A systematic review of nonpharmacologic interventions to reduce anxiety in adults in advance of diagnostic imaging procedures.

Simon King[1], Julie Woodley[1], Nicola Walsh[1]

[1]Faculty of Health and Applied Sciences, University of the West of England, Bristol, UK

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Corresponding author address:
Mr Simon King
Glenside Campus
Blackberry Hill
Stapleton
Bristol
BS16 1DD
Simon5.king@uwe.ac.uk

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Abstract

Objectives: Anticipation of a diagnostic imaging (DI) procedure, particularly one involving advanced technology, can provoke feelings of anxiety in patients. Anxiolytics (anxiety reducing drugs) can be used to reduce pre-procedural anxiety in patients, however there are several known disadvantages to this approach. The aim of this systematic review was to identify and evaluate any preparatory non-pharmacological interventions used to reduce patient anxiety in advance of DI procedures.

Key findings: Database searches revealed twelve studies met the eligibility criteria and were included in the review. A narrative synthesis identified three intervention categories: patient information/education, cognitive strategies (i.e. guided imagery, breathing techniques, imaginative visualisation) and music therapy.

Conclusion: The current review demonstrates that despite the existence of a number of studies providing some evidence for the effectiveness of a range of anxiety reducing interventions for patients prior to DI, the small number and overall low quality of studies identified makes it difficult to draw firm conclusions regarding the application of a specific intervention in clinical practice.

Implications for practice: The majority of interventions included in this review were shown to be practical for inclusion in the clinical setting and did have some positive effect on patient anxiety levels. As a result those professionals working with adults undergoing advanced technology DI procedures may consider implementing some of the strategies that have been discussed within their practice.

Keywords

Diagnostic imaging, anxiety, non-pharmacology interventions, systematic review

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Introduction

Advanced technology imaging, such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and hybrid imaging techniques are more complex than other conventional imaging procedures, such as X-ray, more difficult to conduct and require imposing equipment[1]. As a result, the anticipation of a diagnostic imaging (DI) procedure (particularly one using advanced technology) is an event likely to provoke feelings of anxiety in patients[2,3].

Anxiety is a fundamental aspect of the human experience and is understood to be a complex reaction to situations that may be potentially dangerous or are at least perceived to be dangerous, if only because of the uncertainty of the circumstance[4]. An unfamiliar environment, loss of control, perceived physical risk, dependence on strangers and separation from friends and family are all factors that can contribute to the development of such feelings[5].

MRI-associated anxiety is a well-documented phenomena, in which claustrophobia is a key patient concern[6]. Studies have also demonstrated that many patients undergoing CT and nuclear medicine procedures, including Positron Emission Tomography/CT (PET/CT) and Single Photon Emission Computed Tomography/CT (SPECT/CT), can also experience significant levels of anxiety prior to the procedure[3,7,8,9]. A variety of reasons have been reported to cause increased anxiety including fear of the resulting diagnosis and of the procedure itself[3,10,11].

Anxiety reducing drugs, or anxiolytics, can be used to reduce pre-procedural anxiety in patients awaiting a DI procedure, however there is currently no consensus on the actual benefits for this. Furthermore, the administration of such pharmacologic anxiolytics may introduce several other disadvantages, including; difficulty with registration of procedural objections, the inability of out-patients to drive afterward, and adverse reactions to other prescribed drugs[12]. The combination of these factors therefore emphasises the importance of understanding what non-pharmacologic interventions might be effective in reducing patient anxiety.

Research into patient experiences of medical imaging suggests that anxiety can often be linked to a certain aspect of the procedure which the patient does not understand, but which is integral to the production of the image[1]. These aspects might include, the noise during MRI, exposure to radiation, breath holding, contrast agents and the close proximity of imaging equipment[1]. Providing information and explanation about the procedure to the patient has been shown to be especially important for those who undergo DI, as it can provide a means for people to feel in control, in addition to acting as a support measure[1,13,14].

This review sought to answer the following question: Can the available evidence identify an effective non-pharmacological intervention to reduce patient anxiety prior to undergoing a DI procedure? The focus on preparing patients for the imaging procedure rather than simply trying to reduce feelings of anxiety during it, is appropriate when you consider the impact that the pre-cancellation and/or termination of a scan can have on patient care and the clinical department, in terms of workflow and the costs associated with rescheduling of patients.

Methodology

Details of the inclusion criteria for this systematic literature review are as follows:

- Randomised or quasi-experimental studies of non-pharmacological preparatory interventions. This was not limited to randomised control trials (RCTs) to provide as comprehensive a picture as possible of the published evidence.

