



An Investigation of Potential Factors Leading to Shoulder Injury in Adolescent Rugby Union Players: A Retrospective Cohort Study

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Abstract

Objectives: To investigate the association between potential factors that may lead to shoulder injury in adolescent male rugby union players.

Methods: A self-administered questionnaire consisting of 10 standardised questions was used to investigate the incidence of shoulder injury in adolescent male rugby union players. Participants had previously partaken in a study by Rowland and colleagues in 2014 investigating shoulder range of motion, strength and generalised joint hypermobility. Data from the previous and current study was correlated in order to determine the relationship between the aforementioned variables and shoulder stability.

Results: Twenty three (23) participants completed the questionnaire with 9 participants (39%) reporting a shoulder injury. No statistically significant association was found between shoulder injury and generalised joint hypermobility ($p=0.32$), average shoulder range of motion ($p=0.38$), body mass index ($p=0.60$) or hand dominance ($p=0.53$). A statistically significant association was observed between shoulder injury and shoulder muscle strength ($p=0.04$). Similarly, a statistically significant association was found between left shoulder flexion strength ($p=0.03$), right shoulder flexion ($p=0.03$), left shoulder abduction ($p=0.03$) and right shoulder internal rotation at 90 degrees abduction ($p=0.008$).

Conclusions: Reduced strength of the shoulder musculature appears to be associated with an increased risk of sustaining a shoulder injury in adolescent male rugby union players. However, it is inconclusive if overall generalised joint hypermobility along with increased active shoulder ranges of motion are associated with shoulder injury. Further investigations are required to determine if muscle strengthening programs are effective in reducing shoulder injuries.

Keywords

Football; Hypermobility; Injury; Risk factors; Shoulder; Youth; Shoulder

Introduction

Rugby union football is a contact sport which is played throughout the world by more than 6.6 million participants across 119 countries [1]. Approximately half a million of these participants are Australian of whom 10% are junior players (under 18 years of age) [1]. The high impact and collision nature of the game exposes players of all ages, and levels of play to injury. However, there appears to be an overall trend which identifies a high injury rate in adolescent rugby union players, with shoulder injuries representing the greatest time loss from play [2,3].

It is recognised that a combination of both intrinsic and extrinsic factors, of a multifactorial nature, interact to cause injury [4,5]. Nonetheless, it would appear that few studies have focused on identifying key risk factors for shoulder injury in adolescent rugby union players.

It is important to investigate key risk factors which may be contributing to injury in adolescent athletes as these factors can have both short and long term consequences on health, wellbeing, growth and development [2,6]. Joint hypermobility and a lack of active and passive control of the shoulder have been hypothesised as potential key risk factors for sustaining shoulder injury [7,8]. However, studies investigating hypermobility have not only been inconclusive, but have predominantly investigated adult populations [6,9,10]. While the prevalence of hypermobility in children and adolescents is generally acknowledged [8,11], it would appear the relationship between joint hypermobility and shoulder injury has been examined exclusively in the adult rugby union population.

The significant severity and time loss from play associated with shoulder injuries in the adolescent population render the shoulder joint a primary focus for research and subsequent preventative measures [3,7,12]. Yet, incongruity between the quantity of research into injury prevention and the societal burden of injury in youth sport is apparent [13]. It has been estimated that 8% of adolescents abandon sports activities each year due to injury [2]. In a society overwhelmed by lifestyle related disease, sports participation should be strongly encouraged, particularly throughout adolescence, with the anticipation that active involvement will progress into adult activity behaviours. Thus, informed injury prevention is central to maintaining player health, participation and a safe sporting environment. Injury surveillance and the recognition of key risk factors inform injury prevention strategies. Nevertheless, it would appear few studies in the adolescent rugby union population have examined the association between injuries and risk factors. Currently there appears to be no study investigating whether generalised joint hypermobility is a significant contributing factor for sustaining shoulder injury in adolescent rugby union players.

Therefore, the primary aim of this study was to ascertain if generalised joint hypermobility or increased shoulder active ranges of motion are potential risk factors for sustaining shoulder injury in adolescent male rugby union players. Secondary aims were to examine the association between shoulder injury and shoulder muscle strength, Body Mass Index (BMI) and hand dominance. The hypothesis was that players who were identified as hypermobile, or who had greater

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than expected active shoulder ranges of motion, would be more likely to sustain a shoulder injury.

