Does the Application of a Lycra Arm Sleeve Change Shoulder Biomechanics in Young Healthy People? A Mechanistic Study

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ABSTRACT

Introduction: Glenohumeral subluxation (GHS) is commonly reported in people with stroke. Lycra sleeves provide a compressive and supportive effect, influencing the neuromuscular activity in the affected body segment. A recent study reported reduction in GHS (acromion-greater tuberosity [AGT] distance) after application of Lycra arm sleeve; however, its mechanism on the shoulder region as a whole is unclear. The aim of this study was to investigate if application of a Lycra sleeve changes the AGT distance, muscle activity around the shoulder region, and scapular position.

Methods: Healthy participants aged older than 18 years were recruited. Measurements were taken before and immediately after application of the sleeve. Portable diagnostic ultrasound, surface electromyography, and a tape measure were used to measure AGT distance, muscle activity (biceps, triceps, deltoid, and supraspinatus), and position of the scapula, respectively.

Results: Thirty-one participants (11 men, 20 women) with mean age 25 ± 10 years participated. Paired test showed significant mean reduction of 0.12 cm (95% confidence interval [CI], 0.07–0.16 cm) in AGT distance measurements (t = 5.112, df = 30, P = 0.003) and scapula measurements (0.3 cm; 95% CI, 0.04–0.4 cm; t = 2.501; df = 30, P < 0.01) when compared without and with sleeve application.

Conclusions: Future research should investigate the effects of the Lycra sleeve on people with GHS in the different phases of rehabilitation. (J Prosthet Orthot. 2020;32:32–37)

KEY INDEXING TERMS: Lycra arm sleeve, acromion-greater tuberosity distance, muscle activity, glenohumeral, subluxation, stroke

The shoulder is a highly mobile and less stable joint. As compared with the hip joint, the glenoid is much shallower than the acetabulum, allowing for a greater range of motion of the glenohumeral joint in various planes.1 Given this increased mobility, the glenohumeral joint is associated with increased instability as compared with other joints. Consequently, disorders of the shoulder complex are common after stroke leading to pain, glenohumeral subluxation (GHS), and impaired upper-limb function.2,3 GHS is a common poststroke complication reported in up to 81% of patients depending on the measurement methods used and the time frames over which it is assessed.2 The rotator cuff provide force coupling mechanism to align the head of the humerus in the glenoid cavity; however, this mechanism is compromised due to loss of motor control after stroke causing GHS.4,5 A cross-sectional study on chronic patients with stroke (n = 45) investigated the correlation between postural alignment and postural control in sitting.6 The study found that the degree of forward head posture correlates directly with seated postural control and inversely with degree of kyphosis, and that the postural control is directly related with the Brunnstrom stage of recovery in the affected upper limb in sitting.6 There is some evidence to support the relationship between scapular orientation and GHS.7,8 Varied approaches including supportive devices and functional electrical stimulation have been proposed for prevention and management of GHS9–12; however, evidence to support the effectiveness of current approaches for management of GHS is limited.13 The functional basis of Lycra garments is to exert a compressive and supportive effect, which increases sensory attention and thus positively influences alignment, biomechanics, and neuromuscular activity in the affected body segments.14 Limited studies have shown some beneficial effects of Lycra arm sleeve in people with poststroke hemiplegia.15,16 In a small (n = 16) crossover study, people with poststroke hemiplegia were asked to wear a Lycra sleeve (from the wrist to the middle of the upper arm) for 3-hour periods. Patients showed improvement in the 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).15 These effects were significantly different when compared with patients not wearing the sleeve.

In our recent study on people with chronic stroke (n = 5),16 the Lycra arm sleeve was applied from the wrist joint up to the insertion of deltoid on the humerus. Patients were advised to wear the sleeve for at least 7 hrs/d. GHS was measured using ultrasound (acromion-greater tuberosity [AGT] distance) before

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and after the application of the sleeve on day 1 and after 1 week of wearing a sleeve. There was a mean reduction of 0.24 cm and 0.18 cm in AGT distance on days 1 and 8, respectively. When AGT distance measurements from “sleeve off” on day 1 were compared with “sleeve on” on day 8, it showed a mean reduction of 0.27 cm. Despite the fact that Lycra arm sleeve does not cross the shoulder joint, there was a reduction in AGT distance. However, the mechanism of Lycra arm sleeve on the shoulder region is not clearly understood.

