IJCMCR Open Access

International Journal of Clinical Studies & Medical Case Reports

ISSN 2692-5877
DOI: 10.46998/IJCMCR.2023.35.000868

Research Article

Shoulder Laxity Among Badminton Players: Instrumented Measurement Comparing Arm Dominance, Gender and Years of Play

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Received: October 23, 2023 **Published:** April 03, 2024

Abstract

Background: Badminton is an overhead sport and requires significant shoulder joint mobility, which may compromise shoulder stability.

Hypothesis/Purpose: The aim of this study is to investigate if there is significant difference in laxity between the dominant and non-dominant shoulder in badminton players. The prevalence of shoulder injuries in badminton players in Singapore will also be investigated.

Study design: A cross sectional study on shoulder laxity amongst competitive badminton players.

Methods: Forty-six competitive badminton players who have represented the combined schools or the country (Singapore) were selected for this study. A survey and two questionnaires, UCLA Shoulder Score (USS) and Oxford Instability Score (OIS), were administered. Assessment of shoulder laxity was performed using a shoulder mechanical device that was fitted on the participants' shoulders. The translation of the displaced humeral head on the glenoid cavity was measured anteriorly and posteriorly. This test was performed on both shoulders.

Results: Increased laxity in the non-dominant shoulder was observed. The anterior-posterior translation ranged from 3 to 15.2 millimeters for the dominant shoulder and from 3.6 to 22.5 millimeters for the non-dominant shoulder. Female badminton players had more shoulder laxity (3.6 to 22.5 millimeters) compared to male badminton players (3 to 14.5 millimeters). Sixty-five percent of participants had maximum scores for USS and 36.9% for OIS. The prevalence of shoulder injuries in the studied group was 40%.

Conclusions: The decreased anterior-posterior translation of the humeral head in the dominant shoulder of badminton players demonstrates that it has greater stability despite the need for greater mobility. Female badminton players have greater humeral head translation compared to males.

Clinical relevance: These data will help orthopaedic surgeons and physical therapists validate the use of selected therapeutic and surgical procedures.

Keywords: Shoulder general; Shoulder instability; Medical aspects of sports; Biomechanics general

What is known about the subject?

Several studies have reported that laxity in the dominant or throwing shoulder is greater than that in the non-dominant shoulder

What this study adds to existing knowledge:

This study focuses on shoulder laxity amongst a particular group of athletes, namely competitive badminton players. Such a study has not been done in the past and this study is value-adding since it aims to explore about shoulder laxity in a sport requiring multi-directional stability of the shoulder for good athletic performance.

Introduction

Shoulder injuries are the most common form of upper limb injury among badminton players [9]. Badminton matches typically last an average of 20 minutes [15]. It is not surprising that injuries are more common during training due to longer dura-

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tion of play. Badminton is a sport that requires a large range of shoulder motion including overhead motion and thus multi-directional stability of the shoulder would be essential for athletic performance. The resemblance of this overhead action required in badminton is similar to that of a baseball pitcher and could result in repetitive microtrauma and Glenohumeral (GH) laxity and eventually instability, which is a pathologic condition that causes symptoms due to excessive motion of the humeral head on the glenoid [2].

Laxity testing has been used widely to assess the anterior-posterior translation of the GH joint [10]. The range of shoulder laxity is wide and it varies in different populations. Several studies have reported that laxity in the dominant or throwing shoulder is greater than that in the non-dominant shoulder [17]. However, there has not been any studies done on shoulder laxity amongst competitive badminton players. The general hypotheses prior to commencement of this study were that shoulder laxity would be greater in the dominant arm (in view of the dominant arm being more susceptible to injuries) and more so in females (due to relatively lesser muscle bulk around the GH joint). The purpose of this study is to: (1) measure the anterior-posterior shoulder translation of the GH joint in badminton players, (2) compare difference in shoulder laxity between dominant and non-dominant shoulder in badminton players, (3) to do a comparison between GH joint laxity between males and females and (4) investigate the prevalence of shoulder injuries in badminton players.

Materials and Methods

Participants: Forty-six badminton players that have played competitively at a national level (25 men, 21 women; mean age = 25.85 ± 9.77; height 1.7 = ± 0.07; weight = 65.52 ± 12.46) were tested. Each athlete voluntarily participated after providing informed consent as mandated by our institutional review board (CIRB/2012/304/D; most recent extension 10/11/05-02 – IRB was extended till 31 December 2021).

