Immediate effects of two types of stretching techniques on glenohumeral internal rotation deficit and posterior shoulder tightness; a crossover randomised controlled trial.

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Abstract

Objectives: Various stretching techniques have been proposed to prevent or improve Glenohumeral Internal Rotation Deficit (GIRD) and Posterior Shoulder Tightness (PST). Common stretching techniques include modified sleeper stretch and cross-body stretch. The current evidence is unclear which stretching technique is more effective. This study aimed to examine immediate effects of modified sleeper stretch and cross-body stretch on GIRD and PST.

Methods: This study was a crossover randomised controlled trial. 12 young healthy individuals (nine men and three women, age 20.9 ± 0.3 years, body mass index 21.3 ± 1.3) were recruited. At two separate sessions, participants actively performed a randomly assigned stretching technique; modified sleeper stretch, or cross-body stretch. Range of motions (ROM) of dominant shoulder in external rotation (ER), internal rotation (IR) and horizontal adduction (HA), were assessed before and after stretching interventions.

Results: Both stretching interventions led to significant immediate improvements in IR and HA ($p<0.01$), however not in ER. There was no significant difference between the two intervention groups in terms of ROM changes.

Conclusion: Both modified sleeper stretch, and cross-body stretch might be applied effectively to treat GIRD and PST in the short term, as long as they do not provoke pain.

Keywords: Glenohumeral internal rotation deficit, Posterior shoulder tightness, Modified sleeper stretch, Cross-body stretch, Crossover randomised controlled trial.

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Introduction

Glenohumeral internal rotation deficit (GIRD) and Posterior shoulder tightness (PST) are commonly reported in overhead sports, such as baseball, volleyball and tennis [1-3]. GIRD is generally defined as decreased internal rotation (IR) range of motion (ROM) in the dominant arm compared with the non-dominant side [4]. PST is typically evaluated as passive shoulder horizontal adduction (HA) ROM with the scapula stabilized in supine or side lying [5,6]. A dominant theory regarding the mechanism of these impairments is thickening of posterior glenohumeral capsule and stiffness or shortening of posterior muscles, such as the posterior deltoid, infraspinatus and teres minor muscles [7,8]. Some authors suggested that repetitive tensile stress to posterior structures during the follow-through phase in throwing movements could lead to inflammation and scar formation, resulting in increased stiffness of these tissues [9]. In addition, GIRD can also be influenced by humeral retrotorsion. Increased humeral retrotorsion can occur due to repetitive throwing activities at younger ages [10]. Although soft tissue changes might be changed by passive stretch, osseous changes will not respond to stretching interventions. Since both PST and GIRD are thought to reflect stiffness of posterior structures in the shoulder, the term PST is occasionally used instead of GIRD in order to describe decreased IR ROM [11].

A growing body of evidence suggests that GIRD and PST can contribute to shoulder pain [6,12-15]. Incidence of shoulder pain due to subacromial impingement is thought to be high [16-18]. Subacromial impingement accounts for 44-60% of all shoulder pain complaints during physician visits [17,18]. The presence of GIRD and PST has been reported to be associated with subacromial impingement symptoms in the general population [19]. In fact, one cadaveric study found that PST led to a significant increase in peak subacromial contact pressure during shoulder motions [12]. Symptomatic internal impingement, the other form of impingement is most commonly found in throwing sports, such as baseball [20]. One cross-sectional study with competitive baseball players in the USA showed that athletes with pain due to internal impingement demonstrated significantly greater GIRD and PST compared with control subjects [6]. Another cadaveric study confirmed that simulated posteroinferior capsular tightness could significantly increase glenohumeral contact pressure, causing internal impingement at maximum external rotation [13]. A prospective cohort study among high school baseball and softball players reported that players with GIRD appeared to have a higher risk for shoulder or elbow injury compared to those without GIRD [21]. Another prospective cohort study reported that resolution of symptoms was associated with correction of PST in athletes with internal impingement symptoms [15]. Based on these studies, it is reasonable to assume that GIRD and PST may contribute to shoulder pain due to subacromial or internal impingement.