- Primary aim of the intervention is to minimise or reduce patient anxiety levels prior to a DI procedure.
- Interventions delivered to adult participants (aged 18+) only. This decision was made due to the complexity of a child's experiences within the imaging department environment and the fact that there is generally an increased need for pharmacological intervention (such as patient sedation) in paediatric cases, in order to complete the imaging procedure[15].
- Interventions could be delivered in any format or on any platform
- Level of patient anxiety reported as primary outcome measure. Anxiety levels could be measured using self-reporting scales such as State-Trait Anxiety Inventory (STAI) forms or a physiological response to anxiety.
- Any country of origin but English language papers only due to resource constraints and the challenges of translation.

Study identification

An initial limited search of four key databases was undertaken and this was followed by analysis of the text words and index terms contained in titles and abstracts. The following online databases were searched, using the identified keywords and index terms, from inception to August 2019; Allied and Complementary Medicine (AMED), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Controlled Trials Register (CENTRAL), EMBASE, MEDLINE, PsycINFO and Science Citation Index.

Selection of studies

All abstracts were screened by the lead author and full texts of remaining articles were assessed by two members of the research team. Any disagreements would have been discussed with a third member of the research team for consensus, however this was not necessary. Reference lists of the included studies were checked for further potentially relevant publications, however conference proceedings and abstracts were not included unless the corresponding full text articles were available. Abstract authors were contacted to request further details where necessary.

Risk of bias

Risk of bias was assessed using the Cochrane risk of bias tool[16,17]. This approach ensured that the following five key domains were assessed:

1. Sequence generation (selection bias)

2. Allocation concealment (selection bias)

3. Blinding of participants (performance and detection bias)

4. Incomplete outcome data (attrition bias)

5. Selective outcome reporting (reporting bias)

Results

Figure 1 shows the results of the study selection process. A total of twelve relevant studies were eligible for this review. Ten of these were obtained from the original database search and two additional studies were found through reviewing reference lists.

