The effects of Lycra arm sleeves on Glenohumeral Subluxation in Post-stroke Hemiplegia – A Preliminary Study

ABSTRACT

Objective: The primary aim of this preliminary study was to assess the effects of Lycra arm sleeves on the glenohumeral subluxation (Acromion-greater tuberosity distance) in people with post-stroke hemiplegia. A secondary aim was to explore patients' perceptions regarding the practicality of applying the Lycra arm sleeve.

Design: Prospective cross-sectional study

Setting: Community care in the South West of England

Participants: Patients with chronic stroke (n=5; 2 men, 3 women; mean±SD age = 51±8 years) with one-sided weakness who gave informed consent were recruited.

Intervention: Patients were instructed to wear the Lycra arm sleeve for 7 hours a day for 7 consecutive days.

Main Outcome measures: 1) Ultrasound measurements of AGT distance 2) :Pain - Numeral Rating Scale 3) upper limb function using Motor Assessment scale were recorded before and immediately after application of the sleeve on day 1 and day 8. A questionnaire was completed by patients on day 8 to explore perceptions.

Results: Analysis of the data using an ANOVA for a 2x2 fully repeated measure design suggests 1) there is no significant mean difference in AGT distance between day 1 and day 8 (F (1,4) = 1.28, MSE=0.014, p= .322) 2) there is a significant mean difference in AGT distance due to wearing of sleeve (F (1,4) = 19.258, MSE=0.011, p=.012) and 3) the change in AGT distance on day 1 due to wearing of sleeve is not statistically different from

the change on day 8 (F (1,4) = 0.537, MSE=0.008, p= .504). Three patients' experienced decreased pain and one patient showed improvement in the upper limb function score. The mean time the Lycra arm sleeve was worn each day was 6.7 hours. Three patients found the sleeve easy to wear and 4 patients found the sleeve beneficial.

Conclusions: Trends towards reduction in mean AGT distance suggests Lycra arm sleeves may be beneficial in GHS management. Further research is required to establish their effectiveness in acute and chronic settings using a well-designed fully powered randomised controlled trial.

Key words: Lycra **Arm** sleeve, dynamic orthosis, Glenohumeral subluxation, Stroke, Hemiplegia

ABBREVIATIONS

AGT- Acromion-greater Tuberosity

ANOVA – Analysis of Variance

CI –Confidence intervals

FES –Functional Electrical Stimulation

GHS – Glenohumeral subluxation

RCT - Randomised Controlled Trial

SD- Standard Deviation

INTRODUCTION

Glenohumeral subluxation (GHS) is a common post-stroke complication reported in up to 81% of patients depending on the measurement methods used and the time frames over which it is assessed.[1] GHS appears to be caused by a lack of adequate support of the shoulder due to loss of motor control and the reduced force coupling (provided by rotator cuff muscles) to align the head of the humerus in the glenoid cavity while the patient is in the upright position.[2,3] GHS presents considerable challenges to the rehabilitation of the upper limb and has been associated with other post-stroke complications such as hemiplegic shoulder pain and poor motor recovery.[3,4] There is a concern that without treatment, GHS can progress to an uncorrectable degree over time.[4] A wide variety of supportive devices such as pillows, wheelchair attachments (arm trough, lap board), strapping, taping, slings and electrical stimulation / functional electrical stimulation (FES) have been used to reduce GHS.[5,6,7,8,9] Overall, evidence to support the effectiveness of current approaches for management of GHS is limited.[5,9]

To improve clinical outcomes for patients with GHS, other cost-effective and user-friendly interventions are required. Lycra garments are lightweight and flexible and when compared to rigid orthoses, they are better tolerated, do not restrict movement or encourage disuse.[10] The functional basis of Lycra garments is to exert a compressive, and supportive effect, and thus positively influence alignment, biomechanics, and neuromuscular activity in the affected body segments.[11] In addition, they can be easily used in conjunction with other interventions such as therapeutic exercise.

