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Original Article

Isometric Shoulder Strength in Amateur Rugby Union Players

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ABSTRACT

Background. Rugby is a high-intensity sport that involves strength, power, agility, and speed. The shoulder has been reported as the second-most-injured site in rugby union players. Muscle strength imbalances have been reported to increase the injury risk to the shoulder. **Objectives.** This study aimed to measure and evaluate the isometric strength differences by arm dominance differences in isometric shoulder strength measurements and the incidence of previous injuries in amateur rugby union players. M**ethods.** This descriptive, cross-sectional design examines Sharks Academy rugby players in KwaZulu-Natal, South Africa. Sixty-one players between the ages of 18 and 23 participated in the study. All participants completed an injury-prevalence questionnaire, anthropometric (height and weight), and selected isometric shoulder strength tests. These specific tests were performed using the Pressure Air Biofeedback (PAB®) device. Descriptive and inferential statistics were used. **Results.** The mean age of participants was 19.1 years. The only significant difference was between the maximum shoulder flexion strength in the non-dominant and dominant arm strength ($p=0.024$). No significant differences were found between the mean isometric strength values and player position, either a back or a forward. More than one-third of the participants had sustained a previous shoulder injury within the past six months. No significant differences were found between the mean isometric strength values and previous shoulder injury. **Conclusions.** Structured preseason upper-body strength testing and subsequent conditioning programs are recommended to help minimize shoulder injuries in amateur rugby union players.

KEYWORDS: ***Isometric Strength, Shoulder Injuries, Pressure Air Biofeedback (PAB®).***

INTRODUCTION

Rugby is a high-intensity contact sport that results in several injuries (1). These injuries can be attributed to weaknesses and imbalances around the shoulder musculature (1). Crichton et al. (2012) found that tackles accounted for 49 – 72% of shoulder injuries (2). Headey et al. (2007) showed that, during the season, a total of 169 shoulder injuries were reported, which caused 5301 days of absence due to shoulder injuries in players (n=546) (3).

Shoulder injuries accounted for 15% of all days lost away from rugby (3). Epidemiological studies reported that 6 – 13% of rugby injuries occur in the shoulder, with 56% of the injuries being severe and 16% debilitating enough to end the player's rugby for the season (1). Similarly, Heady et al. reported a 9 – 11% incidence of injuries to the shoulder joint amongst professional rugby union players (3). Additionally, shoulder laxity leads to shoulder instability and dislocation, which accounted for the most days lost (7%) to match and train time (4).

Three crucial risk factors for shoulder injuries in collegiate rugby players were determined (5). These were a history of injury, a positive load and

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shift test, and the internal rotation (IR)/external rotation (ER) muscle strength ratio. Players with a history of injury had an injury rate 6.56 times higher than players who did not have a history of injury. Imbalances between the IR/ER muscle strength ratios increased the risk of shoulder injury 1.39-fold. Previous joint dislocation/instability also caused a decreased range of motion, decreased muscle strength, and joint instability, resulting in an increased risk of a shoulder injury.

Crichton et al. (2012) grouped shoulder injuries into the 'try-scorer,' the 'direct-impact,' and 'the tackler' (2). Direct-impact injuries are caused by a direct blow to the arm or shoulder when the side holds the arm in neutral or slight adduction (2). The 'tackler' injuries are caused by the extension of the abducted arm behind the player while tackling (2). The 'try scorer' injuries occur when the injured arm is involved in flexion above 90°, which results in a posterior force that drives the arm backward and exerts leverage on the glenohumeral joint, with the arm either remaining in fixed flexion through contact with the ground or forced into further flexion (2). Glenohumeral joint dislocations were the most common injury in 67% of players (2). Dislocations were accompanied by associated injuries such as anterior, posterior, or SLAP-type labral tears and Hill-Sachs lesions (2). Acromioclavicular joint lesions were found in 8% of players (2). The current study focussed on the direct impact and tackler arm positions, as these were the most prevalent mechanisms for shoulder injuries (2, 3, 5).