Various stretching interventions have been proposed to address GIRD and PST. The most common forms of stretching are the sleeper stretch and the cross-body stretch [22]. In the sleeper stretch, patients lie on the involved shoulder in a side-lying position with the shoulder in 90° flexion. Using the opposite hand, the shoulder is passively moved towards internal rotation. Since this position is similar to subacromial impingement tests, it may provoke symptoms in the painful shoulder and thus, may not be an appropriate intervention for treatment in the early phases of recovery [23]. One author proposed the modified sleeper stretch, where patients rotate their upper trunk posteriorly 20-30 degrees in side-lying so that the shoulder is in 20-30 degrees less of horizontal adduction and closer to the scapular plane, which may decrease pain [24]. In the cross-body stretch, patients horizontally adduct one shoulder with the contralateral hand in sitting or standing [25]. These stretching manoeuvres are thought to be able to stretch posterior muscles and the capsule. Although these forms of stretching are often used in clinical practice, the validity and mechanisms of these two conventional stretching techniques for posterior shoulder structures is still not entirely clear [26,27]. The most recent systematic review concluded that the cross-body stretch might be more effective than the sleeper stretch to reduce GIRD [28].

To date, there is a paucity of literature comparing the effects of the modified sleeper stretch and the cross-body stretch [24]. The objective of this study was to investigate immediate effects of the modified sleeper stretch and the cross-body stretch on GIRD and PST. The author hypothesised that there will be equally significant improvements in GIRD and PST after two types of stretching techniques.

Methods

Ethical approval and trial registration

This study was approved by an ethical committee in Tokyo University of Technology before the commencement of experiments (registration number: E16HS-31). The protocol of this trial was registered in University Hospital Medical Information Clinical Trials Registry (registration number: UMIN000025981) in advance.

Participants

Prior to data collection, all subjects were advised in the risks and benefits of participation in this study. Each subject volitionally signed a waiver. Twelve healthy young collegiate students (nine men and three women, age 20.9 ± 0.3 years, body weight 59.2 ± 5.9 kg, height 166.7 ± 5.0 cm, body mass index 21.3 ± 1.3) with GIRD were recruited for this study. Before initiating data collection, screening tests were taken to identify subjects with GIRD. In this study, GIRD was defined as more than 10° decrease in IR at 90° abduction in the dominant side compared to the non-dominant side [2]. Subjects were excluded if they met any of the following exclusion criteria: pain during either of the two stretching manoeuvres, shoulder pain in the previous three months or positive subacromial impingement signs during Hawkins-Kennedy or Neer test [29].

A sampling process is shown in Figure 1. At first, 26 healthy collegiate students volunteered to participate in this research. Following screening assessments, 14 subjects were excluded due to pain during the modified sleeper stretch (n=7), the absence of GIRD (n=5), shoulder dislocation due to a skiing accident after his first intervention (n=1) or an inability to perform the stretches correctly (n=1). All eligible participants (n=12) were right-handed. Exercise habits of the participants ranged from zero to two times per week of activity. The majority of patients had experiences in overhead sports; baseball (n=5), softball (n=2), badminton (n=1) and swimming (n=1). Other sports included basketball (n=1), rugby (n=1) and football (n=1). Before participation, the contents and the purpose of the study, and protection of personal information were verbally explained. All subjects read documents regarding the study and signed informed consents. Subjects were instructed to refrain from any vigorous overhead exercises or stretching for 48 hours before sessions. Due to the nature of the stretching interventions, it was not possible to blind participants.