Instrumentation: A mechanical shoulder device was used to measure anterior and posterior GH laxity. The measuring instrument consists of an arm support that is wrapped around the subject's arm. This is connected to a sliding block positioned on the shoulder (with a pointer), allowing measurement to be taken. The amount of displacement in millimeters during the translation can be measured by determining the anterior & posterior most position under maximum manual force. **Figure 1(A)** and **Figure 1(B)** depict the components of the mechanical device used:

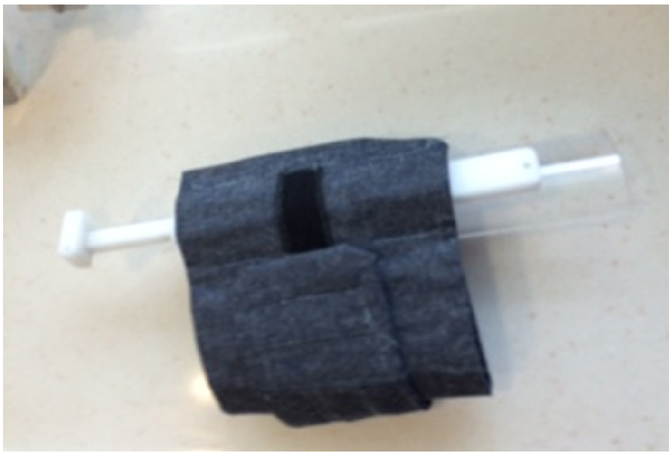

Figure 1(A): Arm support.

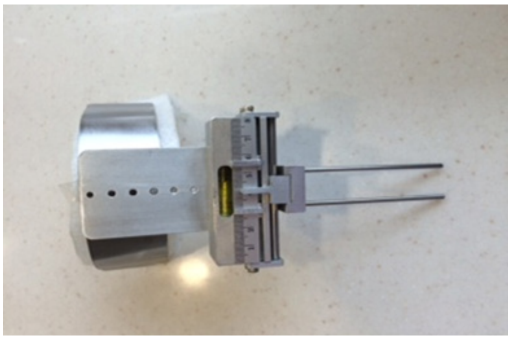

Figure 1(B): Sliding block with pointer (outlined in red)

The following are figures to depict both the mechanical device used and the way in which shoulder translations were carried out:

Figure 2(A-C)

Figure 2(A to E) depicts the shoulder translation measuring device. **Figure 2(A to C)** illustrate how the mechanical device was assembled. The 2 tiny poles extending from the mechanical device were fitted onto a plastic piece secured to the lateral aspect of the subject's arm as seen in **Figure 2(A)**. Once fitted in, the pointer on the sliding block was kept in neutral position.

Figure 2(D-F)

Figure 2(D to F) illustrate how the shoulder translations were carried out. **Figure 2(D)** shows the pointer being in neutral position. **Figure 2(E)** shows the examiner performing anterior translation of the shoulder while stabilizing the shoulder with one hand on the scapula. In **Figure 2(E)**, the pointer has shifted forward with anterior translation of the shoulder. Similarly, in **Figure 2(F)**, posterior translation of the shoulder is attempted with the pointer shifting backwards. In order to better demonstrate how the translations were carried out, 2 videos titled "Vid 1" and "Vid 2" have been added as supplementary videos.

Procedures

Each participant had anterior and posterior GH laxity measured on his or her dominant and non-dominant arm. The UCLA Shoulder Score and Oxford Instability Score questionnaire was also administered [5,7]. The aforementioned scoring systems were chosen for this study since these scores were the ones that were used during our clinic follow-up. In addition, both

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are subjective scoring systems that do not require any objective measurements. The participants' demographics recorded included number of years played competitively and number of hours trained per week. The author (Dr Siti) performed all tests and reliability measurements. This was done to ensure that the amount of force applied during the axial loading of the shoulder was kept fairly constant.