Five strength tests were performed around the shoulder joint in a study conducted on 28 rugby union players during the preseason (6). These tests were administered to determine the time lost due to shoulder injuries during the 2011-2012 season. The rotator cuff muscles of the shoulder are, in part, responsible for the dynamic stabilization of the shoulder joint. Therefore, a decrease in the strength of the shoulder rotator cuff muscles is an intrinsic risk factor for a shoulder injury (6). However, Ogaki et al. also stated that it is essential to remember the shoulder joint's musculature, apart from the rotator cuff muscles. The deltoids, latissimus dorsi, coracobrachialis, teres major, trapezius, biceps brachii, rhomboids major and minor, serratus anterior, as well as pectoralis major and minor are all also needed to avoid injury, as a large external displacement of force is put through the shoulder joint during a rugby tackle. The shoulder would likely dislocate without the necessary supporting musculature (6).

Isokinetic testing provides objective strength data and is often recognized as the gold standard for strength testing, although this method is very costly and time-consuming (7, 8). The equipment is also not readily available for many clinicians. Hence, alternative methods like handheld dynamometers are used. Studies using isokinetic dynamometry primarily focus on muscle concentric strength testing with limited studies on eccentric strength, and studies on isometric strength are further limited (7-8). Furthermore, testing positions (seated, standing, prone, supine), testing angles, muscle contraction velocities, and fiber recruitment and gravity correction must be considered, as these differences result in different isokinetic strength values (7-8). Therefore, these factors need to be considered before comparisons can be made regarding strength ratios and values. Future studies should include testing sport-specific and angle-specific isometric contractions. Baseline strength comparisons between injured and uninjured shoulders are commonly performed following injury, assuming that the uninjured limb is an appropriate reference, regardless of hand dominance (9).

This study is novel as it tests strength with isometric testing, tests both dominant and non-dominant arms, and considers whether the shoulder was previously injured. The selected testing angle also provided the most optimal sport-specific pulling strength angle and remained unchanged in all testing positions.

Hence, the current study aimed to measure and evaluate the isometric strength differences by arm dominance differences in isometric strength measurements and the incidence of previous injury in amateur rugby union players.

MATERIALS AND METHODS

Design. The study was a descriptive, cross-sectional design.

Participants. The study was conducted at the Sharks Rugby Academy in Durban. Eighty registered players were recruited. However, a sample of 61 players volunteered to participate in the study. All participants adhered to the following inclusion criteria: between the ages of 18 and 23; following a weekly training schedule (three to four sessions a day, five times a week) and a match schedule (one to two matches a week); and had to have been playing rugby for at least one year. Players were excluded if they were currently undergoing rehabilitation for an upper-body injury, had any acute injury in the upper body, specifically to the shoulder region, or had previously had surgery anywhere on their upper extremities.

Test procedures and protocol. An information session was conducted at the Sharks Rugby Academy prior to testing. The aim and test protocol were explained in detail to the participants, informing them of all risks and benefits associated with their participation.

A once-off 20 – 30-minute testing session per participant was conducted. A simple injury questionnaire, adapted from Dawson et al., was administered and collected immediately upon completion (10). This questionnaire was selected as it was validated in a previous study and is reliable in identifying player injuries, i.e., Cronbach's alpha for the study questionnaire was 0.91. All items correlated with a total score of more than 0.5. Cronbach's alpha was also compared for the two diagnostic subgroups. In each case, the alpha remained more than 0.9.

After that, height and weight were recorded. Strength tests were then performed using the Pressure Air Biofeedback (PAB®) device. Tests were conducted in the following order, beginning with the dominant (D) arm and then the non-dominant (ND) arm: 30° shoulder flexion (Figure 1-a); shoulder extension (Figure 1-b) with both movements in the sagittal plane; shoulder abduction (Figure 1-c); and shoulder abduction with arm supination (the injury-prone position) (Figure 1-d), with both movements in the frontal plane (10).

Isokinetic testing measuring isometric strength generally uses standardized angles to measure shoulder flexion, extension, abduction, and adduction, i.e., 30°, 60°, and 90° (7-8). Although not an isokinetic test, all tests in this study were conducted at an angle of 30°. This angle was implemented based on the optimal length-tension relationship regarding flexion, abduction, and extension adapted from Hughes et al. (21).

(a) (b) (c) (d)

Figure 1. Strength tests using the Pressure Air Biofeedback (PAB®) device. a) Shoulder Flexion. **b)** Shoulder Extension. **c)** Shoulder Abduction. **d)** Injury Prone Position.

Participants were requested not to participate in strenuous exercise three hours before testing to minimize fatigue. Before testing, the four strength tests were verbally explained and demonstrated to the participants. One trial per participant per test was performed for familiarisation, and immediately afterward, the testing began. One test per movement was performed and recorded. The isometric hold was for a 10-second duration per movement with a 20-second rest period between each movement. The Pressure Air Biofeedback (PAB®) device was calibrated after every test.

