's so good to see people use it, you know. So OK, so what are your thoughts about the intervention now that you have had a go at using it. Any particular thoughts about it at all? **I am interested in the word, intervention. Because to me if you are involved in an intervention you are, I would tend to take more of a passive role in that. Certainly an intervention is a programme, so I am not quite sure about that word but as an experience I am happy to talk about it and please forgive me if I am being too pedantic. So as an activity, yes I think it was very interesting. It was not unenjoyable, I was quite happy, interested to go through it. Some of it I didn't really identify with but I think I**	AA/PE	AA	AA/E	AA

explained that. I think so of it yes, it's very much the journey I have been on and it's nice to know that everybody else is going on a similar journey so that was good Did you, what did you like or not like? Is there anything that can stand out in your mind when you looked at it that you particularly liked or disliked **I did like the circles with the bullet points in because reading is not a string point for me. And I understand that there needs to be some context occasionally so that's fine. I liked that. I do like the fact that you have got different colours and things in it because otherwise it becomes very boring. I do like the black on the white, I like the contrast, it's good to make the reading easy because we all know as we get older our eyesight isn't brilliant.** Anything you didn't like? **Only the thing about settings, roles, I don't want to put it down, it's not going to be anything that I thought about that**	AA/SE None	AA AA	To be used for usability write up AA	Usability – used separately AA

Key: AA = Affective Attitude, B = Burden/intended use, E = Ethicality/Value, IC = intervention coherence, OC = Opportunity costs, PE = Perceived effectiveness, SE= Self-efficacy

INTERVIEW P2	**NW**	**CM**	**AB**	**Final Vote (and any reasoning)**
How do you think you might use it in the future? So if this was perhaps, if it was a real life website you would log in that would be your own personal programme, would that make a difference **It's in my head or I have got my google calendar which is my plan anyway, what am I doing this week and you know, I will have something like, we are walking today and walking to 'place' or something and back. So I already have a vehicle for my plan but it would be useful to have something that you can think, OK can I just review what I am doing, is there, I don't know, so my preference is actually just to talk it through with someone, is there anything else I should be doing really. It's that because I can think about what I need to do and my motivation comes from within but** **as I said recently I got into a pickle and couldn't understand why I couldn't get out of pain and I realised, when I spoke to somebody that I had, I hadn't done the pacing properly. So that's not very helpful I don't think**	AA PE	AA AA	AA/B AA/PE	AA AA/PE

So I mean as part of some of these goals if you were to choose, you know, say, I am going to keep fit, I am going to review it in a month or anything like that, would you, you just mentioned reviewing goals. So there is an option at the bottom here				
I would probably do something every 6 months, that would be quite useful I think. Because it is seasonal what you do anyway. I think that would be quite useful to do, say, what am I doing. It might be that I have a smorgasbord of activities that I do and I can then stick what I do most often at the top for example to the one down the bottom and then have a list of things I might like to do over the next 6 months. That can be useful then to look back and see actually have I done that. And if not, it's not the end of the world because there are other calls on one's time that may be more important for example elderly parents and having to help them. That's more important than me doing my walk	AA/PE OC PE	B/AA E	OC OC/E	AA/OC E (AND OC)

Key: AA = Affective Attitude, B = Burden/intended use, E = Ethicality/Value, IC = intervention coherence, OC = Opportunity costs, PE = Perceived effectiveness, SE= Self-efficacy

INTERVIEW P2	NW	CM	AB	Final Vote (and any reasoning)
Would there be a method then that you would prefer to have. Would that be something you would record yourself or would you like an email, or a face-to-face appointment every 6 months?				
I think an email would be good to remind me. Just say, OK, Hi have you, you know, its 6 months since your last appointment, would you like to review what you said last time. I think that would be great because that's as much as I personally would probably need	PE/E	AA	B/PE	PE (AND B – intended use etc)
Yes. Just something that's external to me and even if it was a nice little table saying, OK, what do you fancy, what do you think you will do, what 3 activities do you think you will focus on over the next 6 months. And you know, is there any challenges to overcome in order to achieve them and how are you going to do that. That sort of thing. I think that would be quite good. So if there was a gap between wants and reality, how can we bridge that gap? Think about it. And it might be then that I do need to think about needing some help here. I might need to go to a class or something. So an email would be great	PE/E	AA	B/PE	PE (AND B – intended use etc)