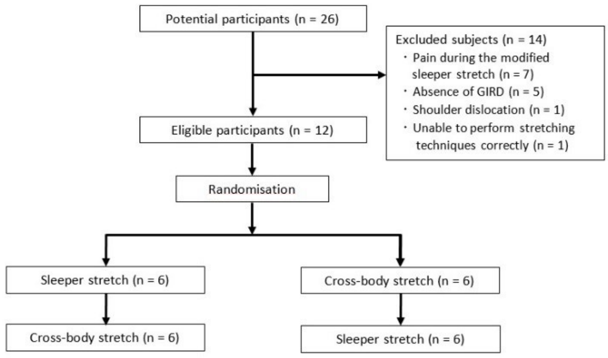

Figure 1. *A flowchart of the study.*

Experimental procedures

This study was a crossover randomised controlled trial, in which each subject completed the stretching interventions for two days. This research design was chosen in order to guarantee as large of a sample size as possible. After the recruitment of eligible subjects, all subjects participated in a five-minute familiarisation session to learn how to perform two active stretching techniques. The modified sleeper stretch was conducted by subjects by rotating their upper trunk posteriorly 20-30° in side-lying, and rotating the dominant shoulder internally at 90° shoulder flexion and 90° elbow flexion using the non-dominant hand [24]. The cross-body stretch was performed by subjects actively in the seated position without a back rest for support. Participants were instructed to hold the end position statically for 20 seconds, and repeat five times with a 10-second rest between stretches. Each stretching intervention lasted for two minutes and 20 seconds in total. The two-posterior shoulder stretching techniques are illustrated in Figure 2.

After the recruitment of twelve subjects, each subject participated in two experiments in a random order, enabling the allocation concealment (see Figure 1). Two testing sessions were separated by a minimum of 48 hours, in order to minimise potential carry-over effects of stretching. In the first experimental sessions, anthropometric measurements were taken, and body mass index was calculated accordingly. In both intervention sessions, the baseline data for ER, IR and HA on the dominant side was collected in this order. The baseline from both testing sessions was utilised to determine the reliability of this outcome measure. ROM measurements were performed by the same two examiners (one physiotherapist and one undergraduate physiotherapy student) using a digital inclinometer (Myzox, Japan). The primary assessor, who has a Master's degree in musculoskeletal and sports physiotherapy, was engaged in passively moving subjects' arms into end range. The secondary assessor was responsible for placement of the inclinometer for all measurements taken. Maximum ROM was defined as when the primary assessor experienced resistance to further humeral motion while the scapula was manually stabilized. The assessments were performed for each subject lying in supine on the same treatment table (see Figure 3). ER and IR were assessed in 90° of shoulder abduction and 90° of elbow flexion with the forearm in a neutral position. Scapula was manually stabilized by the primary assessor in a firm manner to avoid compensatory movements. HA was assessed by the examiner passively moving each subject's humerus into a horizontally adducted position while the glenohumeral joint in a neutral rotational position.

In the first testing sessions, following baseline measurements, the two assessors left the room, and subjects performed a randomly chosen stretching technique (either the modified sleeper stretch, or the cross-body stretch). Excel 2016 (Microsoft, USA) was used for randomisation. After each stretching protocol was completed, the testers entered the room for post-intervention measurements. Post-intervention measurements were performed for the dominant side in the same manner.

For the second testing sessions, subjects were again assessed in the same manner as the first session. In this session, however, the other stretch was performed by the subjects. Thus, each subject performed two different interventions with at least 48 hours between sessions to allow comparisons between the two stretching techniques. The information regarding the order of stretching methods were not given to the two assessors until the completion of post-intervention assessments in second sessions, which enabled blinding for assessors.

Each testing session was held at the same time of day. All testing sessions were conducted in the same room at the same room temperature of 22 degrees Celsius. Participants were instructed to wear a short-sleeve T-shirt in the experiments. All participants were instructed to wear a t-shirt during testing. This maintained patient modesty for females, and thus maximised the subject pool for recruitment. Care was taken to ensure that all participants received the same verbal instructions and visual cues to minimise potential bias.