Instrumentation. Height and body mass were measured by using the Nagata BW-1122H scale. The scale was calibrated before testing started using two weights, of which the exact values were known. A 2kg weight and a 45 kg weight were used. It was used to assess whether the scale produced an accurate reading of lower and higher weights, respectively.

The PAB® is a portable, valid, reliable device designed to test isometric muscle strength. A strong relationship ($r= 0.997$, $p < 0.01$) between average PAB® force data (MB), calculated over the two days concerning calibrated weights, was also found. The calibration results demonstrated high validity between measures (calibrated weights in kg) and the associated criterion (PAB® force in mb) (11).

The PAB® uses air to measure muscle strength and muscle strength imbalances in kg/force. It consists of an air-filled pull ring, air tube, and pressure sensor unit, which connects to a laptop that operates the PAB® software program, where all the data is recorded and stored. Velcro material straps are used to exert a pull force on the pull ring, and the straps are marked with numbers to ensure test-retest reliability. It enables one to adjust the strap to precisely the same number tested in previous tests.

The PAB® unit is calibrated by removing the air tube from the needle attachment for a few seconds, allowing air in the pull ring to equalize with atmospheric pressure. The PAB® is simple, quick to calibrate, and correlates with construct validity (12).

The PAB® strength results are calculated as total work (total strength output over 10 seconds), maximum strength (peak strength output achieved during the 10-second test), average work or strength (total work divided by 1000 recordings for the 10-second test), and relative strength (total work divided by body mass of subject) (12).

The data was collected by trained sports scientists, who were adequately trained to use the PAB® device. The data was collected in a controlled environment, which did not allow excess noise or distractions to minimize measurement errors.

Data Management. Data from questionnaires were manually entered into an Excel spreadsheet. Each participant was allocated a unique code. Before starting the strength testing protocol, their codes were also entered into the PAB® computer software system. Strength data was collected after a 10-second maximum isometric contraction with a sample rate of 10 milliseconds or 100 measurements per second. Data were then exported onto an Excel spreadsheet for statistical analysis.

Statistical Analysis. All the data were analyzed using the Statistical Package for the Social Sciences Version 19. Data were quantified using descriptive statistics through means and standard deviations. The paired sample t-test compared strength values between the D and ND arms. The independent samples t-test was used to test if shoulder strength values differed significantly between those who did and did not have previous shoulder injuries. The level of significance was set at $p < 0.05$.

Ethical Considerations. Informed consent was obtained from each participant included in the study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the university's Biomedical Research Ethics Committee (BE233/18).

RESULTS

Sixty-one rugby union participants aged 18 and 23 were tested; 32 (52.5%) were forwards, and 29 (47.5%) were backs. The mean height was 1.90m (±0.78), and the mean body mass was 90.28kg (±17.29). The majority (98.1%) of the participants were right-arm-dominant.

Isometric strength measurements. Mean isometric strength differences by arm dominance are presented in Table 1.

Previous shoulder injuries and shoulder strength imbalances. The only significant difference was found between the maximum shoulder flexion strength in the ND arm (10.71kg/force) and the D arm (10.16 kg/force) ($t(60) = -2.31$, $p=0.024$). There were no significant differences between the mean isometric strength values and player position, either playing back or forward.

Isometric strength measurements and previous injury. Over one-third (23, or 37.7%) of the participants had sustained a previous shoulder injury within six months. Injuries included fractured clavicles, shoulder dislocations, rotator cuff tears, and impingement. The remaining 38 (62.3%) did not report a shoulder injury but were not limited to other injuries. No significant differences in strength variables were found when comparing those with previous and without injuries.