So perhaps a more simple version of this in an email where it is just very easy to complete and have that as a record				
Yes. That's it, that would be great. I can see myself already filing it into my personal under health **Then I can look it up again in 6 months' time when I get the next one**	PE/AA	AA	B	AA
OK. How confident are you that you can complete tasks on this website. The tasks that you worked through?				
Yeah. If I had to do it I could do it	SE	SE	SE	SE

Appendix F: Publications and Presentations

Chapter 9: Digital Behaviour Change Interventions to Facilitate Physical Activity in Osteoarthritis: A Systematic Review

Introduction

Physical activity is recommended as a core treatment for osteoarthritis (OA), irrespective of disease severity, age, and pain levels (1,2), yet 44% of people with OA report doing no activity at all (3). Low-cost, effective, and accessible interventions are needed to provide information, support and encouragement to stay active (4). Digital Behaviour Change Interventions (DBCIs) employ digital technologies (such as websites, apps, or wearable devices) to promote and maintain health (5), and have the potential to overcome many barriers associated with face-to-face programmes, by offering cost-effective and widely accessible information, that can be tailored to the individual (6–8). A number of systematic reviews have reported small to moderate positive effect sizes of DBCIs for increasing physical activity in healthy adults, adults with a chronic condition, and older adults (4,6,9–11). To the authors' knowledge, no systematic reviews have been published on the effectiveness of DBCIs at increasing levels of physical activity specifically for people with OA. Given OA affects 8.75 million people in the UK (12), even small positive effects could have significant public health consequences (6).

Previous reviews in similar populations describe how a wide range of behaviour change techniques (BCTs) have been used (9), making it difficult to ascertain which are the effective components. BCTs are observable, and replicable components of an intervention proposed to be the 'active ingredients' (13). There are also a lack of reviews which have examined how behavioural theory has been used to develop interventions (14). This makes it difficult to draw conclusions as to whether findings (positive or negative) are due to a lack of theoretical fidelity, or other factors such as inappropriate intervention content (7). Further exploration is needed to learn more about which BCTs and behavioural theories are linked to effectiveness, over the long term (6), so that future

interventions can be more focused and streamlined. Website usage, such as number and duration of log-ins, has also been insufficiently reported (4,9–11). Further exploration of intervention usage is needed, not only to see how usage of a DBCI might be linked to levels of PA, but also to learn more about how people choose to use DBCIs in everyday life, and over longer periods of time.

This review addresses the areas that have been poorly explored and reported in previous studies in this area. Specifically, the aims of this study are to explore; the effectiveness of existing DCBIs in increasing levels of physical activity in people with osteoarthritis; which behavioural theory and BCTs have been used in existing DCBIs; and how physical activity, website usage and attrition have been measured and reported.

Methods

Criteria for considering studies for this review

Details of the inclusion criteria are detailed below:

- Randomised or quasi-experimental studies of interventions for adults with OA. This was purposively not limited to RCTs to provide a more comprehensive picture of published research in this evolving area (Note: It was recognised that interventions existed which were aimed at people with a range of different chronic conditions. Where possible, results of the OA participants (only) were used in this review (Clarification of the sample analysed is provided in the 'sample size' column, in tables 5 and 6 – results)).
- Primary or secondary aim to increase levels of physical activity. Studies focusing on general self-management (for OA) were only included if they had a physical activity element.
- Whole, or part of an intervention delivered via a digital platform (e.g. website, app, telehealth).
- Level of physical activity reported, as primary or secondary outcome measure. Any studies which failed to measure actual physical activity levels were excluded.
- Any country of origin, but English language papers only.

Study Identification

The search strategy (Supplement 1) was established after reviewing search terms in literature reviews in the area of physical activity interventions (digital and non-digital) for arthritis, musculoskeletal pain and other chronic diseases. The following databases were searched from inception to July 2017: AMED, CINAHL Plus, Cochrane Library, Embase, Medline, PsycINFO, Pubmed, SPORTDiscus and Web of Science.

Data collection and analysis

Selection of studies

All abstracts were independently screened by two members of the research team (AB and either NW, CM, SM). Full-texts of remaining articles were independently assessed by two members of the research team (AB and either NW, CM, SM). Any disagreements were discussed with a third team member until consensus was reached. Reference lists of the included studies were checked for other potentially eligible papers. Data from conference abstracts were not included unless corresponding full-text articles were available. Abstract authors were contacted to request further details when necessary.

Data extraction and measurement

All data were extracted using a pre-defined data extraction form. This was based on previous systematic reviews of digital interventions (6,8,10,15), with focus given to the specific information required to meet the objectives of this review.