A single case study on a patient with acquired brain injury who wore a sleeve for 18 weeks reported improvements in the upper limb active range of movement, self-rated function and one component of a writing test, with some suggestion of a carry-over effect when treatment was withdrawn.[12] Similarly, a small (n=16) cross-over study on people with post-stroke hemiplegia reported that a Lycra sleeve (from the wrist to the middle of the arm) worn over 3 hours period, improved wrist posture, reduced wrist and finger flexor spasticity and a mean (4.1°±13.0°) increase in passive range of movement at the shoulder joint (across all movements).[10] These effects were significantly different when compared to patients not wearing the sleeve. In addition, patients in this study also showed reduction in swelling of the arm after wearing the sleeve. The authors hypothesised that weight reduction of the upper limb decreases the vertical force on the shoulder and therefore might minimize subluxation and possibly pain.[10]

To the best of our knowledge, no previous study has explored the effect of Lycra arm sleeves on GHS. The primary aim of this preliminary study was to assess the effects of Lycra arm sleeves on GHS in people with post-stroke hemiplegia. A secondary aim was to explore patients' perceptions regarding the practicality of applying the Lycra sleeve.

MATERIALS AND METHODS

The study used a test-retest design and received ethical approval from the Research Ethics Committee, xxx xxx. Patients aged over 18 years, with stroke resulting in one-sided weakness, with a palpable gap in the lateral side of the shoulder and who were able to sit upright, were eligible to participate. Patients with other neurologic conditions, traumatic brain injury, brain tumours or other serious co-morbidities were excluded. Patients were recruited from the xxx xxx xxx xx. Each patient gave informed written consent to take part. This study adhered to the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[13]

Apparatus

A portable diagnostic ultrasound, (TITAN model, M-Mode, Depth 3.9, L38/10-5MHz broadband 38 mm linear array transducer, Sonosite Limited, Hitchin, UK)[a] was used for recording the AGT distance. Lycra arm sleeve, manufactured by Jobskin Limited UK[b] was used in this study.

Procedure

Baseline demographic data including age, gender, time after stroke and affected side were gathered directly from the patients, as no medical records were available. Researcher 1 (a final physiotherapy student) performed following assessments: 1) **Spasticity of the elbow flexors was assessed using Modified Ashworth Scale[14] on day 1, prior to application of sleeve.** 1) shoulder pain using the Numerical rating scale (NRS)[15] and 2) upper limb function using upper limb section (6, 7, 8) of the Motor Assessment Scale (UL

MAS).[16] **The upper limb subscale (UL-MAS) consists of subset 6: 'Upper Arm Activity', subset 7: 'Hand Movements', and subset 8: 'Advanced Hand Activities'. Each subset has six items (criteria) which are scored from 0: unable to perform any of the items, through to 6: able to perform all six of the items.** A standardized protocol was used and researcher 1 practiced this on three patients prior to actual data collection.

Diagnostic ultrasound has been used for the assessment of GHS in people with post-stroke hemiplegia by measuring the acromion-greater tuberosity (AGT) distance between the lateral border of the acromion and the apex of the greater tuberosity of the humerus.[17] Ultrasound measurements of AGT distance were undertaken by a physical therapist (PK) with an experience of over 10 years in the ultrasound technique. The therapist was previously involved in the reliability studies on healthy volunteers (n=64)[18] and patients with stroke (n=64)[19] and validity study on people with stroke (n=105).[20] The ultrasound measurements of AGT distance were recorded both before and after the application of a Lycra arm sleeve using a standardised protocol.[18] Three measurements were taken before and after the application of sleeve both on day 1 and day 8. In order to ensure the rater was blind to measurements, the values displayed were obscured by placing a sticker on the ultrasound screen.

Researcher 2 (another physiotherapy student) received training from the manufacturer and practiced on few healthy participants prior to data collection.

According to the manufacturers' recommendations, the wrist circumference was measured for each patient and the correct size sleeve was provided. The sleeve was applied from the wrist joint up to the insertion of deltoid on the humerus using the donning on/doffing off material. Patients/family members were also taught to independently put the Lycra arm sleeve on the affected arm (figure 1). Patients were instructed to wear the Lycra arm sleeve for 7 consecutive days, 7 hours a day (as recommended by the manufacturers) and record any observations on the questionnaire. On completion of measurements on all patients (on day 1 and day 8), data was extracted for analysis from the case report forms. On day 8, all patients completed a questionnaire, similar to that used in a previously published study.[10]

Data Analysis

Data were analysed using SPSS, version 24.0 (IBM Chicago, Illinois)[c]. Descriptive statistics were used to calculate the mean and standard deviation of AGT distance measurements. **Repeated measures analysis of variance (ANOVA) for a 2X2 design was used to analyse the data with the 'sleeve off' and 'sleeve on' on day 1 and day 8. Paired t-tests were used to analyse the mean difference between AGT distance without and with the Lycra arm sleeve on day 1 and day 8.** Individual patients data on NRS and UL MAS score was reported. Questionnaire data was analysed using descriptive summaries which included frequencies. For open ended questions, patients reported quotes were extracted.