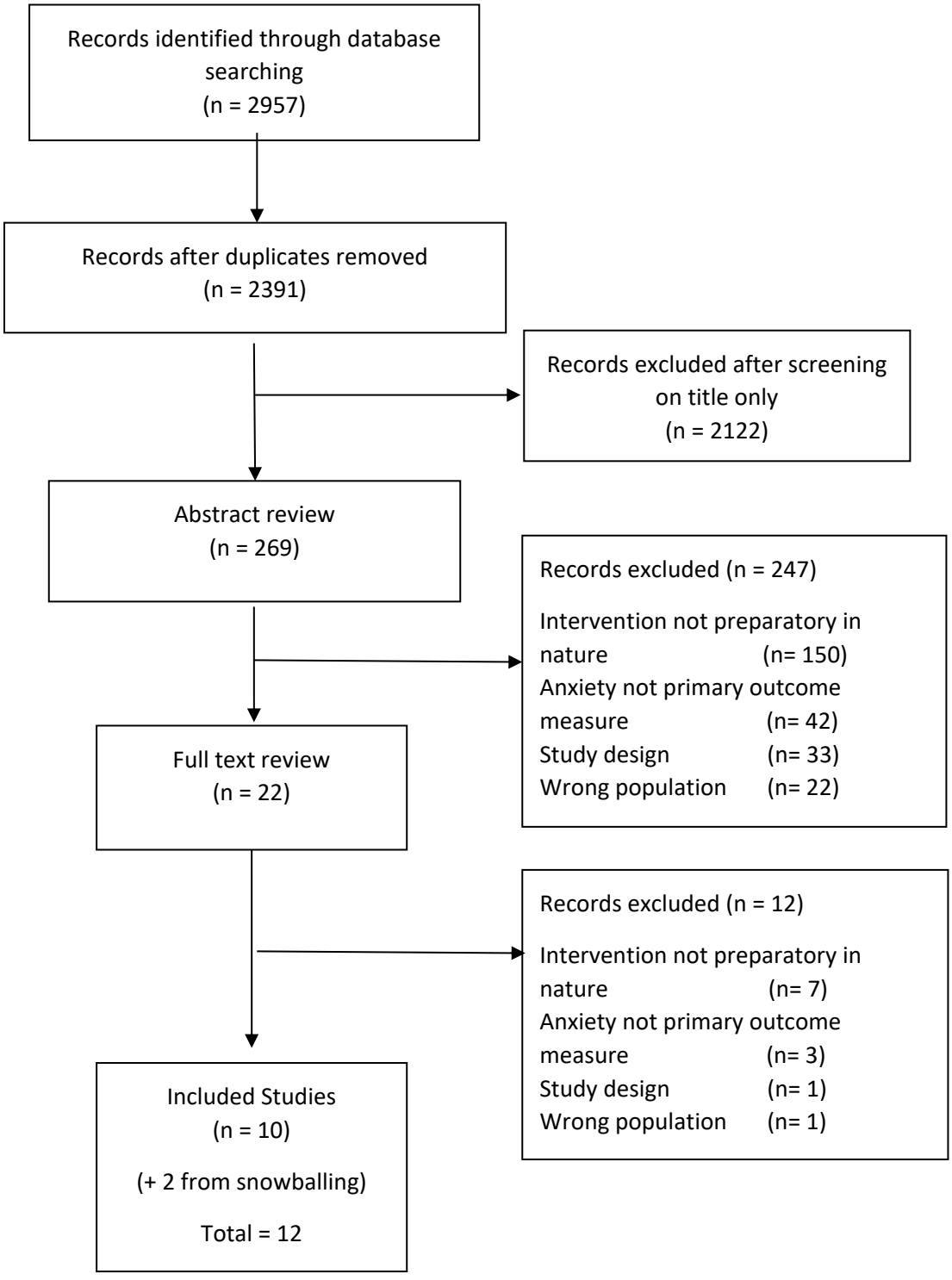

Figure 1 Study selection and screening procedures

Characteristics of studies and populations

The included studies were carried out in the UK, Turkey, Taiwan, Australia, Egypt, Sweden, Netherlands, Canada and USA and the inclusion of results from outside the UK was justified

when you consider the universal nature of anxiety and its potential to impact patients. Included studies represented findings within three different imaging modality settings; MRI (n = 7); Nuclear Medicine (n = 3); and PET/CT (n = 2).

A total of 1604 patients participated in research across the 12 studies and of this total number of participants, 925 patients received some sort of preparatory intervention to reduce anxiety. Sample size varied greatly from 39 to 620 participants and the mean age of patients ranged from 44 years[18] to 60 years[19]. Table 1 provides a summary of the key characteristics of the studies.

Description of preparatory interventions

A wide range of preparatory interventions were investigated across the studies. The interventions were all evaluated for their impact on patient anxiety levels and were categorised within one of the following themes:

1) Patient information/education
2) Cognitive strategies
3) Music therapy

Patient information/education

Patient information interventions were further divided into categories in relation to the format of the intervention including; written, verbal or visual. Two studies investigated the effect of patient information in more than one format[21,23]. Four studies investigated the effectiveness of written information in the form of a leaflet, booklet or letter made available prior to the scan[13,20,21,25] .

Four studies introduced patient information verbally [18,21,22,23]. These verbal interventions included a telephone conversation with the patient prior to attending the imaging department and a scheduled conversation between the patient and radiographer prior to the scan on arrival.

Two studies provided visual information to the patient [23, 24]. These visual interventions involved showing a 10-minute multimedia DVD on the day of the scan explaining the procedure and watching a video clip of the imaging environment prior to attendance.

Of the eight studies investigating the effect of providing patient information/education in addition to a standard appointment letter, five studies demonstrated a statistically significant effect on anxiety levels[13,21,22,23,24]. Two studies found that their ‘patient information’ intervention had no effect [20,25] and one of the studies reported a statistically significant increase in anxiety levels for those patients who received detailed information about the procedure such as radiation exposure and other risk factors[18].

Cognitive strategies

Three studies included some form of cognitive strategy intervention [12,26,27]. There was a range of cognitive strategies represented including using an audiotape of relaxation technique instructions[26]; counselling, in which relaxation techniques, breathing exercises and imaginative visualisation could be discussed[27] and the use of audio-visual imagery in the waiting area[12].

All three studies investigating the effect of cognitive strategies reported a statistically significant reduction in anxiety as a result of their intervention[12,26,27].

Music therapy

One study investigated the effect of listening to meditative music on patient anxiety prior to the procedure[19]. This intervention consisted of a 30 minute recording, integrating Chinese “Chi” and western frequency resonation and reported a statistically significant reduction in anxiety levels in the experimental group.

Outcome measures

All but one of the studies measured patient anxiety using State-Trait Anxiety Inventory (STAI) forms. STAI consists of two separate 20-item self-reporting scales, one for measuring state anxiety and the other for trait anxiety. The questionnaire requires patients to quantify their anxiety levels by indicating their agreement or disagreement with a set of statements such as; “I am tense”, “I feel nervous” or “I am frightened”. Agreement and disagreement are plotted along a four point scale with total possible anxiety scores ranging from 20 to 80. A higher score indicates higher anxiety levels.

These STAI forms were frequently referred to as STAI-S (state) in order to evaluate how the patient felt in that particular situation or moment, and STAI-T (trait) evaluating how the patient felt independent of the situation or condition at that moment. There was marked variation in the use of both or just one of the STAI-S and STAI-T forms, so an overview of which forms were used within each study can be found in Table 1.