The Behaviour Change Technique Taxonomy (v1) (16) was used to identify which BCTs had been used. Each intervention was coded by evaluating all descriptions of the interventions, including any other development papers identified.

Quality Assessment

The quality of studies were evaluated using the critical appraisal skills programme (CASP) tools for RCTs and Cohort studies (17). Each article was independently reviewed by two members of the team (AB and NW). Any disagreements were resolved through discussion.

Risk of bias

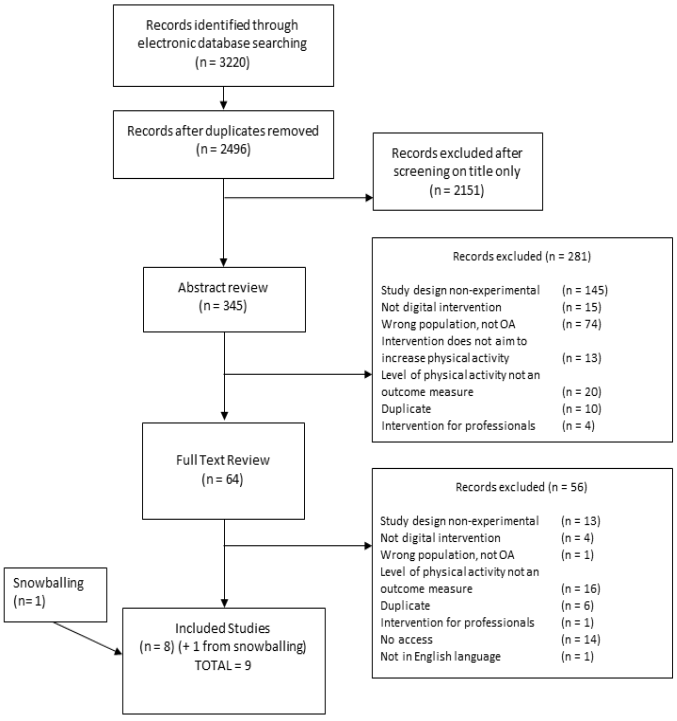
Included papers were assessed using the Cochrane Collaboration's tool for assessing risk of bias (18). A full assessment was carried out for those studies which adopted a randomised design; studies adopting other designs were assessed for attrition bias, reporting bias, and for any other observed source of bias. Studies were assessed independently by two members of the research team (AB and either NW or SM) to ensure consistency.

Results

Results of the search

Figure 1 shows the results of the study selection process. A total of nine studies were eligible for review. Eight of these were obtained from the original search and one additional study was found through a review of reference lists.

Figure 1. Study selection and screening procedures



Characteristics of Studies and populations

The included studies were carried out in Australia, Canada, the Netherlands, UK and USA. Sample size varied greatly from 20 to 958 participants, and females made up the majority of the study

samples. Tables 1 and 2 (RCTs and Non-randomised respectively) show details of the main characteristics of the studies.

Five studies focused on people with 'arthritis' (rheumatoid arthritis, osteoarthritis or fibromyalgia) or analysed the proportion of the sample with arthritis separately (19–23). The four remaining studies included participants with a number of different chronic conditions such as diabetes, heart disease, and arthritis (24–27). These studies did not split the results into sub-groups, therefore all outcomes reported are for the whole cohort.

Table 1 - Characteristics of Included Studies - (Randomised Controlled Trials – RCTs)

Author, year	Location of Study	Study Design	Name of Intervention	Study Aim	Sample Size	Population	Gender	Age range of participants
Bossen et al, 2013 (RCT) (19)	Netherlands	RCT	Join2move	Short (3 months) and long-term (12 months) effectiveness of the intervention in patients with knee and/or hip OA in physical activity , physical function, and self-perceived effect	199	Self-reported knee and/or hip OA	Intervention – 40% male, 60% female Control – 30% male, 70% female	Intervention mean = 61 Control group mean = 63
Lorig et al, 2006 (25)	USA	RCT	Internet-based Chronic Disease Self-Management Program (I-CDSMP)	1-year outcomes (health status, health behaviour and health care utilisation)	958	Arthritis: 24.9% (usual care), 24.9% (online intervention) Other: diabetes, hypertension, lung disease, heart disease.	Female 71.6% usual care, 71.2% online intervention Male 28.4% usual care, 28.8% online intervention	Range 22 to 89) Control: 57.6 (SD ± 11.3) Intervention: 57.4 (SD ± 10.5)