To the best of our knowledge, no previous study has investigated the mechanism of Lycra arm sleeves on the shoulder region. The purpose of this pilot study was to understand the changes in shoulder biomechanics (AGT distance, shoulder muscle activity, and scapula position) after application of the Lycra arm sleeve on healthy individuals before testing this on people with poststroke hemiplegia.

METHODS

STUDY DESIGN

This was a cross-sectional, observational study where a sample of convenience (n = 31) was recruited between February and March 2016. This study adhered to the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

PARTICIPANTS AND RATERS

Healthy individuals aged older than 18 years were eligible to participate in the study, and a convenient sample of n = 31 were recruited from the authors’ academic institution. Participants were invited by email, and those who expressed interest were provided with study details and recruited into the study. People with a previous history of injury to the neck or shoulder were excluded from the study. The study received approval from the Research Ethics Committee of the University of the West of England, and each participant gave informed written consent to take part.

Three raters (final-year physiotherapy students) were involved in the assessment procedure. One rater was involved with ultrasound measurements of AGT, the second rater was involved with electromyography (EMG) recordings, and the third rater was involved with scapula measurements using standard protocols. For ultrasound measurements of AGT, a previously tested training protocol for ultrasound measurements of AGT distance was used. That study reported good intrarater (intraclass correlation coefficient [ICC], 0.88–0.91) reliability when assessed by three physiotherapy students in healthy individuals. The ultrasound training in this study included 1) 1 hour of formal training on the portable ultrasound technique for AGT measurements and 2) practice on five healthy volunteers (2–3 hrs) to become familiar with the protocol and measurement procedure.

APPARATUS

A portable diagnostic ultrasound (TITAN model, M-Mode, Depth 3.9, L38/10-5 MHz broadband 38-mm linear array transducer; Sonosite Limited, Hitchin, United Kingdom) was used for scanning the shoulder and for recording the AGT distance. The equipment was tested and calibrated according to the manufacturer’s guidelines before commencement of the data collection process. The precision of linear measures based on manufacturer specifications is ±2%. A portable electromyography device (Bio-Trac Plus; EMS Physio Ltd, England) was used for recording muscle activity. A tape measure was used to record measurements of scapula position.

PROCEDURE

Baseline demographic data including age, sex, and dominant arm were collected before data collection. AGT distance using ultrasound, muscle activity using EMG, and scapula position measurements were taken before and with application of a Lycra sleeve (Figure 1). The order of data collection was ultrasound measurements, EMG muscle activity (biceps brachii, triceps, deltoid, and supraspinatus), followed by scapula position measurements. All measurements were taken on the participant’s dominant arm.

For ultrasound measurements of AGT distance, each patient was placed in a standardized position to allow measurement of AGT distance. The shoulder was in neutral rotation, with the elbow at 90° of flexion and the forearm in pronation. The forearm rested on a pillow placed on the participants’ lap with the elbow joint itself remaining unsupported. The ultrasound transducer then was placed over the lateral border of the acromion along the vertical/longitudinal axis of the humerus to scan the shoulder. AGT distance was recorded on the frozen image using an onscreen caliper that automatically calculates distances (Figure 2). AGT distance was defined as the relative lateral distance between the lateral edge of the acromion process of the scapula and the nearest margin of the superior part of the greater tuberosity of the humerus. A dark linear acoustic shadow beneath the acromion helped to identify the lateral edge of the acromion. The tendon of supraspinatus was clearly visible as a thick band (acoustic hyperechoic appearance) at its point of

![Figure 1. Application of the Lycra arm sleeve on the arm.](image-url)
insertion, which facilitated identification of the greater tuberosity (Figure 2). To ensure the rater was blind to measurements, the values displayed were obscured by placing a sticker on the ultrasound screen.