The Hospital Anxiety and Depression Scale (HADS) was used in one study[20]. This consisted of seven anxiety questions regarding the patient’s feelings leading up to the procedure and subject ratings were made on a four-point scale representing the degree of anxiety: none = 0, a little = 1, a lot = 2 and unbearable = 3. High scores on each scale indicated the presence of anxiety.

Westerman et al (2004)[20] also employed the use of a visual analogue (VAS) anxiety scale. This was a simple instrument by which patients were asked to rate their level of anxiety on a numerical scale between 0 and 10 with two anchors: “no fear” and “extremely intense fear”.

Two studies utilised some form of physiological response to measure anxiety levels[12,19,]. These physiological responses included heart rate variability (HRV)[12,19], saliva sampling[12] and serum cortisol levels via blood test[12].

Table 2 provides a summary of the quantitative results and key findings in relation to anxiety level scores across the included studies.

Table 3 provides a summary of the key physiological parameters used to measure anxiety across the included studies.

Risk of bias

Table 4 shows the overall risk of bias for the included studies. Two studies were deemed to have low-risk associated with just two criteria[19,23]. Seven studies were judged to be low-risk regarding only one of the criteria[12,20,21,22,24,25,26] and three of the studies were judged to have high or an unclear risk for bias in all criteria[13,18,27].

Random sequence generation and allocation concealment (selection bias)

Only one study provided sufficient information to be judged as low-risk for selection bias[23], reporting the use of a web-access randomisation programme to ensure that selection bias was eliminated as far as possible. Overall the level of detail reported to confirm the randomisation of the process was lacking. Rather than true randomisation of participants several studies reported using a method of convenience randomisation whereby patients were allocated to a group dependant on the day of the week of their attendance.

Blinding (performance and detection bias)

The inconsistent reporting of the blinding processes of participants and research teams in the majority of the studies (n=7), meant that a clear judgement on the risk of performance bias within the included studies was very difficult. The other five studies reported that participants could either not be blinded to the intervention or used a non-blinded design and were therefore judged as a high risk of performance bias.

Incomplete outcome data (attrition bias)

Three studies were judged to be at risk of attrition bias due to missing data[24,25,26]. Risk of attrition bias could not be clearly judged in seven studies due to a lack of reporting detail, however two studies provided sufficient information to demonstrate a low risk of attrition bias whereby all patients who were recruited either completed the study or were accounted for.

Selective reporting (reporting bias)

Eight studies were judged as low-risk for reporting bias as they used or reported the same outcome measures as specified in their protocol. Two studies appeared to apply a selective approach to the reporting of their outcomes[13,18].

Discussion

The aim of this review was to identify and explore the effectiveness of non-pharmacologic interventions at reducing anxiety in adults in advance of diagnostic imaging procedures. Included studies provided evidence that non-pharmacological interventions can significantly decrease patient anxiety levels. The range, complexity and outcome measures of the interventions was varied. This heterogeneity made comparison difficult and excluded a meta-analysis.

Despite some promising findings across the studies' there are limitations, the most telling of which concentrates on the representativeness of the populations in each case. Across all studies, patients who knew themselves to be particularly anxious and suffer with claustrophobia, and who had elected to have sedation or a general anaesthetic could not have been included. Although there is no evidence to suggest that it is these patients which lead to abandoned or repeated scans, this factor would seem to be responsible for a bias towards less fearful individuals being included in the studies than would occur in the wider population.

An awareness of the potential issue of a 'Hawthorne effect' is also important in relation to the findings of the included studies. A Hawthorne effect is a type of reactivity in which individuals modify an aspect of their behaviour in response to their awareness of being observed. The relevance in the context of these studies is therefore that if a patient is aware they are being investigated for anxiety then this knowledge in itself may cause anxiety levels to increase. None of the studies showed a discrepancy between the physiological presentation of anxiety and the levels reported by the patient, and so it would seem that this issue can be applied to all the studies in this review as all participants would have been aware of the purpose and context of the investigations.

The majority of the interventions appear to be developed around the theory that providing patients with detailed information about the procedure prior to the event would reduce anxiety levels as a result of the patient having a greater awareness of what to expect. In particular, Leckie et al (1994)[21] demonstrate that the provision of either written or verbal information result in an apparent similar, albeit significant, reduction in anxiety levels. The fact that there were no significant differences seen in anxiety scores between these experimental groups suggests that a written leaflet may be the preferred method of delivering patient information, due to the practical issue of the extra time taken to give the information verbally and the negative impact this may have on department workload.

Grey et al (2000)[13] were also able to demonstrate that patients in their experimental group experienced less anxiety than those undergoing standard (control) conditions which consisted of an appointment letter with basic information. However the multifactorial nature of their intervention, in which a written information booklet was just one element of a wider 'anxiety reduction protocol', meant that it was not possible to deduce which elements of the experimental procedures were most effective, therefore diminishing the strength of their evidence to support the use of written information.