RESULTS

Over a one month period, 18 patients with stroke were approached. Thirteen patients did not fit the inclusion criteria. Therefore 5 patients (2 men, 3 women) with a Mean±SD age of 51±8 years were recruited into the study. Four patients had right sided hemiplegia and time since stroke varied from 7 to 22 months. **Three patients had a stroke due to infarction (middle cerebral artery area), one patient had haemorrhagic stroke and for one patient, the stroke was undefined.**

Descriptive statistics for the AGT distance are presented in table 1. Tone in three patients was grade 2, one patient had grade 3 and another patient showed grade 1.

Analysis of the data using an ANOVA for a 2x2 fully repeated measure design suggests 1) there is no significant mean difference in AGT distance between day 1 and day 8 (*F* (1,4) = 1.28, *MSE*=0.014, *p*= .322) 2) there is a significant mean difference in AGT distance due to wearing of sleeve (*F* (1,4) = 19.258, *MSE*=0.011, *p*=.012) and 3) the change in AGT distance on day 1 due to wearing of sleeve is not statistically different from the change on day 8 (*F* (1,4) = 0.537, *MSE*=0.008, *p*= .504) (Figure 2).

Paired t-test showed mean reduction of 0.24 cm (95% confidence intervals 0.1-0.4cm) in AGT distance measurements for day 1 and this was

statistically significant (*t*=4.733, *df*=4, *p*=.009,two-sided) on day 1. For day 8, paired t-test showed mean reduction of 0.18 cm (95% confidence intervals -0.02-0.4cm) in AGT distance measurements and this was not statistically significant (*t*=2.423, *df*=4, *p*=.073, two-sided). When AGT distance measurements from 'sleeve off' on day 1 were compared to 'sleeve on' on day 8, it showed a mean reduction of 0.27cm (95% confidence interval 0.13-0.4cm) and this was statistically significant (*t*=5.551, *df*=4, *p*=.005, two-sided).

Three patients' experienced decreased pain and one patient showed improvement in the upper limb function score (table 1). Three patients were able to complete questionnaires independently and two required help with writing answers. The mean time the Lycra sleeve was worn each day by participants was 6.7 hours. Response of participants for the questionnaire is provided in table 2.

DISCUSSION

The aim of this study was to assess the effect of Lycra sleeves on acromion-greater tuberosity distance. To do this, chronic stroke patients were recruited and the measurements were recorded with and without the application of Lycra sleeves. Results showed a mean within-day reduction of 0.24 cm in AGT distance measurements on day 1 and 0.27cm for between-day measurements. These findings suggest a very tentative trend towards a Lycra sleeve reducing

AGT distance both within and between days.

AGT distance was measured using a diagnostic ultrasound machine, which in many studies has been used to measure the level of shoulder subluxation.[17,18,19] Application of the Lycra sleeve resulted in reduction in the AGT (mean 0.24cm) when compared to the distance prior to application of the sleeve. Four out of five patients showed a reduction of ≥0.2 cm which could be considered clinically meaningful. Previous studies have shown that ultrasound is sensitive to detect minor changes in AGT distance. A study on young healthy participants (n=16; mean±SD age 28±11 years), that investigated the effect of different arm position reported that a change of greater than ±0.1cm in AGT distance measurements would be necessary to indicate a real change in measurements across different arm positions.[21] Likewise, a study on patients with stroke (n=26; mean±SD age 71±10 years) reported that minimum detectable change with 90% confidence intervals (MDC90) value of ±0.2cm would be required to predict a change in AGT distance measurements on the affected shoulder.[19] Similar findings were reported in a larger study on patients with stroke (n=105) which reported a cut-off point of ≥0.2cm was considered optimal for ruling-in or ruling-out GHS in people with stroke.[20] The magnitude of the findings in the current study therefore suggests a potential ‘real’ beneficial effect of the Lycra sleeve in reducing the AGT distance. However, the results were not statistically significant and also very wide CIs were associated with this, therefore an adequately powered randomised controlled trial (RCT) would be needed to confirm the findings.