For electromyography, each participant was seated in a relaxed position with arms down by the side. To measure the levels of muscle activity, electrodes were placed on supraspinatus, deltoid, triceps, and biceps in the positions advised by the Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM), and the measurement was taken individually with ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM), and the measurement was taken individually with the surface electrodes were in situ and the Lycra sleeve was applied over the top of electrodes.

Scapula measurements were recorded in both sitting and standing positions, with arms relaxed at the side using the previously described protocol. To facilitate a natural posture, participants were asked to swing their arms gently backward and forward three times by their sides and stop in a position that felt natural and comfortable to them. To ensure consistency, each participant received this instruction before each data collection period. Two linear measurements were taken for the position of the scapula: 1) from the medial aspect of the spine of scapula (point A) and the spine process parallel to the spine of the scapula (B); and 2) from the inferior angle of the scapula (C) to the parallel spino process (D). Both sitting and standing positions were selected because the upper limb plays an important role in functional activities in sitting and during standing for balance and gait.

Researcher 4 (another physiotherapy student) received training from the manufacturer on the application of the sleeve and practiced on few healthy participants before data collection. According to the manufacturers’ recommendations, the wrist circumference was measured for each participant 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. Each participant was seated in a chair with the arm resting in his or her lap and the forearm in the midprone position. First, the donning on/doffing off material was applied, followed by the application of the Lycra sleeve. During the application, a torque was applied while pulling up to assist with external rotation (ER), and this was confirmed with the label and “see” facing posterior-lateral aspect of the arm (Figure 1).

**RESULTS**

Over a period of 4 weeks, 31 healthy participants (11 men, 20 women) with a mean age ± SD of 25 ± 10 years (range, 19–58 years) were approached and recruited into the study. A summary of descriptive data for AGT, EMG, and scapula measurements both without and with a sleeve is presented in Table 1.

Paired test showed significant mean reduction of 0.12 cm (95% CI, 0.07–0.16 cm) in AGT distance measurements ($t = 5.112, df = 30, P = 0.003$) and scapula measurements (0.3 cm; 95% CI, 0.04–0.4 cm; $t = 2.501; df = 30; P < 0.01$) when compared without and with sleeve application. Both Wilcoxon test and post hoc testing with pairwise comparisons using Bonferroni corrected levels of significance revealed no statistically significant mean difference for all other tested variables when compared without and with sleeve application (Table 2).

**DISCUSSION**

The aim of this study was to understand the mechanism of Lycra sleeves on the shoulder girdle by exploring AGT distance, muscle activity, and scapular position. To do this, healthy participants were recruited and the measurements were recorded without and with the application of Lycra sleeves. Paired test showed significant mean reduction of 0.12 cm in AGT distance measurements and 0.3 cm in inferior scapula measurements after the application of Lycra sleeve.
Application of the Lycra sleeve resulted in a statistically significant reduction in the AGT (mean, 0.12 cm) when compared with the distance before application of the sleeve. This is in agreement with a previous study on people with stroke, which showed a mean reduction of 0.24 cm immediately after the application of sleeve. In that study, an experienced rater was involved with ultrasound measurements of AGT distance. In contrast, in this study, a physiotherapy student trained in ultrasound measurements recorded AGT distance. Ultrasound was found to be a reliable and valid tool for measurement of AGT distance, both in healthy and stroke populations even when used by novice raters including physiotherapy students. One study involving three physiotherapy students reported excellent interrater reliability (ICC, 0.79) of AGT measurements for the right shoulder in a relatively younger age group (mean age ± SD, 21 ± 2 years). Another recent study assessed interrater reliability of ultrasonographic measurements of AGT distance between experienced and novice raters in healthy individuals. This study found good (ICC, 0.61) to excellent (0.87) interrater reliability.

Previous studies have shown that ultrasound is sensitive in detecting minor changes in AGT distance. A study on young healthy participants (mean age ± SD, 28 ± 11 years) that investigated the effect of different arm position reported that a change of greater than ±0.1 cm in AGT distance measurements would be necessary to indicate a real change in measurements across different arm positions. These findings suggest a beneficial effect for the Lycra sleeve in reducing the AGT distance, which is equivalent to the smallest detectable change previously observed in healthy participants.