Lorig et al, 2008 (21)	USA	RCT	Internet-based Arthritis Self-Management Programme (I-ASMP)	6-month and 1-year outcomes (health status, health behaviour, self-efficacy, and health care utilisation).	855	546 (63.9%) had OA. Usual care: 26.6% RA, 64.9% OA, 51.3% Fibromyalgia Intervention: 28.3% RA, 62.3% OA, 49.2% Fibromyalgia	Usual care: 9.5% male 90.5% female Intervention: 10.2% male 89.8% female	Usual Care: 52.5 (SD ± 12.2) Intervention: 52.2 (SD ± 10.9)
Skrepnik et al, 2017 (22)	USA	RCT	OA GO	To evaluate the impact of a mobile app, plus wearable activity monitor/pedometer (Jawbone UP 24) used for 90 days on the mobility of patients with knee OA treated with hylan G-F 20	211	Adults with OA	Intervention: male = 45%, females = 55% Control: male = 55%, females = 45%	Total sample: mean 62.6 (SD = 9.4) Intervention: 61.6 (SD ± 9.5) Control: 63.6 (SD ± 9.3)
Trudeau et al, 2015 (23)	USA	RCT	painACTION.com	To assess the efficacy (outcomes included: arthritis self-efficacy, pain	228	OA only (59%),	Female = 68.4% Male = 31.6%	49.9 (SD ± 11.6)

				catastrophizing, pain awareness, exercise behaviours, symptoms mngt, communication with physicians, and pain levels) of the intervention, at 1, 3, and 6 months.		RA or other arthritic condition (41%)		

Table 2 – Characteristics of Included Studies – (Non-Randomised/Cohort Studies)

Author, year	Location of Study	Study Design	Name of Intervention	Study Aim	Sample Size	Population	Gender	Age range of participants
Bossen et al, 2013 (20)	Netherlands	Pre-post test	Join2move	Preliminary effectiveness (physical activity, physical function and self-perceived effect), feasibility and acceptability of join2move in patients with knee and/or hip OA?	20	Self-reported knee and/or hip OA	Female – 75% Male – 25%	Mean = 64 (SD ± 6.6)
Jaglal et al, 2012 (24)	Canada	Two-group, pre-post test	Telehealth version of Chronic Disease Self-management Programme (Tele-CDSMP)	Does access to tele-CDSMP in rural and remote communities improve self-efficacy, health behaviours, and health status and whether there are differences in outcomes between the two delivery models (single/multiple site).	213	Arthritis (76.5%). Other conditions included: Heart, lung, diabetes, other MSK, and stroke	Female: 158, Male: 52 (3 unknown)	45-88, median = 67

Lorig et al, 2008 (21)	UK	Implementation study	Expert Patients Programme Online (EPP Online) (version of I-CDSMP)	6 and 12 month outcomes (health distress, self-rated health, illness intrusiveness, disability, fatigue, pain and shortness of breath), four behaviours (aerobic exercise, stretching exercise, stress mngt and communications with physician), and five utilization measures (GP visits, pharmacy visits, PT/OT visits, emergency visits and hospitalisations)	593	Arthritis (30.5%). Other: Diabetes, hypertension, lung disease, heart disease, mental health conditions, ME, MS, back problems	Female = 77.9% Male = 22.1%	median age = 45
Lorig et al, 2013 (27)	Australia	Implementation study		1: Could the ICDSMP be successfully implemented in South Australia? 2: Could the ICDSMP reach rural and aboriginal people less served by CDSMP? 3: Effect on health behaviours, health	254	Arthritis (40.1%) Other: Asthma, cancer, COPD, diabetes, heart disease, lung disease,	Female = 68.5% Male = 31.5%	Median age = 45

				status, health care utilisation, reduction in lost workdays?		mental health condition, Other chronic condition		

Description of Digital Interventions

Across the nine included studies, five different interventions were evaluated. Details about how each of the interventions was delivered, is given below.