The interventions used in two further studies[20,25] included both procedural and sensory information alongside brief explanations about why things appear as they do, as part of a comprehensive written information sheet. However they were not able to demonstrate any significant advantage of using detailed written information on anxiety levels and their overall conclusion was that it is difficult to improve upon personal interaction with the patient for pre-test preparation. This is an idea that is supported by Carlsson & Carlsson (2013)[28] whose qualitative study into patient experiences of MRI found that although patients were satisfied with the written information they received, many of them emphasised the importance of personal contact with staff in order to build trust and the confidence they felt in them.

Yucel et al (2005)[29] report that providing more complex information about a procedure can increase patient knowledge but does not necessarily reduce anxiety. It may therefore be the case that providing a lot of detail about the procedure does not necessarily lead to a reduction in anxiety but can in fact, as a study by Kaya et al (2010)[18] report, have the opposite effect and increase anxiety.

The intervention used by Kaya et al (2010)[18] provided, upon patient request, detailed information about radiation exposure, risk factors and potential adverse reactions of radiopharmaceutical administration. The results certainly highlight a need for further discussion around how much and what type of information should be given. Consideration as to the complexity and detail of the information provided to patients, and whether or not a patient's right to fully informed consent may be compromised by a lack of detail in the patient information provided, appears to be very important.

It is a patients' ethical, medical and legal right to be made aware of potential side effects of procedures applied to them[29]. However, evidence would suggest that this level of detail may at times be at odds with minimising patient anxiety, and there appears to be a large variation in detail provided to patients according to local regulations and traditions[18].

A 10-minute 'multi-media' DVD was provided to patients as part of one of the studies[24], the results of which showing that this type of intervention can produce a significant reduction in anxiety levels. A key contributory factor to this success appears to be the fact that the multimedia format allows for verbal and visual information to be delivered simultaneously. Lee et al (2012)[24] suggest that although written or printed materials are often provided, many of these materials are not developed appropriately and are unsuitable for patients to understand. Furthermore they argue that often patients either do not read the materials or, due to stress and anxiety, are less likely to absorb and correctly interpret the information.

This idea is supported by Tugwell et al (2018)[23], who report that their video-clip intervention was effective in reducing anxiety levels. Importantly it was also easy to implement. They claim that it could be administered to all patients with no associated additional time or financial implications, however some of the patients in the study were required to view the video in a separate waiting area on their arrival, rather than at home prior to their appointment, due to a lack of accessibility of the link.

The impact of this variation in the timing of the delivery of the intervention is not discussed within the study, however evidence suggests that timescales are an important consideration for patient anxiety levels, promoting the idea that if a patient has longer to dwell on an impending scanning procedure then this might increase feelings of anxiety still further[8].

Significant results have been produced to suggest that patients who receive instruction on relaxation techniques prior to an MRI scan can display an overall reduction in anxiety levels compared with those patients in a control group who simply received an information letter[27]. This suggests that in order to reduce anxiety, patient preparation should include more than the provision of information alone.

In support of this, a 'relaxation audiotape' used by Lukins et al (1997)[26] also provided some relief from anxiety for patients. Despite some statistically significant results however, this

study cannot be certain that the changes they observed via state anxiety scores in the relaxation group were entirely due to the relaxation elements of the intervention rather than other non-specific factors such as distraction, which were not under investigation. They also conclude that whilst the intervention provides a positive effect within their study, a relaxation intervention designed for general use would probably require a range of techniques because patients experience anxiety differently across environments[26].

There has also been considerable interest in the anxiolytic potential of listening to music in a variety of clinical settings, such as coronary care[29], mental health[30], dental surgery[31] and at different stages of a patient's hospital experience[32,33]. Two reviews[34,35] have explored music and its effect on anxiety in short waiting periods, concluding that listening to music can have a positive effect on reducing a patient's pre-procedural anxiety.

Despite there being a clear body of knowledge related to the therapeutic potential of listening to music however, none of these studies investigated the use of music for patients awaiting a diagnostic imaging procedure. This review identified a study by Lee et al (2017)[19] which examined the effects of meditative music and indicates that patients who receive 30-minutes of relaxing music during the uptake phase before PET imaging experience a significant reduction in state anxiety and heart rate. Patients usually lie on a bed in the uptake room and worry about the imminent scanning procedure; consequently this exacerbates feelings of anxiety. Listening to music is an intervention which is safe, inexpensive and easy to implement. The results of this study[19] support the use of music to alleviate state anxiety in patients prior to undergoing PET scans and may have wider implications for this approach in other diagnostic imaging settings.

