Risk Factors for Shoulder Injury in Collegiate Rugby Union Players

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This prospective cohort study examined the associations of shoulder dislocations, instability or rotator cuff injuries in collegiate rugby union players with potential risk factors recognized in preseason medical screening examinations. The study subjects were 69 elite rugby players from one university rugby club. Basic demographics, injury experience and current physical findings were assessed, and shoulder injuries sustained during two playing seasons were recorded. Risk factors for shoulder injuries were determined using a logistic regression model. Fifteen players sustained shoulder injuries during the two seasons. A history of injury (OR, 6.56; 95% CI, 2.04-20.98; p = 0.00), a positive result in the load and shift (LAS) test (OR, 2.55; 95% CI, 0.92-7.06; p = 0.07) and the internal/external rotational (IR/ER) muscle strength ratio (OR, 1.39; 95% CI, 1.08-1.77; p = 0.00) were associated with shoulder injuries. A history of injury, a positive LAS test result, and the IR/ER muscle strength ratio are important risk factors for injury in collegiate rugby players.

Keywords: prospective study, rugby, shoulder injury, risk factor

1. Introduction

Shoulder injuries are among the most frequently encountered injuries arising during rugby union (Brooks et al., 2005a; Brooks et al., 2005b; Fuller et al., 2008), and are associated with repeated contact play (Fuller et al., 2007b; Garraway et al., 1999; Takemura et al., 2009). Brooks et al. investigated the epidemiology of injuries among English professional rugby union players during training and matches and demonstrated that the shoulder was the most common site of upper body injury (Brooks et al., 2005a; Brooks et al., 2005b).

Headey et al. (2007) presented epidemiological data on time-loss shoulder injuries in professional rugby union players on the basis of medical diagnoses. The most common types of shoulder damage were rotator cuff/shoulder impingement (2.23 injuries/1000 player-hours) and dislocation/instability (1.25 injuries/1000 player-hours). These types of injury show a high rate of recurrence; dislocation/instability is particularly likely to require surgical repair (Bathgate et al., 2002; Brooks and Kemp, 2008a). To prevent or minimize subsequent injuries, risk factors need to be identified and managed. Additionally, an understanding of the risk factors for shoulder injuries would be useful for rehabilitation and prehabilitation, which might involve specific muscle-strengthening exercises.

Tackling is the most common playing phase responsible for these two types of shoulder injury (Headey et al., 2007). Although injuries around the gleno-humeral joint sustained during rugby union have different signs and symptoms, the mechanisms responsible seem similar, and therefore it seems likely that similar risk factors are involved. The most recent studies of injury risk factors in rugby union have focused on the relationships between extrinsic factors related to the characteristics of rugby union (game level, type of play, tackle characteristics, field position, training volume, time of play, and ground surface (Bottini et al., 2000; Brooks et al., 2008b; Fuller et al., 2010; Haseler et al., 2010; Takemura et al., 2007)), and injury occurrence.

Repeated tackling play (Takemura et al., 2009), one of the specific features of rugby union and a well-recognized factor associated with injury, requires shoulder joint stability to prevent injury and
maximize playing performance. Therefore, instability and insufficient muscle strength would be expected to increase the risk of shoulder injury. Accordingly, there is a need to investigate physical characteristics such as range of motion (ROM), muscle strength, joint instability and joint laxity. However, the association of shoulder injuries with the physical features of rugby union players, including the findings of medical screening examinations (ROM, muscle strength, joint instability and laxity), has not been investigated. To detect these risk factors and implement preventive measures, it is significant to screen high-risk players before the start of each new rugby season.

The aim of the present study was to examine the associations between potential risk factors, assessed at preseason medical screening examinations, and subsequent shoulder injuries in collegiate rugby union players.

2. Methods

2.1. Subjects

This prospective cohort study initially registered 79 rugby union players from one university club, who usually trained together for the All Japan University Championship. At the first screening, demographic data such as playing position, age, and concerns about shoulder joints were investigated using a questionnaire, and body composition was measured. Players with a history of shoulder surgery, those who complained of shoulder pain during the medical screening, or those who had been injured before the start of the study, were excluded after the first screening.

Consequently, 69 rugby union players (138 shoulders) (mean age, 19.5 ± 1.3 years; height, 176.0 ± 5.4 cm; body mass, 83.6 ± 11.2 kg) from one university club were enrolled in the study. The group comprised forwards (FW, n = 34: Prop, 9; Hooker, 5; Lock, 9; Flanker, 7; Number 8, 4) and backs (BK, n = 35: Scrum half, 6; Standoff, 5; Centre, 11; Wing, 6; Full back, 7).

2.2. Procedure

All players received a preseason medical screening that included basic demographics, history of injuries and physical findings. The occurrence of shoulder injuries was recorded by a team doctor and medical trainers during the 2008-2009 and 2009-2010 playing seasons.

The Ethics Committee of the Graduate School of Comprehensive Human Sciences at the University of Tsukuba approved this study, and all players provided written informed consent before participating.