Findings from our study is in agreement with a previous study which reported improvement in swelling, postural improvement in the distal joints and increase in passive range of movement at the shoulder joint following the application of Lycra sleeve for 3 hrs in people with post-stroke hemiplegia (n=16, mean age 65 years).[10] That study used a cross-over design where the patients had worn sleeve for 3 hrs and were off-sleeve for next 3 hrs. In contrast, in our study patients were asked to wear the sleeve for seven hours/day for a week and patients showed reduction in AGT distance both on day 1 and at day 8.

The mechanism underlying the benefits of Lycra arm sleeve is uncertain, given that the sleeve does not cross the shoulder. However, a previous study[10] using a similar arm sleeve reported effect on the shoulder joint. The authors reasoned that, the changes occurring distally may produce improvements proximally. This may be attributed to the regional gate control effect that is produced at the spinal level by the multi-segmental, large-fibre, cutaneous input from the skin due to contact of the sleeve.[22,23] Also, that study reported improvement in elbow proprioception task following application of Lycra sleeve. There is some evidence to suggest that Lycra sleeve provides proprioceptive feedback to the skin.[10,24]

In addition to changes in the AGT distance measurements noted in this study, patients' positive feedback on the benefits of a Lycra sleeve provides further support to its usefulness. Three patients found donning and doffing easy, however one of them required help from a family member. Four patients found the sleeve beneficial of which 2 were more aware of their affected arm after wearing the sleeve. These findings on comfort and benefits are in agreement with the previous study that reported Lycra sleeve were deemed comfortable when worn by people with stroke in their study.[10]

Study Limitations

The present study has several limitations. First, a small convenient sample was selected; therefore, generalisability is limited. Second, because of a lack of control group and other clinical outcomes, it is difficult to conclude that the small changes noted are clinically relevant. A larger feasibility study would be required to determine the potential for conducting a definitive trial in this area. This would provide more accurate estimates of data variability and likely effect size to inform a sample size calculation. **Thirdly, this study did not include demographic information such Brunnstorm levels or Fugl Meyer stages of recovery. Future study should consider these outcomes as it might provide some insight about which patient with stroke may get benefit from the use of lycra arm sleeve.** Fourthly, the Lycra arm sleeves were not worn for a long period of time and measurements were not repeated multiple times. Finally, future study should consider if a Lycra arm sleeve could be used as an adjunct to improve upper limb function in people with stroke.

CONCLUSION

In conclusion, this preliminary study has demonstrated the potential tentative trend towards a Lycra arm sleeve reducing GHS. However, a properly designed definitive trial would be required to confirm the effectiveness of the Lycra sleeve in reducing GHS in people with both acute and chronic stroke.

ACKNOWLEDGEMENTS

This project has been undertaken as part of an undergraduate research study on the BSc. (Hons) Physiotherapy programme at the xxxxxxxxxxxxx, xxxxxx. The authors would like to thank students for help with the data collection, xxxxxxx, xxxx for providing the Lycra **arm** sleeves for the study, Colleagues for the critical comments on the manuscript, xxxx xxxxx for statistical support, manager ……..) for support and recruitment of participants, and volunteers for their participation.

Declaration of Interest

The authors report no conflicts of interest. The author alone is responsible for the content and writing of the article.

REFERENCES

1.Lindgren I, Jonsson A, Norrving B and Lindgren A. Shoulder Pain after Stroke: A Prospective Population-Based Study. Stroke 2007; 38 (2):343-48.

2. Faghri PD, Rodgers MM, Glaser RM, Bors JG, Ho C, Akuthota P. The effects of functional electrical stimulation on shoulder subluxation, arm function recovery, and shoulder pain in hemiplegic stroke patients. Arch Phys Med Rehabil. 1994; 75(1):73–79.

3. Paci M, Nannetti L, Taiti P, Baccini M, Rinaldi L. Shoulder subluxation after stroke: relationships with pain and motor recovery. Physiother Res Int 2007; 12(2): 37-50.

4. Wang RY, Yang YR, Tsai MW, Wang WT, Chan RC. Effects of functional electric stimulation on upper limb motor function and shoulder range of motion in hemiplegic patients. Am J Phys Med Rehabil. 2002; 81(4):283-90.

5. Stolzenberg D, Siu G, Cruz E Current and future interventions for glenohumeral subluxation in hemiplegia secondary to stroke. Top Stroke Rehabil. 2012; 19(5):444-56.