Previous studies have proposed that Lycra garments provide a directional pull, which encourages the arm to adopt an improved position for functional tasks. The application of Lycra arm sleeve in this study may have caused approximation of the humerus into the socket and ER at the shoulder joint. During shoulder ER, the infraspinatus muscle, one of the RC muscles, stabilizes the shoulder joint and acts as the prime mover. The infraspinatus muscle reportedly has a larger stabilizing role as EMG (electromyographic) activity was not recorded for the infraspinatus muscle in our study.

The changes noted in AGT distance could be attributed to the effect Lycra sleeve has on the forearm. One study investigated the mechanical effects of Lycra garments on 10 healthy

Table 1. Descriptive data for AGT distance, EMG activity, and scapula position without and with Lycra arm sleeve

|                     | Presleeve          | With Sleeve        |
|---------------------|--------------------|--------------------|
| AGT (cm)            | Min 2 Max 2 Mean ± SD 1.8 ± 0.3 95% CI 1.7–1.9 | Min 2 Max 2 Mean ± SD 1.7 ± 0.2 95% CI 1.6–1.8 |
| EMG Activity (μV)   | Biceps 1 4 2.7 ± 1 2.4–3.0 | Biceps 2 7 4.0 ± 1 3.2–4.0 |
| Triceps 1 5 2.5 ± 1 2.1–2.9 | Triceps 2 13 4.5 ± 2 3.6–5.3 |
| Supraspinatus 1 20 4 ± 3 2.8–5.1 | Supraspinatus 12 5.1 ± 3 4.1–6.1 |
| Deltoid 2 7 3.6 ± 1 3.1–4.0 | Deltoid 2 9 4.6 ± 2 4–5 |
| Scapula position (cm), standing | Superior (A to B) 6.5 11 8 ± 1 7.5–8.4 | Superior (A to B) 5 10 7.7 ± 1 7.3–8.2 |
|                      | Inferior (C to D) 7.5 13.5 9.7 ± 1 9.1–10.1 | Inferior (C to D) 7.5 13.5 9.4 ± 1 8.9–10.1 |

AGT indicates acromion-greater tuberosity distance; EMG, electromyography; A to B, the medial aspect of the spine of scapula (point A) and the spino–process parallel to the spine of the scapula; C to D, from the inferior angle of the scapula (C) to the parallel spinous process (D); SD, standard deviation; CI, confidence interval.

Table 2. Mean difference, SE, CI for AGT distance, EMG muscle activity, and scapula measurements without and with Lycra arm sleeve

|                      | MD      | SE      | 95% CI   | P      |
|----------------------|---------|---------|----------|--------|
| AGT distance (cm)*   | 0.1     | 0.02    | 0.02–0.2 | 0.003  |
| EMG activity (μV)    | 0.8     | 0.22    | −0.05 to 1.78 |
| Biceps               | 0.47    | −0.01 to 3.81 |
| Triceps 1.9          | 1.2     | 0.55    | −1.07 to 3.40 |
| Supraspinatus        | 0.9     | 0.31    | −3.40 to 2.21 |
| Deltoid              | 0.24    | 0.08    | −0.59 to 0.10 |
| Scapula Measurements | Superior (A to B) 0.25 | 0.10  | −0.67 to 0.17 |
|                      | Inferior (C to D) −0.24 | 0.01  | −0.63 to 0.15 |
|                      | Superior (A to B) 0.25 | 0.10  | −0.85 to −0.05 |
|                      | Inferior (C to D) −0.50 | 0.10  | −0.85 to −0.05 |

*Statistically significant.