Figure 2. *Methods of stretching techniques; conventional sleeper stretch (left), modified sleeper stretch (middle) and cross-body stretch (right).*

Figure 3. *Measurement methods; ER (left), IR (middle) and HA (right).*

Statistical analysis

The results are presented as mean ± standard deviation (SD) values. The baseline data was utilised to calculate intraclass correlation (ICC) and determine the reliability of the ROM measurements. ICC was evaluated accordingly; <0.20 as slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial and 0.80< as almost perfect [30,31]. Shapiro-Wilk test was performed to test the distribution normality of each data set. A paired t-test or a Wilcoxon signed-rank test was performed for differences between pre- and post-intervention data within each condition. An independent t-test was used to assess differences between the two stretching conditions. Statistical tests were conducted with SPSS (IBM, USA). The differences were considered statistically significant at $p<0.05$. Hedges' g and 95% confidence intervals (CI) were calculated to determine within-group effect sizes [32,33]. Effect size was categorised as large (>0.8), moderate (>0.5) or small (>0.2) [34]. In addition, post-hoc power analysis was performed using G*Power [35].

Results

As a result of screening tests, mean deficit in IR ROM among twelve participants was 19.3 ± 5.7°. All subjects (n=12) participated in both testing sessions and there was no dropout (see Figure 1). ICC of the ROM measurements for ER, IR and HA were 0.99, 0.84 and 0.93 respectively. Thus, ROM measurements in this study were proven to have an almost perfect reliability [30,31]. Descriptive statistics for the results are summarised in Table 1. Shapiro-Wilk tests were not significant, except for the baseline data for HA ROM in the cross-body stretch group ($p<0.05$). There was no significant difference between each baseline data set in the two stretching groups, which confirmed the baseline comparability.

Evaluation of the within-group data using paired t-test and Wilcoxon signed-rank test showed statistically significant improvements in IR and HA ROM in both stretching groups after interventions ($p<0.01$). However, there was no significant difference in ER ROM between baseline and post-intervention data in both groups.

Table 1. *Results in ROM measurements.*

	ER pre	ER post	IR pre	IR post*	HA pre	HA post*
MSS	121.8 ± 10.4°	123.8 ± 10.0°	50.3 ± 5.8°	57.5 ± 6.4°	0.4 ± 8.5°	6.6 ± 9.1°
CBS	122.3 ± 9.3°	122.9 ± 8.9°	51.2 ± 6.5°	57.1 ± 7.3°	1.3 ± 7.9°	6.3 ± 7.6°

MSS=modified sleeper stretch, CBS=cross-body stretch, pre=pre-intervention data, post=post-intervention data, ER=external rotation, IR=internal rotation, HA=horizontal adduction, *=statistically significant improvement compared to pre-intervention data ($p<0.01$).

In terms of the between-group comparisons, independent t-tests demonstrated no significant difference in changes in ROM for ER, IR or HA between the two groups (p=0.29, p=0.41 and p=0.53 respectively) (refer to Figure 4). Modified sleeper stretch displayed large and moderate effect sizes, 1.13 (95% CI -1.32 to 3.57) for IR ROM and 0.68 (95% CI -2.83 to 4.19) for HA ROM respectively. Cross-body stretch also showed large and moderate effect sizes, 0.83 (95% CI -1.95 to 3.61) for IR ROM and 0.63 (95% CI -2.46 to 3.72) for HA ROM respectively. A post-hoc analysis revealed low statistical power (0.19 and 0.22 in terms of IR and HA respectively).

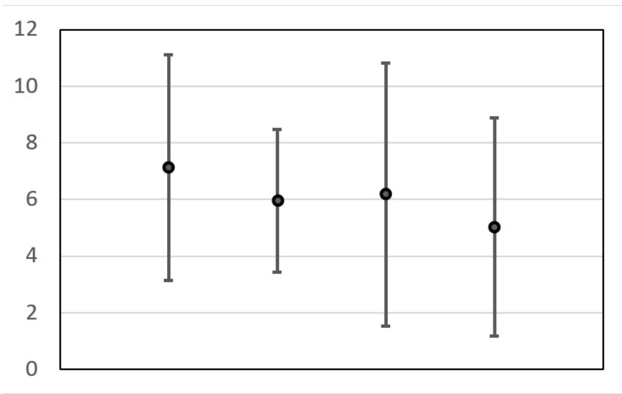

Figure 4. *A comparison of changes in ROM; (from left to right) 7.1 ± 4.0° (sleeper stretch for IR), 6.0 ± 2.5° (cross-body stretch for IR), 6.2 ± 4.6° (sleeper stretch for HA) and 5.0 ± 3.9° (cross-body stretch for HA).*