Each participant was required to do rotational exercises prior to the examination to keep the shoulder supple before measurements were taken.8 Rotational exercises, as opposed to other more strenuous exercises, were also easier to perform and were less likely to cause pain, which will confound measurements. None of them were involved in a badminton training session at least 12 hours prior to the examination. Each participant was seated and the arm placed in 20° of abduction, 20° of forward flexion, and in neutral rotation. Each participant wore a vest that served as a scapula support. The device was placed on the participant's shoulder with the support strapped around the arm. With the participant in the upright position, the examiner stood behind the participant's arm to be tested. The examiner stabilized the scapula with one hand on the shoulder support and grasped the proximal arm near the joint with the humeral piece using the other hand. A slight axial load was then applied between the humeral head and glenoid, which facilitated the ability to feel the humeral head slide over the rim. As the humeral head was being loaded, anterior and posterior forces were applied to assess the translation of the humeral head on the glenoid [12]. Each shoulder underwent three cycles of anterior-posterior translation. The mean translation of all three cycles was used for the data analysis. The above was then reproduced for the non-dominant arm as well for both male and female badminton players.

To review prevalence of injuries amongst the badminton players, a retrospective survey of injuries was conducted.

Statistical Analysis

Statistical analysis was performed using SPSS version 13. Independent T-test was used to compare dominant and non-dominant shoulders while Paired T-test was used to compare differences within each group. Spearman correlation was utilized to determine the association between (1) duration of badminton played and shoulder translation as well as determine the association between (2) muscle bulk and shoulder translation. Essentially, increased shoulder translation would imply an increase in shoulder laxity. Statistical significance was set at $P \leq 0.05$.

Results

The results of the male and female participants' glenohumeral joint laxity are summarized in Graph 1. A significant difference in shoulder translation was observed in non-dominant shoulders as compared with dominant shoulders ($P < .001$).

The participants' dominant shoulder laxity ranged from 3 millimeters to 15.2 millimeters with a mean of 7.99 millimeters. The non-dominant shoulder laxity ranged from 3.6 millimeters to 22.5 millimeters with a mean of 11.51 millimeters. Female participants had increased laxity in both the dominant and non-dominant shoulders when compared to males ($P = .002$). Female participants' shoulder laxity ranged from 3.6 millimeters to 22.5 millimeters while male participants' shoulder laxity ranged from 3 millimeters to 14.5 millimeters. Below are graphs to summarize the results obtained.

Figure 3: Graph representing a comparison of dominant shoulder laxity among both male and female badminton players.

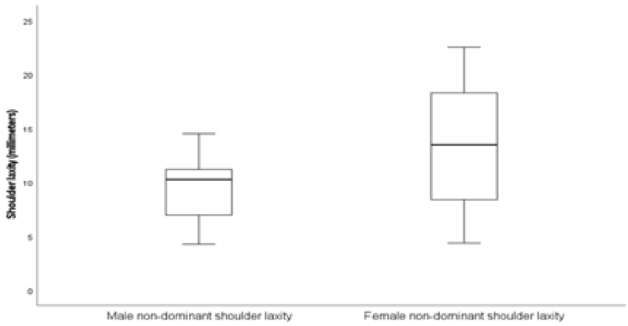

Figure 4: Graph representing a comparison of non-dominant shoulder laxity among both male and female badminton players.

There are multiple factors that could account for difference in shoulder laxity such as the duration of badminton played and muscle bulk. A Spearman correlation test was done to evaluate the correlation between numbers of years of badminton played and shoulder translation. There was a negative correlation between the number of years of badminton played and dominant ($r_s(46) = -0.519$, $P < .001$) and non-dominant ($r_s(46) = -0.401$, $P = .006$) shoulder translation. From these results, it can be inferred that with a longer duration of badminton played, there was lesser shoulder translation/shoulder laxity in both the dominant and non-dominant shoulders. The following graphs (scatter plots) demonstrate the relationship between number of years of badminton played and shoulder translation (dominant shoulder translation – **Figure 5**; non-dominant shoulder translation – **Figure 6**).

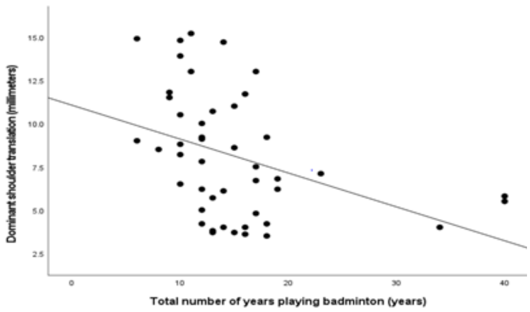

Figure 5: Graph representing the relationship between duration of badminton played and dominant shoulder translation.