Table 1. Mean Strength Scores for Dominant (D) and Non-dominant (ND) Arms

TEST	ARM DOMINANCE	MEAN SCORE (kg/force)	STANDARD DEVIATION (kg/force)
Maximal shoulder flexion	D	10.16	2.58
	ND	10.71	3.07
Relative strength - shoulder flexion	D	95.45	31.21
	ND	100.51	29.10
Relative shoulder extension strength	D	75.99	24.79
	ND	80.35	28.47
Relative shoulder abduction strength	D	91.52	28.68
	ND	90.78	30.24
Relative shoulder abduction strength with external rotation	D	88.34	27.68
	ND	88.20	29.98

DISCUSSION

The present study aimed to measure and evaluate the isometric strength differences in arm dominance and the incidence of previous injury in amateur rugby union players. There were no significant differences between D and ND arms for extension, abduction, and abduction (injury-prone position). The only significant difference was between the maximum shoulder flexion strengths, with the ND arm being more potent than the D arm. This finding could be associated with Oldfield's Handedness Inventory, which states that the D arm may not always be more potent when compared to the ND arm, especially if the D arm is the left arm due to societal pressure to be right-hand dominant. [13-18] This could also be due to the middle crossed syndrome, whereby an individual may have a muscular imbalance along their muscular chain. Clinical observations reflect that it is more common to find that a right-arm dominant person is more stable standing on their left leg or jumping off but better at throwing, pushing, or pulling with their right arm. It may explain why the trunk is better supported and is more stable on the ND side when standing and performing a shoulder flexion strength test, thus allowing a more effective pull from the extended lever arm (19). Furthermore, cross-dominance is a known anomaly (20). However, previous studies have found that, on average, the D arm was 4-12.7% stronger than the ND arm due to more motor unit recruitment (13).

Studies have indicated that most injuries are due to macro-trauma or direct contact; hence, it is essential to consider all significant muscle groups (2, 4, 8). Furthermore, the pectoralis major and deltoid muscles resist shoulder hyperextension during tackles. Increasing rotator cuff strength and the strength of the significant muscle groups decreases the risk of injury (15-16). Therefore, shoulder rotator cuff muscle exercises and high-intensity upper body strength training are typical conditioning training for rugby union players (8). Compared to backs, forwards endure more impacts (+60%) and participate in more tackles, tackle assists, and rucks (17). Therefore, particular playing demands are placed on the shoulders of forwards and backs. The current study compared these playing positions but found no significant strength differences between forwards and backs. This finding is of particular concern, as it is clear that strength differences should be apparent due to the different playing demands of each position.

Ogaki et al. found that shoulder isometric IR, isometric ER, and isometric abductor muscle strength were significantly lower in injured rugby union players than in non-injured players during preseason testing (8). However, this study found no significant differences between the mean isometric strength values and previous shoulder injuries. This could be because testing is conducted during the in-season rather than preseason.

Studies have been conducted on isokinetic devices using absolute values specific to the isokinetic device. Hence, comparisons of normative data cannot be made with other devices. Shoulder movements are generally in the sagittal and/or frontal plane. However, converting absolute values to ratios allows for comparing normative data from any system (7). It is suggested that there is a 2:1 ratio for abduction/adduction and 3:2 IR/ER (8). There is limited research on flexion/extension ratios. Based on the anatomical structures and muscles, the extensors exceed the flexors in muscle mass. Therefore, one can infer that a strength ratio of 1:1 is not acceptable. Findings in the current study show minimal differences between flexion and extension strength. Furthermore, the flexors are more potent than extensors, possibly predisposing players to injury.

CONCLUSION

The present study aimed to measure and evaluate the isometric strength differences in arm dominance and the incidence of the previous injury in amateur rugby union. Results suggest that position-specific, upper-body strength training is essential for rugby union players. The shoulder musculature must be adequately and expressly conditioned to decrease the risk of injury. Structured preseason strength testing and subsequent conditioning programs are recommended to help minimize shoulder injuries in amateur rugby union players.

A significant limitation in the current investigation is the generalisability of a single rugby union team. Secondly, the study did not consider the effect of in-season strength training. Thirdly, shoulder strength was only tested isometrically at one angle. Furthermore, although the shoulder test angles were standardized at 30º, the 30º shoulder flexion test only represents 16.7% (30º of 180º normal shoulder flexion) of the start of flexion, while the 30º shoulder extension test represents 60% (30º of 50º) of the end-of-shoulder extension. These angles may have influenced or skewed the flexion/extension strength scores due to the different length-tension relationships of the muscles. Lastly, testing in the scapular plane may be more clinically appropriate.

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AUTHORS' CONTRIBUTION

The authors contributed to the interpretation of the data and to writing/reviewing the manuscript. All authors take final responsibility for submitting the manuscript for publication.

ARTIFICIAL INTELLIGENCE (AI) USE

The author declares no AI usage.

CONFLICT OF INTEREST

The authors declare no conflict of interest concerning this article's authorship and/or publication.

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