MD indicates mean difference; SE, standard error; CI, confidence interval; A to B, the medial aspect of the spine of scapula (point A) and the spinous process parallel to the spine of the scapula; C to D, from the inferior angle of the scapula (C) to the parallel spinous process (D).
The aim was to assess the stretch of pronator muscles produced by a specifically designed upper-limb Lycra garment that could have a better acceptability than rigid splints in treating upper-limb spasticity. The study investigated if custom-designed Lycra garments exert continuous stretch in predetermined directions and focused on a supinator action. The Lycra sleeve was applied with the arm in neutral position with a pull in the direction of supination. The study found that the garment supinated the forearm in all subjects (mean, 17°; P < 0.01; range, 5° to 44°). The Lycra garments can improve range because of how the arm was placed in a better alignment, due to increased stability in the arm as a result of compression, and because of awareness to assist with active movement proximally in the shoulder.

Similarly, another study on people with stroke found a mean (4.1° ± 13.0°) increase in passive range of movement at the shoulder joint (across all movements) after application of Lycra arm sleeve applied from wrist to the insertion of deltoid. Also, that study reported improvement in elbow proprioception task after application of Lycra sleeve. There is some evidence to suggest that Lycra sleeve provides proprioceptive feedback to the skin. The authors postulated that the changes noted distally may have produced improvements proximally due to the effect occurring at the spinal level by the multi-segmental, large-fiber, cutaneous input from the skin due to contact of the sleeve.

EMG measurements showed no statistically significant difference in the activity of the biceps and triceps when wearing the sleeve. However, there was some increase in the activity in these muscles leading to the assumption that any resulting contraction of these muscles was helping pull the head of the humerus into better alignment with the glenoid fossa, thereby reducing the AGT distance. This could potentially explain the reduction in AGT distance found in this study. As biceps and triceps are two-joint muscles, their activation in the elbow region may lead to the positive effects found in the shoulder region. A recent study found that electrical stimulation of the long head of biceps along with supraspinatus and posterior deltoid was more effective in reducing GHS after stroke, when compared with just stimulating the supraspinatus and deltoid alone.

This study found a reduction in the inferior angle of the scapula position measurements after wearing the Lycra sleeve. The position of the scapula that enables optimal function of the upper limb for functional tasks is the retraction position. It allows for maximal activation of the muscles that originate on the scapula and puts muscles at a biomechanical advantage for normal scapulohumeral rhythm, which is necessary for smooth, controlled shoulder motions. Although not all scapular measurements reached a statistically significant difference in our study, evidence from the literature supports the positive effect of scapula retraction on shoulder joint rehabilitation.

LIMITATIONS

Despite these favorable findings, the present study has several limitations. First, a small convenient healthy sample with a relatively younger age group was selected; therefore, generalizability is limited. Second, because of a lack of randomization, the raters always performed the measurements in the same order; therefore, order effects cannot be excluded. Third, a portable EMG machine was used. EMG signal acquires noise while traveling through different tissues. Moreover, the EMG detector, particularly if it is at the surface of the skin, collects signals from different motor units at a time, which may generate interaction of different signals. Detection of EMG signals with powerful and advance methodologies is recommended, and this should be considered for future research. Fourth, pre-post postural alignment in standing or sitting focusing on a plumb line bisecting the ear-acromion-humerus side view or posterior view of the scapula was not recorded and would be helpful in the future study. Finally, Lycra sleeves were not worn for a long period, and measurements were not repeated over time. This should be considered when testing the effect of Lycra sleeves on patient populations.

CONCLUSIONS

In conclusion, the application of Lycra sleeves reduced AGT distance, increased activity in some muscles in the shoulder region, and positioned scapula in a mechanically advantaged position in healthy individuals. Further investigations on patients with stroke and targeting other rotator cuff muscles during EMG testing are required to understand the mechanism and to establish the clinical effectiveness of Lycra sleeve.

ACKNOWLEDGMENTS

This project has been undertaken as part of an undergraduate research study on the BSc (Hons) Physiotherapy programme at the University of West of England. The authors would like to thank Felicity Hamilton and Zinor Dillen for the help with the data collection; Lydia Dean from Jobskin Limited, UK for providing the Lycra sleeves for the study; Professor Shea Palmer, Dr Sue Barnett, and Vincent Singh for their critical comments; and the volunteers for their participation.

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