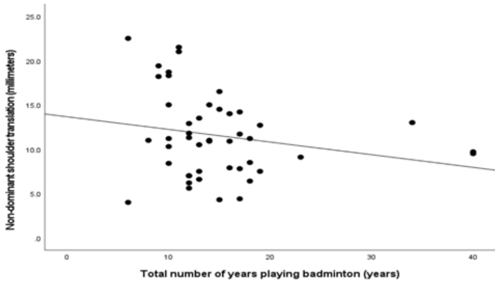

Figure 6: Graph representing the relationship between duration of badminton played and non-dominant shoulder translation.

Besides exploring the relationship between number of years of badminton played and shoulder translation, another aspect that we studied was the relationship between muscle bulk and shoulder translation. We measured arm girth as a surrogate of muscle bulk. Once again, Spearman correlation was used to evaluate the correlation between arm girth and the shoulder translation. There was a negative correlation between arm girth and shoulder translation in the dominant (rs(46) = -0.588, P < .001) and non-dominant (rs(46) = -0.370, P = .011) shoulders. From these results, it can be inferred that with greater arm girth/muscle bulk, there was lesser shoulder translation/ shoulder laxity in both the dominant and non-dominant shoulders. The following graphs (scatter plots) demonstrate the relationship between arm girth and shoulder translation (dominant shoulder translation – **Figure 7**; non-dominant shoulder translation – **Figure 8**).

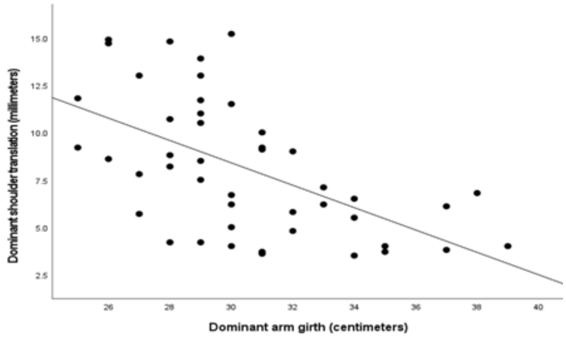

Figure 7: Graph representing the relationship between dominant arm girth and dominant shoulder translation.

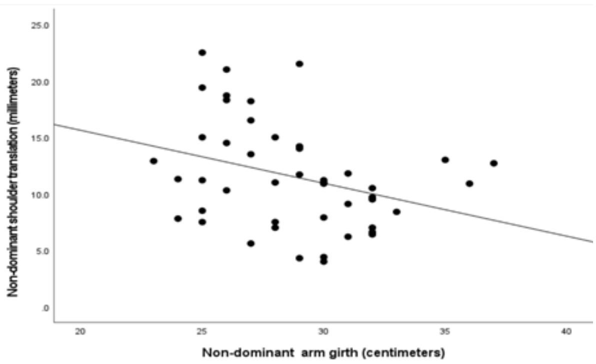

Figure 8: Graph representing the relationship between non-dominant arm girth and non-dominant shoulder translation.

A review of shoulder laxity and instability showed that most badminton players had stable and asymptomatic shoulders. This is evidenced by both the UCLA shoulder score and Oxford instability score. For UCLA shoulder scores, 31, 13 and 2 participants scored between 34 and 35, 29 and 33, less than 29 respectively. Generally, a UCLA shoulder score of more than 27 implies good to excellent shoulder stability while a score of less than 27 implies fair to poor shoulder stability. For the Oxford instability score, 37, 7 and 2 participants scored between 40 and 48, 30 and 39, 19 and 20 respectively. The Oxford instability score ranges from 0 to 48. Generally, a score of 40 and above suggests excellent stability. A score between 30 and 39 suggests good stability while a score between 20 and 29 is indicative of fair stability. Finally, a score of less than 19 implies poor stability.

A retrospective survey of injuries showed that the knee was the most commonly injured body part. However, shoulder injury was still the most common upper limb injury. Below is a graph **(Figure 9)** which portrays the distribution of injuries among badminton players.