Limitations of the review

There are some limitations to acknowledge in this review. Although a thorough systematic search was conducted as far as possible across an appropriate range of electronic database sources, this search process was carried out by a single reviewer and so it is possible that some studies may have been missed. This includes studies that may have been carried out and published after the search and therefore have not been included. This will mean that an update of this review is necessary in the future as further relevant studies are published in this area.

Conclusion

The current review demonstrates that despite the existence of a number of studies that provide evidence for the effectiveness of a range of anxiety reducing interventions for patients prior to DI, the small number and overall low quality of studies identified makes it difficult to draw firm conclusions regarding the application of a specific intervention in clinical practice.

There is a need for further high quality research in this area to determine the most effective theory-based intervention to reduce patient anxiety. This includes defining some important parameters such as timing, duration and amount of detail to include in the intervention. It is clear however that the majority of interventions included in this review were shown to have some positive effect on patient anxiety and as a result those professionals working with adults undergoing diagnostic imaging may consider implementing some of the strategies that have been discussed within their practice.

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Table 1: A summary of the key characteristics of the studies included in this review.

Study	Methods	Participants	Setting	Control conditions	Intervention	Outcome measure
Grey et al (2000)	Quasi-randomisation to either control or experimental group.	64 patients (35 control, 29 experimental) 22 M, 42 F Mean age 45 – adults only	Maudsley Hosp. MR unit, UK	Appointment letter with basic info.	Appointment letter + info. booklet incl. details about the scan and simple relaxation strategies. Given a few days before.	STAI-S, STAI-T, STAI-R Measured before and after scan.
Kaya et al (2010)	Quasi-experimental, prospectively controlled study	620 (247 M, 373 F) Control = 232, Study = 388 Adults (18-78 years) Mean age: 44 At least graduated from primary school.	2 NM depts. Turkey	'Simple' informed consent form	Detailed informed consent form (repeated verbally)- when requested	STAI-S, STAI-T Measured on day of scan- before scan.
Leckie et al (1994)	RCT- random allocation to 1 of 3 conditions	42 (22 F, 20 M) Control = 14, written = 14, verbal = 14. 18-70 years old. Mean age- 45.2 All referred for bone scan. New patients to NM dept.	NM dept. London, UK	Standard info (appointment letter) sent by hospital.	Two groups: 1. Standard info + written info leaflet. 2. Standard info + verbal explanation.	STAI Measured on arrival and before scan.

Lee et al (2012)	Non-randomised allocation to control or exp. Group.	98 (46 M, 52 F) Control = 45, Exp = 53 Mean age- 52	Teaching hospital, Taiwan	Routine MRI printed material	10 min Multimedia DVD watched in waiting room	STAI Measured on arrival prior to scan and after.
Lee et al (2017)	RCT - 2 group randomized experimental design.	72 completed (32 M, 40 F) Control = 37, Study = 35 Mean age: 60 years	PET medical centre. Taiwan.	Control – no music	30 min meditative listening to music prior to scan.	STAI-S Heart rate variability (HRV) Measured on arrival prior to scan and after.
Lukins et al (1997)	RCT- random allocation to 1 of 3 conditions	139 completed (87F, 84M) (52 in control, 44 in intervention 1 and 43 in intervention 2). Age range: 17-76 Mean age: 47	MRI unit- Australia	'Routine conditions' which included music before/after the scan.	2 interventions: 1. 20 min relaxation audiotape before scan 2. 20 min relaxation audiotape before scan + adapted version during scan.	STAI Measured on arrival before and during scan.
Quirk et al (1989)	RCT- random allocation to 1 of 3 conditions	50 subjects (1: 16, 2: 18, 3:16) Male/Fem and 'mean age' details not given. None previously has MRI None on stress-reducing meds	MRI unit, Medical Centre, USA	Information only (video and short discussion) – 10mins	2 interventions: 1. Info plus discussion of relaxation strategies – 11mins 2. Info plus relaxation exercise (listened to a relaxation audio) – 18 min	STAI-S Measured on arrival before and after scan.

Selim (2001)	RCT- experimental research	60 subjects (30 control, 30 study) Male/Fem and 'mean age' details not given.	MRI unit, AL Manial University Hospital, Egypt	Routine hospital instructions	Routine instructions + pre-scan verbal instructions (10-15mins) covering nature of the scanner and relaxation techniques	STAI-S Measured on arrival before the scan and after.
Tornqvist et al (2006)	RCT- randomised to control or intervention group.	242 patients (130F, 112 M) (Control = 118, intervention = 124). Outpatients scheduled for head and/or spine. 18 + years of age. Ability to complete questionnaire.	MRI unit, Sweden.	Standard practice. Basic written information and brief verbal explanation by staff	Standard practice + extended written information- 2 page document covering procedural, sensory and temporal information	STAI-S Measured on arrival before the scan and after.
Tugwell et al (2018)	RCT – single blinded Randomised to 1 of 3 interventions	74 patients (33M, 41F) Control = 24, Study = 50 Head, spine, cardiac scans. Outpatients in the Excluded if required contrast or benzodiazepines	MRI unit, Wales	Standard info appointment letter sent	2 interventions; 1. Short video clip (4mins) 2. Semi-structured phone conversation with Radiographer.	STAI Measured prior to and following intervention Both interventions took place before scan.