- Join2Move (19,20) – A fully-automated, web-based intervention containing automatic (tailored) functions (text messaging and e-mails) without human support; self-paced; nine week programme.
- Internet-based Arthritis Self-Management Programme (I-ASMP) (21) – A six week internet-based course; peer moderators; email reminders to encourage participation; tailored information to participants.
- Internet-based Chronic Disease Self-Management Programme (I-CDSMP) (25–27) - A six week internet-based course; peer moderators; email reminders to encourage participation; tailored information to participants. (Note: (26) This study evaluated the Expert Patients Programme – an intervention based on the I-CDSMP).
- Telehealth-CDSMP (24) – Same content as CDSMP programme described above, course ran via live video and audio communications between the participants and moderators.
- OA GO App (22) – Mobile phone app providing motivational messages; goal setting (daily steps); linked to wearable activity monitor; self-monitoring (pain and mood); No moderator.
- PainACTION (23) - Web-based patient education, self-management intervention. Modular; No moderator.

Quality Appraisal

Tables 3 and 4 (attached as supplement file 2) present a summary of the results.

In summary, the quality of RCTs was moderate to strong. Strengths included; adequate reporting of all patient outcomes at conclusion (4/5), similarities between control and intervention groups at baseline (5/5), the measurement of clinically important outcomes (5/5), and results that can be applied to people with osteoarthritis (5/5). Details of randomisation, blinding procedures, and confidence limits, were not always reported.

The cohort studies were found to be of moderate quality. Strengths included: acceptable recruitment procedures (4/4), accurate measurement of outcomes (self-reported, but validated instruments used) (4/4), and sufficient fit of results in line with similar studies (4/4).

Risk of Bias

Tables 5 and 6 show the overall risk of bias for the included studies. (Attached as supplement file 3).

Risk of bias for RCTs:

Three studies were considered to have a predominantly low risk of bias (19,22,23) , by adequately describing how group allocation was concealed, how incomplete data was dealt with (such as using intent-to-treat analysis), and reported all *a priori* analyses. Two RCTs (21,25) failed to provide detailed information about random sequence generation, allocation concealment, and blinding, therefore were judged to be at a higher risk of bias. Sources of other bias, such as an inappropriate study design, or extreme baseline imbalance, were also explored. One study (23) provided a financial incentive to participants of $250, and therefore was judged to be of high risk.

Risk of bias for Implementation and pre-post-test studies

Risk of bias assessments for incomplete outcome data, selective reporting, and other sources of bias were carried out for these studies. Two were judged to sufficiently report outcome data (19,26). One study reported a data collection error, resulting in incomplete outcome data, therefore was considered to have a high risk of bias (27). All studies reported outcome measures that were initially described, and were therefore considered to have a low risk of bias for selective reporting.

Effectiveness of Digital Behaviour Change Interventions

A statistically significant difference between intervention and control groups were seen at post-intervention in three of the RCT studies (Table 7) (19,22,25). Three of the non-randomised studies (Table 8) also found levels of physical activity were significantly improved post-intervention (24,26,27). Furthermore, the studies which reported non-significant improvements in levels of physical activity, noted a trend towards increased participation (20,21,23)

Table 7 - Effectiveness of Interventions evaluated by RCTs

Author (year)	Sample Size	Physical activity outcome measures	Endpoints	PA Change (difference between gps) (mean)	P Value
Bossen, 2013 (19)	199 (All OA)	Physical Activity Scale for the Elderly (PASE) Accelerometer	3 months 12 months 3 months 12 months	-1.6 (-16.6 to 13.5) 21.2 (3.6 to 38.9) 3 (-26 to 32) 24 (0.5 to 46.8) (Mean (95% confidence interval))	0.84 0.02* 0.83 0.045*
Lorig, 2006 (25)	958 (not split) 24.9% of sample had arthritis	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	12 months 12 months	10.75 4.11	0.024* 0.701
Lorig, 2008 (21)			12 months	-1.97	0.999

	Total sample: 855 (OA sample reported here = 292)	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	12 months	22.28	0.260
Skrepnik et al 2017 (22)	Total = 211 Group A = 107 Group B = 104 (All OA)	Least squares (LS) mean number of steps per day – change from baseline to 3 months	3 months	732	0.03*
Trudeau 2015 (23)	228 (Not split – arthritis – OA,RA, or other arthritic condition)	Stretching/strengthening (minutes per week) Aerobic exercise (minutes per week)	6 month 6 month	2.58 3.53	NSD NSD

*significance at $p<0.05$, NSD = No significant difference

Table 8 - Effectiveness of interventions evaluated by Implementation/cohort studies