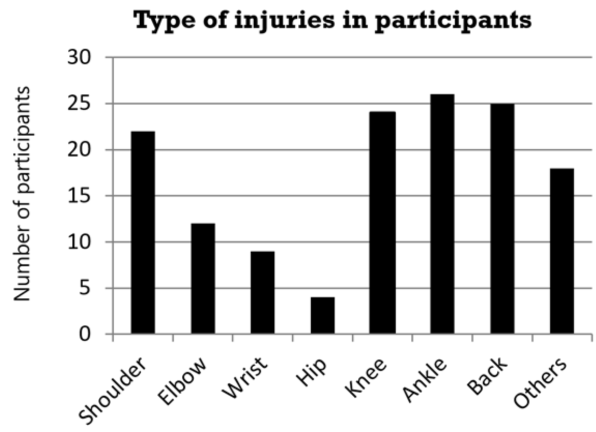

Figure 9: Graph depicting the type of injuries among badminton players.

Discussion

Badminton players, like other athletes playing sports involving overhead motion, require a balance of mobility and stability in order to perform in their sport. Secondary structural changes in the joint have been hypothesized to cause shoulder instability or mobility [14]. Assessment using various methods has been performed to evaluate shoulder laxity that could lead to shoulder instability.

Measurement of the GH laxity include the use of manual tests such as the sulcus sign and load and shift test, instrumented arthrometer, ultrasound, radiography scanning as well as electromagnetic tracking devices [13]. Some of these devices demonstrated poor reproducibility due to inconsistent force application, inconsistent humeral centering and patient positioning and poor diagnostic value. This study uses a mechanical shoulder device that reliably provides consistent results (See Supplemental file).

This is a pilot study on badminton players; a group that has not been previously studied. Laxity values in previous studies use healthy subjects or athletes of other sports. The device in this study is used with participants in a seated position, which would put their shoulder in a neutral position compared to other studies that were done with participants in a supine position. This difference in position could have accounted for the difference in values of GH laxity.

The results of this study showed that in competitive badminton players, shoulder laxity was lesser in the dominant shoulder. This study differed from studies done in other overhead athletes [1]. Previous studies in overhead athletes have shown that there is increased laxity in the dominant arm. This difference could be due to shoulder movement in badminton players being multi-directional and not solely overhead compared to other athletes. Furthermore, the UCLA shoulder score and Oxford Instability score in this study demonstrated that badminton players had relatively stable shoulders that could account for more shoulder stability.

Our results of shoulder laxity measurement values were also less compared to other studies. This could be due to badminton athletes having shoulders that were less lax or the lack of standard force used. Borsa et al. estimated a force of about 200 N was required to reach the capsular end-point, translating the humeral head by 23 millimeters [3]. This suggested that translations less than that could be due to inadequate force. However, in studies conducted on swimmers using cutaneous electromagnetic position sensors and sonography stress measurement respectively [4,16], values of shoulder laxity were equally lesser compared to Crawford et al. study on baseball pitchers [6]. This shows that athletes from different sports are likely to have diverse ranges of shoulder laxity and hence, badminton players could have a lesser laxity value.

Overuse injuries are common and have deleterious effects to the shoulder joint in the long run [11]. This study has shown that with increased number of years playing badminton, the shoulder laxity will decrease. This decrease in shoulder laxity could be attributed to increased muscle bulk (arm girth) which may be achieved with a longer duration of playing badminton. The increase in muscle bulk would essentially provide greater stability to the joint resulting in reduced shoulder translation when a certain force is applied to the shoulder. In addition, this information may be of value in the long run since it implies that these athletes will have more stable joints. However, the extent of this stability would need to be further investigated as less laxity could result in shoulder stiffness. Physiological mechanism from repetitive trauma may also cause the joint to be less lax due to fibrosis.

Limitations of this study would include participants being awake during the study, thus limiting their ability to fully relax, small sample size of badminton players from a single country and no control group to compare in non-badminton playing healthy individuals. Retrospective data was also used for both the nature and number of injuries sustained.

Conclusion

The results of this study are different from previous studies as dominant shoulders had less laxity in our study group, leading to the conclusion that badminton players have decreased GH laxity in the dominant arm.

The device referenced in our study afforded an objective measurement of shoulder laxity in patients who have suffered shoulder injuries and essentially provides a feasible manner to collect meaningful data to quantify shoulder laxity pre- and post- treatment if used in the clinical setting. Quantified measures of glenohumeral joint laxity will add objectivity to an outcome process that has been traditionally subjective in nature. These data will help orthopaedic surgeons and physical therapists validate the use of selected therapeutic and surgical procedures. Furthermore, it will also enable certified athletic trainers to train the athletes with suitable and relevant coaching techniques.

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