Vogel et al (2012)	RCT - 2-stage random controlled study. Random allocation to 1 of 2 conditions	101 patients 1st stage (n=35) 2nd stage (n=66) 51 patients received intervention Age range: 18-81 Mean age: 58	PET/CT unit, Cancer institute-Netherlands.	Standard treatment-uptake room without audio-visual installation	Standard treatment + audio-visual installation in uptake room.	STAI, saliva sampling (cortisol levels), HRV Measured before and after intervention
Westerman et al (2004)	RCT- random allocation to receive a mailed info pamphlet	39 (11 M, 28 F) Control = 22, Study = 17 Mean age: 55 years Not undergone PET previously	NM dept. Canada	Standard care-phone call 2 weeks before scan to discuss appointment details, instructions on preparation	Standard care + information pamphlet by post prior to appointment	Visual Analogue Scale (VAS), HADS Measured 2 weeks before (baseline) and again at pre-test.

Table 2: A summary of the quantitative results and key findings in relation to anxiety level scores across the included studies.

Study	**Control (mean) anxiety scores**	**Experimental (mean) anxiety scores**	**Key findings (with p-values)**	**Summary of findings**
Grey et al (2000)	STAI-S = 41.03 Pre-anx = 3.88 Entering scanner = 3.66 (final) Leaving scanner = 3.63 STAI-R = 40.60	STAI-S = 36.72 Pre-anx = 3.34 Entering scanner = 3.10 (final) Leaving scanner = 2.28 STAI-R = 32.48	Experimental group had significantly lower final anxiety scores (p = 0.040) Experimental group had significantly lower retrospective anxiety scores (p = 0.019)	Patients undergoing experimental conditions showed reduced anxiety on leaving the scanner and retrospectively.
Kaya et al (2010)	STAI-T = 49.62 STAI-S (after simple info) = 40.48	STAI-T = 49.82 STAI-S (after simple info) = 41.45 STAI-S(after detailed info) = 43.12	No significant differences between groups for STAI-T (p = 0.741) or STAI-S (p = 0.945) Experimental group had significant difference in STAI-S after detailed info given (p = 0.001)	Requested detailed information increased state anxiety.
Leckie et al (1994)	STAI = 46.0	Verbal: STAI = 35.9 Written: STAI = 37.5	Experimental groups had significant difference in STAI (p = 0.029) No significant difference seen between verbal and written groups (p = 0.05).	Verbal or written information can reduce anxiety.
Lee et al (2012)	STAI: Pre-test = 32.04 Post-test = 31.13	STAI: Pre-test = 37.79 Post-test = 34.34	Experimental group showed significant improvement in the level of anxiety (p= <0.05)	Multimedia educational intervention prior to scanning can reduce anxiety levels

Lee et al (2017)	STAI-S: Pre-test = 37.73 Post-test = 38.38 Pre-test = 59.68 Post-test = 58.84	STAI-S: Pre-test = 40.26 Post-test = 34.97 Pre-test = 59.49 Post-test = 54.77	Independent t-test found a significant reduction in anxiety of the experimental group compared with the control group (t= -4.40, p= <0.001)	Music listening can reduce state anxiety rate in PET pre-scan waits.
Lukins et al (1997)	STAI: Pre-scan = 35.1 During scan (R) = 38.5 (R) = retrospective	STAI: Audiotape before: Pre-scan = 34.4 During scan (R) = 33.6 Audiotape before and during: Pre-scan = 35.0 During scan (R) = 32.2	Anxiety ratings increased significantly during the scan in the control group (p= <0.05) but this was unrelated to pre-scan state anxiety. Anxiety ratings decreased significantly during the scan in the 2 experimental relaxation groups (p= <0.05)	Anxiety levels reduced in both intervention groups. Little difference between 2 relaxation groups.
Quirk et al (1989)	STAI: Pre-exam = 37.8 During-exam (R) = 46.1	STAI: Group 2- Info + discussion: Pre-exam = 36.9 During-exam (R) = 40.7 Group 3- Info + relax exercise: Pre-exam = 43.1 During exam (R) = 39.3	Patients in control group (info only) showed significant increase in overall anxiety levels (p= <0.03). Patients in experimental groups 2 and 3 showed no significant increase in overall anxiety levels (p = NS). Control showed significant anxiety increase in 8 of 20 items (p= <0.05) Gp 2 showed significant anxiety increase in 3 items (p= <0.05) Gp 3 did not show significant anxiety increase in any items.	Psychological preparation including relaxation exercises is more effective than information alone.