Material and Methods

This study was conducted as a follow up to a previous study [14] in 2014 by Timothy Rowland, Dr Jane Butler and Kimberley Cochrane of the Australian Catholic University (HREC 2014 13N). Ethics approval for the current study has been granted by the Australian Catholic University Human Resources Ethics Committee (HREC 2015 00004H). Participants and parents/caregivers were provided with the opportunity to renew their consent to participation in this study. Participants were adolescent males aged 13 to 19 years who had participated in rugby union football since January 2014 in metropolitan Sydney, NSW. Participants were sourced from two independent boy's schools in Sydney, who engage in the winter Independent Schools Association sport competition. Participants were excluded if they had previous shoulder or neurosurgery prior to January 2014, cardiac or respiratory conditions which precluded them from exercising at a high intensity or if severe cognitive and/or language deficits were present which may preclude them from involvement in the study (clinical judgement).

Twenty seven (27) participants were invited to complete a self-administered questionnaire (supplementary material A) in May 2015. This consisted of 10 standardised questions relating to the participants engagement in rugby union football since January 2014. The questions pertained to whether the participant sustained a shoulder injury during this time, the circumstances surrounding their injury, medical management and subsequent outcome.

The questionnaire was provided at the participant schools at a mutually agreed time and date. Participants who were unable to attend the designated time were followed up, where possible, by email. All data was de-identified at the time of completion of the questionnaire.

Data attained from this study was then compared to generalised joint hypermobility (Beighton hypermobility score) [15,16], shoulder range of motion (goniometry), isometric shoulder strength (hand held dynamometry) and BMI scores obtained in the previous study by Rowland et al. [14] to identify any associations or trends.

Data was analysed using the statistical analysis program SPSS V22.0 (IBM, USA). Tests of associations between variables were conducted using independent sample t tests. Yates chi square analyses were used to determine any association between hand dominance and the side of shoulder injury. Effect sizes (ES) were calculated

using Cohens-*d* and interpreted using Cohen's principles of effect sizes (0.2-0.5 small, 0.5-0.8 moderate, >0.8 strong). This study was adequately powered to demonstrate effect sizes of 0.43 or larger to be significant at $p < 0.05$.

Results

Of the 27 participants invited to partake in the study, 23 (85%) completed the questionnaire. Four (4) participants were unavailable to complete the questionnaire. The mean scores for participants was age 15.6 years old (SD 0.7), height 178.3 cm (SD 6.6), weight 77.3 kg (SD 15.0) and BMI of 24.3 kg/m² (SD 4.4). Individual group characteristics are presented in Table 1. Thirty-nine percent (39%) of participants (n=9) reported sustaining a shoulder injury whilst participating in rugby union football since January 2014 until May 2015. Of these 9 participants, one reported sustaining more than 1 shoulder injury during the time period. These injuries affected the same shoulder but were not severe enough to require medical attention. Injury severity ranged significantly with an exponential relationship reported between severity and time loss from play. Self-reported time loss from play ranged from no absence to 6 months absence from play. Five (5) participants reported seeking advice from a medical professional (physiotherapist, general practitioner or other health professional) regarding their shoulder injury. However, not all of these participants received a clear diagnosis for their injury. Participants (n=3) who did receive a diagnosis reported a "rotator cuff tear", "instability" and "shoulder dislocation" requiring subsequent surgery. The most commonly reported mechanism of injury was involvement in a tackle (89%). All reported injuries occurred in a game situation with the exception of one player who sustained 2 injuries during the study period. This player sustained 1 injury during a game and 1 during training. The most commonly reported management of shoulder injury was rest from play followed by a physiotherapy exercise program and over the counter medications (Table 2).

Independent sample t-tests were used to investigate associations between shoulder injury and generalised joint hypermobility, shoulder range of motion, shoulder muscle strength and BMI. Statistical significance was set at $p < 0.05$ and confidence intervals (CI's) were 95%. Effect size calculations (Cohens-*d*) were evaluated to account for the possibility of type II errors due to the small study population size. There was no statistically significant association observed between overall scores on the Beighton hypermobility scale and shoulder injury ($p=0.32$) but results did produce a small effect size (ES 0.45). The mean of all shoulder range of motion scores revealed no statistically significant association with shoulder injury ($p=0.38$) and only a small effect size (ES 0.37). Similarly, no individual

Table 1: Participant characteristics (n=23).

Characteristics	Participants' n (%)	Mean age yr (SD)	Mean height cm (SD)	Mean weight kg (SD)	Mean BMI ^a kg/m ² (SD)
Injured	9 (39.1)	15.4 (0.6)	174.9 (6.8)	72.8 (13.4)	23.7 (3.5)
Not Injured	14 (60.9)	15.6 (0.8)	180.4 (5.8)	80.3 (15.8)	24.7 (5.0)

^aBMI - body mass index (wt(kg)/ht(m)²)

Table 2: Participant reported shoulder injury management.