Discussion

The purpose of this study was to investigate the acute effects of two different types of stretching on GIRD and PST. This is the first study comparing the effects of modified sleeper stretch and the cross-body stretch on GIRD and PST. The author hypothesised that there will be equally significant improvements in GIRD and PST after two types of stretching techniques. The results of this study were in line with the hypothesis and suggest that modified sleeper stretch, and the cross-body stretch might be equally effective to immediately improve GIRD and PST when performed actively without pain.

One randomised controlled trial by McClure et al. compared the effects of four-week stretching programs (the sleeper stretch, or the cross-body stretch) on GIRD of asymptomatic subjects [36]. They reported that only the cross-body stretch group showed significantly greater improvements in GIRD compared to control group. They speculated that more frequent pain during stretching in the sleeper stretch group might have confounded the findings. Although the timeframes of interventions were different, our study indicated equal effects of the modified sleeper stretch and the cross-body stretch. A possible explanation to this difference between the study by McClure et al. and our study is that only subjects who did not feel pain during stretching were recruited in our study [36]. Furthermore, the modified sleeper stretch might cause less mechanical stress to subacromial tissues and less discomfort, without preventing sufficient end range to stretch muscles and periarticular tissues of the posterior shoulder. Therefore, the modified sleeper stretch might have a clinical advantage over the traditional sleeper stretch.

It should be noted that seven subjects were excluded due to pain during the modified sleeper stretch in the screening tests. Out of 26 subjects who volunteered to participate in this study, no subject reported pain during the cross-body stretch. This trend corresponded to the finding from one RCT investigating the effects of traditional sleeper stretch and cross-body stretch [36]. Given that the cross-body stretch is less provocative and there is no significant difference between effects of the modified sleeper stretch and the cross-body stretch, the cross-body stretch might have better clinical utility, particularly for patients with shoulder pain. However, there is no laboratory study to substantiate the relationship between pain during different stretching methods and subacromial contact pressures.

Several methodological limitations in this research must be reflected. A first weakness exists in the sampling method. Since subjects with varied exercise habits and different sporting experiences were recruited through convenience sampling, this heterogeneity might have potentially biased our findings. Potential existence of humeral retrotorsion among subjects who participate in overhead sports might have also biased the findings because GIRD due to humeral retrotorsion does not respond to stretching interventions. A post-hoc power analysis revealed low statistical power (0.19 and 0.22). The failure to guarantee a large sample size may have compromised the statistical precision to detect a potential statistical significance between the two stretching interventions [37]. Since only healthy subjects without shoulder pain were recruited in this study, the findings might not be applicable to patients with symptomatic shoulders. Since seven subjects were excluded due to shoulder pain during the modified sleeper stretch, it is difficult to generalise the findings in this study to patients with shoulder pain. Although the two examiners were blinded, the absence of a genuine control group with placebo intervention or no intervention might have introduced measurement bias. Furthermore, we allowed all participants to wear their own short-sleeve T-shirts during the measurement sessions. ROM measurements were potentially affected by the resistance from T-shirts being stretched, especially in the assessment of HA ROM. Another limitation of this study are the effect sizes of the two stretching groups. Although these effect sizes were large or moderate to improve GIRD and PST, 95% CI of effect sizes consistently included the value of zero. We need to consider these potential limitations carefully to interpret the findings of the study.

Conclusion

Based on the findings of this crossover randomised controlled trial, both the modified sleeper stretch, and the cross-body stretch appear to be effective to treat GIRD and PST of asymptomatic subjects, when they are applied without provoking pain. The cross-body stretch might be more appropriate and clinically useful for patients with subacromial pain, compared to the modified sleeper stretch. Further studies are required to examine their long-term effects and effects on patients with shoulder pain.

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