Author (Non-RCTs)	Sample Size	Outcome measures	Endpoints	PA Change between baseline and endpoint (mean/SD)	P Value
Bossen 2013 (20)	20 (All OA)	Total PA (mins per week)	3 months	347	0.3
		Moderate PA (mins per week)	3 months	230	0.43
Jaglal 2013 (24)	213 (not split) 76.5% of sample had arthritis	Stretching/strengthening (minutes per week)	4 months	17.9 (67.1)	<0.001*
		Aerobic exercise (minutes per week)	4 months	39.8 (133.1)	<0.001*
Lorig 2008 (26)	593 (not split) 30.5% of sample had arthritis	Stretching/strengthening (minutes per week)	6 months	10.7 (54.4)	<0.001*
			12 months	6.62 (52.2)	0.009*
		Aerobic exercise (minutes per week)	6 months	9.40 (76.2)	0.008*
			12 months	14.6 (83.3)	<0.001*
Lorig 2013 (27)	254 (not split) 40.1% of sample had arthritis	Stretching/strengthening (minutes per week)	6 months	7.08 (55.7)	0.131
			12 months	21.0 (84.0)	<0.001*
		Aerobic exercise (minutes per week)	6 months	22.1 (89.8)	0.004*
			12 months	32.2 (130)	<0.001*

*significance at p<0.05

Behavioural Theory

Social cognitive theory (SCT) (28), or the key construct of SCT 'self-efficacy', was described as guiding the development of the majority of interventions (n=6). However, further details of which aspects of each intervention were intended to improve levels of self-efficacy were not reported.

Three studies did not report the use of any theoretical concept (19,20,22), however they did provide information about behaviour change techniques employed within the interventions.

Behaviour Change Techniques (BCTs)

The use of BCTs was described in different ways, making it difficult to ascertain which were present. Figure 2 shows the BCTs most commonly used, these included; goals and planning, feedback and monitoring, and social support.

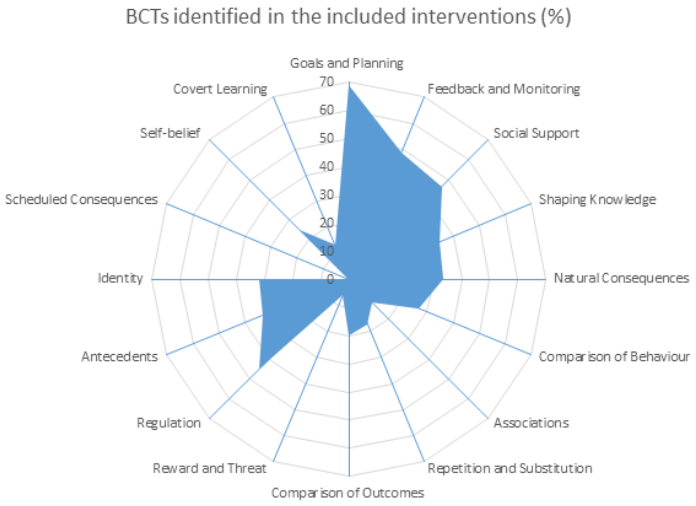
The Join2Move intervention (19,20) contained a range of different BCTs. Key areas included goal setting, action planning, and reviewing the behaviour. This was done by self-monitoring; no external human support was given. Performance charts were built into the programme.

The Arthritis Self-Management Programme (ASMP) (21) and the Chronic Disease Self-Management Programme (CDSMP) (25) had similar content, and a large number of BCTs including: goal setting, action planning and feedback on behaviour, information about health consequences and information about how to perform physical activity, emotional support, distraction, framing/re-framing, valued self-identity, and self-talk. These interventions were human-supported, with feedback provided by trained moderators. They had interactive bulletin boards and an internal messaging centre where participants and facilitators could leave private messages for other users.

The OA GO app (22) focused on goal setting, action planning, self-monitoring of goals, emotional and physical forms of social support, and information about health consequences. This intervention was self-guided, with personalised feedback, and made use of a wearable monitor, so participants could see if personal step goals had been achieved.

The PainACTION intervention (23) made use of similar BCTs, with goal setting, action planning, information about health and emotional consequences, body changes, framing/re-framing, and discussion about incompatible beliefs, included. This intervention was largely self-guided, though did provide automated email reminders to log-on to the website.

Figure 2 – BCTs identified in the included interventions



Interventions which focused specifically on arthritis were more likely to report improvements in physical activity. Significant outcomes were also found for interventions which focused on setting goals, and monitoring behaviours (either peer, or self-monitoring). A key feature of one intervention (19) was the positive reinforcement of gradual physical activity (such as walking or cycling), despite the presence of pain.