Reported management	Yes	No
Surgery	1	8
Physiotherapy exercise program	4	5
Rest from play	6	3
Prescription medication	1	8
Over the counter medication	3	6
Clearance to return to play	7	2

Table 3: Independent sample t tests of isometric shoulder muscle strength in injured (n=9) vs non-injured (n=14) participants.

Isometric contraction	Mean strength injured Mean (SD) Nm ^a	Mean strength non-injured Mean (SD) Nm	p value ^b	Effect size ^c
Flexion L ^d	16.3 (6.4)	22.1 (5.6)	0.03	0.96
Flexion R ^e	17.6 (6.0)	22.9 (5.2)	0.03	0.94
Extension L	16.0 (5.7)	21.3 (6.7)	0.06	0.85
Extension R	19.3 (6.2)	23.7 (7.3)	0.12	0.65
ABD ^f L	14.3 (4.8)	19.9 (6.1)	0.03	1.02
ABD R	18.6 (7.3)	21.1 (5.6)	0.36	0.38
IR ^g 90° L	9.6 (1.6)	11.9 (3.7)	0.1	0.81
IR 90 R	9.1 (1.7)	11.7 (2.3)	0.008	1.29
ER ^h 90 L	9.1 (1.6)	11.3 (3.1)	0.06	0.89
ER 90 R	9.9 (1.7)	12.5 (3.9)	0.08	0.86
IR neutral L	11.2 (3.3)	14.0 (3.7)	0.07	0.8
IR neutral R	12.0 (2.3)	15.0 (4.3)	0.07	0.87
ER neutral L	8.7 (2.2)	10.6 (3.1)	0.12	0.71
ER neutral R	9.7 (2.7)	10.3 (2.9)	0.61	0.21
IR 90/20 ⁱ L	9.6 (1.6)	11.7 (3.3)	0.09	0.81
IR 90/20R	10.1 (3.0)	12.7 (3.6)	0.09	0.78
ER 90/20 L	8.3 (2.8)	10.7 (3.6)	0.1	0.74
ER 90/20 R	9.2 (1.6)	11.1 (3.8)	0.17	0.65
Mean strength	12.1 (2.3)	15.2 (3.8)	0.04	0.99

^a Nm-Newton metres

^b Significance for all t-tests p<0.05

^c Effect size values small 0.2-0.5, moderate 0.5-0.8, strong >0.8

^d Left

^e Right

^f Abduction

^g Internal rotation

^h 90 - shoulder positioned in 90 degrees of shoulder abduction

ⁱ External rotation

^j 90/20 - shoulder positioned in 90 degrees shoulder abduction and 20 degrees shoulder extension, a position considered more functionally relevant to a rugby player

shoulder range of motion score reached statistical significance. However, greater range of right shoulder flexion approached statistical significance (p=0.08) with a moderate effect size (ES 0.82).

Associations between strength of the shoulder musculature and shoulder injury were found to yield statistically significant outcomes (Table 3). Reduced average shoulder muscle strength was associated with shoulder injury (p=0.04, 95% CI -6.1,-0.1) with a strong effect size (ES 0.99). Examining individual strength measures, decreased shoulder flexion strength on the left (p=0.03, 95% CI -11.1,-0.5, ES 0.96) and right (p=0.03, 95% CI -10.2, -0.5, ES 0.94) were both associated with shoulder injury as was shoulder abduction on the left (p=0.03, 95% CI -10.6, -0.6, ES 1.02). Decreased strength of the right shoulder internal rotators with the arm positioned in 90 degrees abduction was most closely associated with shoulder injury (p=0.008, 95% CI -4.5, -0.8) with a strong effect size (ES 1.29).

No statistically significant association was observed between BMI and shoulder injury (p=0.60) with a small effect size (ES 0.23). A Yates chi square correlation was used to determine any associations between hand dominance and the shoulder injured. No statistically significant association was found between these factors (p=0.53).

Discussion

It is well noted that there is a lack of research into intrinsic injury risk factors in adolescent rugby union football [2]. Extrinsic factors, such as the tackle, have consistently been reported as the

most common mechanism of injury [2,17,18], a similar finding in our study. It has further been proposed that in schoolboy rugby, injuries are more likely to occur to the player making the tackle opposed to the ball carrier [19]. However, it would appear that currently, no study has investigated the association between shoulder injury and generalised joint hypermobility or greater active shoulder range of motion in adolescent rugby union players. Results of this study identified no statistically significant association between shoulder injury and generalised joint hypermobility or increased shoulder range of motion. Despite the lack of statistical significance, a small effect size was observed between hypermobility and shoulder injury. This may indicate a potential association that was unable to be detected due to the small sample size and may warrant further investigation. However, similarly inconclusive results have been reported in studies of the association between hypermobility and shoulder injury in the adult rugby union population which may indicate other factors are involved [9,10].