6. Griffin C. Management of the hemiplegic shoulder complex. Top Stroke Rehabil. 2014; 21(4): 316–318

7.Ada L, Foongchomcheay A, Canning C. Supportive devices for preventing and treating subluxation of the shoulder after stroke. Cochrane Database Syst Rev. 2009; 5 (1): DOI: 10.1002/14651858.CD003863.pub2

8. Dajpratham P, Sura P, Lektrakul N, Chanchairujira G. Efficacy of shoulder slings in shoulder subluxation of stroke patients. J Med Assoc Tha. 2006; 89(12): 2050-5.

9. Vafadar AK, Cote JN, Archambault PS. Effectiveness of functional electrical stimulation in improving clinical outcomes in the upper arm following stroke: a systematic review and meta-analysis. BioMed Res Int. 2015; [online]. https://www.hindawi.com/journals/bmri/2015/729768/

10. Gracies J, Marosszeky JE, Renton R, Sandanam J, Gandevia SC and Burke D Short-term Effects of Dynamic Lycra Splints on Upper Limb in Hemiplegic Patients. Arch Phys Med Rehabil. 2000; 81(12):1547-1555.

11. Matthews M, Payne C and Watson M. The use of a dynamic elastomeric fabric orthosis to manage painful shoulder subluxation: a case study. J Prosth Orthot. 2011; 23(3): 155-158.

12. Watson M, Crosby P and Matthews M. An Evaluation of the Effects of a Dynamic Lycra Orthosis on Arm Function in a Late Stage Patient with Acquired Brain Injury. Brain Inj. 2007; 21(7): 103-107.

13. Elm V E, Altman D G, Pocock S J, Gotzsche P C, Vandenbroucke J P The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Epidemiology. 2007; 18(6):800-4.

14. Bohannon RW and Smith MB Interrater reliability of a modified Ashworth scale of muscle spasticity. Phys Ther. 1987; 67 (2):206-7.

15. Ferreira-Valente M A, Pais-Riberio J L, Jensen M P Validity of four pain intensity rating scales. Pain. 2011; 152(10): 2399-404

16. Lannin N Reliability, validity and factor structure of the upper limb subscale of the Motor Assessment Scale (UL-MAS) in adults following stroke. Disabil Rehabil. 2004; 26(2): 109-16.

17. Park GY, Kim JM, Sohn SI, Shin IH, Lee MY. Ultrasound measurement of shoulder subluxation in patients with post-stroke hemiplegia. J Rehabil Med 2007; 39: 526-30.

18. Kumar P, Bradley M, Swinkels A. Within-day and between day intra-rater reliability of ultrasound measurements of acromion-greater tuberosity distance in healthy people. Physiother Theory and Pract 2010; 26(5)**:** 347-51

19. Kumar P, Bradley M, Gray S and Swinkels A Reliability and validity of ultrasonographic measurements of acromion-greater tuberosity distance in poststroke hemiplegia. Arch Phys Med Rehabil. 2011; 92(5):731-6. doi: 10.1016/j.apmr.2010.10.018.

20. Kumar P, Mardon M, Bradley M, Gray S, Swinkels A Assessment of glenohumeral subluxation in post-stroke hemiplegia: Comparison between ultrasound and fingerbreadth palpation methods. Phys Ther. 2014; 94(11):1622-31.

21. Kumar P, Bourke C, Flanders J, Gorman T, Patel H The effect of arm position on the ultrasonographic measurements of the acromion-greater tuberosity distance. Physiother Theory Pract. 2014; 30(3):171-177.

22. Melzack R, Wall PD. Pain mechanisms: a new theory. A gate control system modulates sensory input from the skin before it evokes pain perception and response. Science 1965;150:971-9.

23. Willer JC. Comparative study of perceived pain and nociciptive flexion reflex in man. Pain 1977;3:69-80.

24. Gracies J, Fitzpatrick R, Wilson L, Burke D and Gandevia S 1997 Lycra garments designed for patients with UL spasticity: Mechanical effects in normal subjects. Arch Phys Med Rehabil. 1997; 78(10):1066-1071.

Suppliers

a. SonoSite Ltd, Alexander House, 40A Wilbury Way, SG4 OAP Hitchin, Herts, UK.

b. Jobskin Limited UK, Unit 13a Harrington Mill, Leopold St, Long Eaton, Nottingham NG10 4QG

c. IBM UK, Business Analytics - SPSS, 2 New Square (B32S), Bedfont Lakes, Feltham, Middlesex TW14 8HB, UK.

Figure Legend:

Figure 1: Application of the Lycra sleeve on the arm

Figure 2: A graph to illustrate the effect of Lycra arm sleeve on AGT distance measurements on day 1 and day 8