Studies which found non-significant changes in physical activity, reported heterogeneous populations (21), and lack of peer interaction (23) as possible reasons for the lack of positive outcomes.

Physical Activity Outcome Measures

The majority of interventions used self-report questionnaires to measure physical activity. Self-reported aerobic exercise (minutes over the last 7 days), and strengthening and stretching exercises (minutes over the last 7 days) were the most common measures. These measures were developed and validated by the Stanford Patient Education Research Centre and have been used in a number of previous studies at Stanford University (29).

Other measures included the Physical Activity Scale for the Elderly (PASE) and the Short Questionnaire to Assess Health-enhancing Physical Activity (SQUASH) (20).

The PASE questionnaire asked participants to report on activity over the last 7 days, the SQUASH questionnaire asked participants to think about an average week over the last few months.

Two studies utilised wearable physical activity monitors (19,22). One study (22) provided participants with Jawbone UP 24 activity monitors, in both control and intervention groups. Another (19) gave accelerometers to a random sub-sample of participants.

Uptake and usage of digital interventions

A clear picture of how many participants completed each online session was often not provided, with only one study giving full details of the number of participants to complete each session (19). Other studies described information such as the average number of log-ins (25),

number of posts generated on discussion boards (26), number of minutes using the intervention (23) and most frequently visited pages (23). One study (22) reported the percentage of participants who were 'compliant' (used the app 80% of the time).

The percentage of people reported to participate in all sessions ranged widely from 31.5% to 79%. One study (23) reported that levels of user engagement were significantly correlated with an improvement in outcome measures, whilst another (19) reported that level of participation had no influence on outcomes. Other studies did not explore how usage was related to any change in levels of PA. The rate of use declined over time in all of the intervention studies, at varying rates. One study (22) reported high adherence with the use of their app, with 96% of the intervention group using the app 80% of the time. This study also reported significant improvements in levels of PA.

Discussion

The aim of this review was to explore the effectiveness of existing DBCIs for increasing levels of physical activity (PA), in those with OA. Included studies provided evidence that people with OA can significantly increase their levels of physical activity (for up to one year post-intervention) using a digital programme. Complexity of interventions varied, and a range of BCTs were used, however, all interventions included a form of goal setting, action planning, provided feedback, and ways of self-monitoring behaviour. Most of the interventions were based on Social Cognitive Theory, or 'self-efficacy' (28).

In particular, two RCT studies with positive outcomes (19,22), focused primarily on increasing PA levels and mobility, as opposed to the general self-management of arthritis (21,25). Bossen et al (19) tested a web-based intervention (Join2Move) which focused on gradually increasing levels of physical activity (determined by participant), over of 8 weeks, and had no human support. Factors that potentially contributed to this success include: 1) focus on gradually increasing chosen activity, despite the presence of pain, 2) users were encouraged to select day-to-day activities that were easy to integrate into a daily routine, 3) intervention was systematically developed and evaluated by potential end-users, prior to testing (19). Skrepnik et al (22) tested a mobile app (OA GO App) linked to an activity monitor, and a daily step goal was set up by the trial coordinator. This support may have been an important factor in the success of the trial. A high percentage of the sample used the app for 80% of the trial (3 months). However, despite the majority choosing to continue using the intervention after the initial 90 days, compliance between 90 – 180 days dropped to just 35.6%. This highlights the issue of long-term engagement both with interventions, and the behaviour they are attempting to influence.

Two RCTs (21,25) evaluated a programme which was previously shown to be effective in small group settings. Both studies aimed to change multiple health indicators and behaviours. One (21) focused on patients with arthritis or fibromyalgia, but failed to significantly increase physical activity. Conversely, the trial which included patients with a range of chronic conditions (25) did report a significant increase for stretching and strengthening exercises, but not aerobic exercise.

Three of the four cohort studies reported significant improvements in PA. Once again, these were based on the chronic disease self-management programme evaluated in two of the RCTs (21,25). Significant findings were reported at 12 months post-intervention, however, results for those with OA were not reported separately. The interventions all had peer moderators, and one was a telehealth version of the self-management programme, so included live interaction via video link between groups and moderators etc. This element of additional moderator support is potentially an important aspect of the success of the programmes.

Despite the majority of studies being based on the concept of 'self-efficacy', none explicitly reported which elements were intended to improve this. Improved descriptions of how self-efficacy has been used to guide content, during the development stages are needed.