A statistically significant association was observed between decreased shoulder muscle strength and shoulder injury (Table 3). It would appear shoulder flexion strength is the most consistent predictor of shoulder injury with both the left and right shoulders yielding statistically significant outcomes. However, the average of all shoulder strength scores also produced a large association. These results are not overly surprising given the inherent instability of the shoulder joint related to its anatomical structure [8]. This instability is countered by a number of active and passive stabilisers. Active

stabilisers include the surrounding muscular structures and tendons which provide a compressive mechanism to hold the humeral head against the glenoid fossa [20]. In adolescent athletes, these structures may be less developed compared to that of an adult due to skeletal immaturity [20]. This reduction in muscular development surrounding the shoulder may render it vulnerable to injury [21]. It has been proposed, weakness within the rotator cuff muscles coupled with a muscular imbalance of agonist and antagonist muscles, play a key role in determining shoulder stability [18]. In this study, it would appear greater active stability of the shoulder joint during adolescence is a protective factor against shoulder injury.

It is noteworthy that adolescent males undergo a series of growth and development changes which result in increased power, strength and speed [6]. However, biological maturation is highly variable between individuals and may result in observable and unobservable player mismatches in the adolescent rugby union setting [22,23]. The unobservable strength mismatch during adolescence appears to be strongly associated with shoulder injury in the present study. It has been noted that adult professional rugby union player's engage considerable time and effort into muscle strengthening programs, both global and shoulder specific, but shoulder instability and injury is still an issue in the adult population [9]. These conflicting ideas appear to indicate that more research is required in this area. In particular, whether shoulder muscle strengthening programs in adolescent rugby union players may offer protection from shoulder injury during the growth years. Furthermore, the optimal parameters for such programs would also require investigation.

This study found no association between hand dominance and shoulder injury. However, this finding is not consistent with others who suggest injury to the non-dominant shoulder is more prevalent in rugby union players [24]. No association was observed between BMI and increased risk for shoulder injury and it would appear that no study has investigated the association between these factors and shoulder injury in adolescent rugby union football. Physical size is not considered to be an accurate predictor of greater performance and is not consistently related to injury in adolescent rugby union players [22]. It is important to note that BMI does not differentiate the proportion of muscle mass compared to fat mass [25]. The adolescent rugby union population have demonstrated consistently heavier body weights compared to age matched normative data [22]. This finding has been replicated in adolescent athletes with the BMI misidentify athletes as obese [25]. This may indicate the BMI is a poor measure to use in this group due to the inability to differentiate individuals who possess greater muscle mass compared to players with increased fat mass. In relation to our finding of greater muscle strength of the shoulder appearing to be a protective factor against shoulder injury, it could be argued a higher body mass, providing this was due to increased muscular development, may protect against injury. However, this hypothesis was not considered in this study and therefore would require more specific body composition analysis.

While this investigation of intrinsic injury risk factors, especially generalised joint hypermobility and the association with shoulder injury, appears to be unique there are recognised limitations of this study. Firstly, the small study population makes it difficult to produce conclusive results that can be generalised to a broad adolescent population. Indeed, type II errors may be apparent due to the small sample size and while there was no significant difference demonstrated for generalised joint hypermobility, shoulder range of motion, BMI and hand dominance, a clinically important effect

may be apparent. Secondly, not all player variables were monitored that may have impacted the likelihood of sustaining an injury. Such variables include hours of game exposure between the time periods of study, participation in multiple competitions, if the injury was sustained during the school competition, club or representative game, the level of play, number of training sessions undertaken and the age group participated in compared to chronological age. This study also did not monitor the participant's involvement in pre-season or in-season conditioning programs. Thirdly, in terms of study design, self-report questionnaires are reliant on memory, recall and honesty and thus may not be the most accurate account of the injury.

Recommendations from this study would be to investigate a larger and geographically diverse cohort to allow for generalisation of results to a broader population. Despite the limitations of this study, important trends and associations between shoulder injury in adolescent rugby union football and seemingly un-investigated risk factors have been identified. Therefore, this study has made a positive contribution to the current body of knowledge surrounding shoulder injury in adolescent rugby union players and may provide more specific direction to future research.

Conclusion

This study identified a strong association between shoulder muscle strength and shoulder injury in adolescent rugby union players. Subsequently, this finding has revealed the need for further investigations into the effectiveness and optimal parameters of preventative muscle strength training, particularly of the shoulder region, in preventing injury in this population. Further investigations are required to more specifically identify if generalised joint hypermobility and active shoulder range of motion are associated with shoulder injury in adolescence and to determine whether shoulder muscle strengthening programs can prevent injuries from occurring.

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