Selim (2001)	STAI-S: Pre intervention = 41.93 Post intervention = 61.34	STAI-S: Pre intervention = 39.97 Post intervention = 43.97	No significant statistical difference was found in anxiety levels between groups prior to intervention (p = NS) A highly significant decrease in total anxiety levels was shown in the experimental group post intervention/scan (p = <0.0001)	Patients in experimental group (receiving designed instructions) reported significantly lower levels of anxiety immediately after the scan.
Tornqvist et al (2006)	STAI-S: Pre-scan = 33.8 During scan (R) = 30.5	STAI-S: Pre-scan = 35.0 During scan (R) = 32.0	No significant difference found between the control and intervention groups regarding anxiety levels either before (p = 0.641) or during (p = 0.635) the scan.	More information did not decrease anxiety but may help patients lie still. Further research needed into other interventions on patient anxiety.
Tugwell et al (2018)	STAI: Pre interv. (at home) = 71.3 Post interv. (on arrival) = 76.3	STAI: Video: Pre-interv. (at home) = 72.5 Post interv. (on arrival) = 66.8 Telephone: Pre-interv. (at home) = 74.4 Post-interv. (on arrival) = 70.9	Significant reduction in post intervention STAI scores in the 'video' group compared to control (p = 0.001) Significant reduction in post intervention STAI scores in the 'telephone' group compared to control (p = 0.015) When comparing post intervention STAI scores across 'video' and 'telephone' groups there was no significant difference (p = 0.419).	Both interventions demonstrated reduction in anxiety compared to control group. No significant difference seen in anxiety levels between intervention groups.

Vogel et al (2012)	Mean scores not given. Change in STAI: Mean = -2.39 SD = 3.88	Mean scores not given. Change in STAI: Mean = -1.02 SD = 3.45	Audio-visual intervention significantly lowered patient anxiety (p = 0.04).	Patient anxiety decreases whilst in uptake room. Audio-visual intervention further reduced anxiety levels.
Westerman et al (2004)	VAS: 2 weeks prior = 3.0 HADS: Over time = 7.2	VAS: 2 weeks prior = 3.9 HADS: Over time = 7.5	Anxiety levels at baseline (2 weeks prior) did not differ between intervention and control groups (p = NS). No significant difference on HADS anxiety scale scores between groups (p = 0.84).	Additional information pamphlet did not reduce pre-test anxiety.

Table 3: A summary of the key physiological parameters used to measure anxiety across the included studies.

Study	Control (mean) HRV/Cortisol	Experimental (mean) HRV/Cortisol	Key findings
Lee et al (2017)	**HRV-** Pre-test: 59.68 Post-test: 58.84	**HRV-** Pre-test: 59.49 Post-test: 54.77	Statistically significant reduction in anxiety based on HRV measurement (p= <0.001)
Vogel et al (2012) *	**HRV-** no specific statistics provided * **Cortisol-** no specific statistics provided *	**HRV-** no specific statistics provided * **Cortisol-** no specific statistics provided *	AV imagery led to a significant reduction in anxiety during the uptake period based on HRV levels (p value not given)* AV imagery led to a significant reduction in anxiety during the uptake period based on cortisol levels (p value not given)*
Westerman et al (2004)	**Cortisol-** Mean = 388.95	**Cortisol-** Mean = 427.18	No significant reduction in anxiety based on cortisol levels (p= 0.57)

HRV= Heart rate variability

*This study was able to show a reduction in anxiety using STAI, but physiologic measurements did not correlate with the STAI. This non-correlation may, to an extent, be explained by other processes influencing physiology, such as thermoregulation. Because of this, STAI was considered the only valid anxiety measurement in this study (Vogel et al, 2012).

Table 4: A summary of the risk of bias of included studies

Study/lead author	Sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding (performance and detection)	Incomplete outcome data (attrition bias)	Selective outcome reporting (reporting bias)
Grey, 2000	−	−	?	?	−
Kaya, 2010	−	−	−	?	−
Leckie, 1994	?	?	?	?	+
Lee, 2012	−	−	−	−	+
Lee, 2017	−	−	−	+	+
Lukins, 1997	−	?	?	−	+
Quirk, 1989	−	?	?	?	?
Selim, 2001	?	?	?	?	+
Tornqvist, 2006	−	−	−	−	+
Tugwell, 2018	+	?	?	?	+
Vogel, 2012	?	?	?	+	?
Westerman, 2004	?	?	−	?	+

+ = low risk, ? = unclear risk, − = high risk