Levels of physical activity and use of interventions were measured in a variety of different ways. This heterogeneity amongst outcome measures made comparison difficult, and excluded a meta-analysis. Previous systematic reviews evaluating the effectiveness of digital interventions in non-OA specific populations report similar heterogeneity of outcome measures (4,6,10).

Coding of the elements of each intervention against the behaviour change taxonomy (16) was difficult, due to a lack of detailed reporting on how various elements were attempting behaviour change. MRC guidance (30) calls for improved methods of specifying and reporting intervention content, to address this problem of lack of consistency and consensus.

The findings in this review are in-line with previous reviews. One review (31), explored factors affecting adherence to exercise in people with chronic musculoskeletal pain. They reported effectiveness of trials which targeted exercise adherence specifically, as well as those which studied broader self-management programmes. They also reported on one study which found a positive relationship between graded activity, and exercise adherence, similar to a study included in this review (19). Another review (10) examining internet-delivered interventions for increasing PA levels, found that the inclusion of educational components significantly increased intervention effectiveness. All studies in the present review did include an element of education (coded as 'shaping knowledge'), though techniques such as goals and planning, feedback and

monitoring, and social support, were considered to have a more prominent role. Finally, a review which examined the effectiveness of non-face-to-face physical activity interventions for older adults (32), found the majority of interventions were based on Social Cognitive Theory, individual tailoring was found in most studies, and also reported that intervention dosage varied greatly.

Limitations

Design and population heterogeneity was present across studies making it difficult for comparisons (or meta-analysis) to be made across the whole sample. In particular, the studies evaluating the chronic disease self-management programme were heterogeneous for disease, age, education and symptom distribution (25).

Conclusion

Results of this review show that DBCIs can have a positive effect on levels of physical activity in this population, for up to 12 months post-intervention. Key findings from this review show that interventions with a focused primary aim, which do not try to change multiple behaviours simultaneously, resulted in more effective clinical outcomes, for this population. Importantly, a focus on realistic, and autonomous goals that can be easily integrated into everyday life seemed to produce stronger outcomes.

Both interventions with, and without human support were associated with improved outcomes, making it difficult to judge which is optimal.

In-depth development and evaluation (with potential end-users) prior to full trial, was seen as necessary, and recognised as a strong point for any intervention.

Optimal intervention dosage needs further exploration, as it remains unclear how use of an intervention is associated with long-term engagement with physical activity. Future exploration of intervention burden, optimal frequency of prompts and moderator interaction would provide new evidence in this area.

Future interventions should clearly document which theories, and BCTs were used during the development stage, and use accepted taxonomies to record this. Up-to-date guidelines on the most accepted and valid measure of physical activity adherence should be used, and the uptake and usage of interventions reported in detail.

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Conferences and Seminars

1. Berry A, McCabe CM, Muir S, Walsh N (2018) Beliefs, Motives, and Gains associated with Physical Activity in People with Osteoarthritis. Presented at the 7th International Society for Physical Activity and Health Congress, London, October 2018 (Poster).

2. Berry A, McCabe CM, Muir S, Walsh N (2018) Co-development of a Digital Behaviour Change Intervention to Facilitate Engagement in Physical Activity for people with Osteoarthritis. Presented at the 7th International Society for Physical Activity and Health Congress, London, October 2018 (Oral poster presentation).

3. Berry A, McCabe CM, Muir S, Walsh N (2018) Development of a Digital Behaviour Change Intervention to Facilitate Engagement in Physical Activity for people with Osteoarthritis. Presented at the UWE Annual Postgraduate Conference, Bristol, June 2018 (Oral Presentation).

4. Berry A, McCabe CM, Muir S, Walsh N (2018) Developing a digital behaviour change intervention using Intervention Mapping and the Behaviour Change Technique Taxonomy (v1), to facilitate sustained engagement in physical activity for people with osteoarthritis. Presented at UCL Centre for Behaviour Change Annual Conference – Behaviour Change for Health: Digital and Beyond, London, February 2016 (Poster).

5. Berry A, Walsh N, Muir S and McCabe C (2016). Digital Behaviour Change Interventions for Osteoarthritis - A Systematic Literature Review. Front. Public

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6. Berry A, McCabe CM, Muir S, Walsh N (2015) Digital Health Behaviour Change Interventions to Facilitate Physical Activity in Osteoarthritis - A Systematic Review. Presented at Just Good Medicine – British Heart Foundation National Centre for Physical Activity and Health Annual Conference, Loughborough, UK, September 2015 (Poster).