2.3. Definition of injury

This study was designed to consider only time-loss injury (Fuller et al., 2007a), meaning any injury that prevented a player from fully participating in the next training session or rugby match. Shoulder dislocation, instability or rotator cuff injuries were included as injuries. All injured players were clinically diagnosed by team medical doctors, using techniques including imaging studies.

2.4. Medical screening

Medical screening consisted of two parts: demographic identification including history of injuries, and assessment of potential risk factors. Questionnaires were used for the first part of the screening at the beginning of the study. History was assessed by a team medical doctor and defined as any previous shoulder dislocation, instability or rotator cuff injury occurring at the same location (Fuller et al., 2007a). Time-loss injuries were included without considering the severity of the injury or the time elapsed before return to play.

We collected data on ROM, isometric muscle strength, joint instability, joint laxity and history of injury. A goniometer was used to measure shoulder passive ROM of internal (IR) and external (ER) rotation at two positions: (1) 90 degrees of shoulder abduction and 90 degrees of elbow flexion in a supine position [90 degrees of abduction], and (2) 90 degrees of horizontal shoulder adduction and 90 degrees of elbow flexion in a supine position [horizontal adduction]. The end of ROM motion was determined with the end feeling by the same examiner.

A handheld dynamometer (micro-FET, Hoggan Health Industries, Draper, UT, USA) was used for measurement of isometric muscle strength during shoulder IR and ER at two positions: (1) 90 degrees of elbow flexion in a seated position [0 degrees of abduction] (Figure 1a), and (2) 90 degrees of shoulder
abduction and 90 degrees of elbow flexion in a supine position [90 degrees of abduction] (Figure 1b). The dynamometer was applied to the wrist joints of the players, and isometric contraction was continued for three seconds. Considering the absence of any compensatory operation and the time of measurement, we calculated IR/ER muscle strength using the measured ER muscle strength as the denominator. Isometric muscle strength was measured by the same examiner. ICC (1.1) for the intra-rater reliability of shoulder muscle strength measurement was as follows: IR = 0.93 (95%CI, 0.82-0.97), ER = 0.90 (95%CI, 0.72-0.96) in 0 degrees of abduction, and IR = 0.92 (95%CI, 0.78-0.97), ER = 0.91 (95%CI, 0.77-0.97) in 90 degrees of abduction.

Joint instability including apprehension sign was also investigated. The apprehension test was applied in a standing position. The shoulder was passively moved into a position whereby maximum external rotation in abduction and forward pressure was applied to the posterior aspect of the humeral head. When a patient becomes apprehensive and complains of pain in the shoulder, a positive test result is recorded (Anastasia and William, 2007).

Joint laxity was also investigated using the sign of load and shift (LAS) test and the sulcus sign. The LAS test was conducted while the examiner stood behind the patient and stabilized the scapula with one hand, while grasping the humeral head with the other. Both anterior and posterior stresses were applied, and the amount of translation noted (Anastasia and William, 2007). The sulcus sign was applied by exerting downward traction on the humerus, and a positive test result was recorded if the examiner observed dimpling beneath the acromion (Anastasia and William, 2007).

2.5. Statistical analysis

The relationships between the results of medical screening and subsequent shoulder injuries were analyzed. The analysis included 138 shoulders. Risk factors potentially related to shoulder injuries were analyzed using a stepwise logistic regression model (Enter, 5%; Remove, 10%). The following variables were input to the logistic regression models: continuous variables: shoulder ROM (90 degrees of abduction and horizontal adduction) and IR/ER strength ratio (0 and 90 degrees of abduction); nominal variables: history of injury, apprehension sign, LAS test, and sulcus sign. Statistical analysis was performed using the IBM SPSS version 18 package and the significance level was set at \( p = 0.05 \).

3. Results

Fifteen players sustained injuries to the right or left shoulder during the two seasons (Table 1). Table 2 shows the shoulder injury events. Table 3 shows the results of medical screening for all players, with and without shoulder injury (No injury group: 54 players, 108 shoulders; Injury group: 15 players, 30 shoulders).

History of injury (OR, 6.56; 95%CI, 2.04-20.98; \( p = 0.00 \)), positive LAS test result (OR, 2.55; 95% CI, 0.92-7.06; \( p = 0.07 \)) and the IR/ER muscle strength ratio in 0 degrees of abduction (OR, 1.39; 95%CI, 1.08-1.77; \( p = 0.00 \)) were associated with shoulder injuries (Table 4). Players with a history of injury had a shoulder injury rate 6.56 times higher.
Table 1  Number of shoulder injuries during 2008-2009 and 2009-2010 seasons

|                  | New (n = 6) | Recurrent (n = 9) | All (n = 15) |
|------------------|-------------|------------------|--------------|
| Dislocation/instability | 4           | 4                | 2            |
| Rotator cuff injuries     | 2           | 0                | 3            |

Days until return to play (mean ± SD) 42.1 ± 36.9

Days until return to play, the number of days that have elapsed from the date of injury to the player's return to full participation in team training or availability for match selection. There were no players who have the past history of both dislocation/instability and rotator cuff injuries.

Table 2  Injury event for shoulder injuries

|                  | Dislocation/instability (n = 10) | Rotator cuff injuries (n = 5) | All (n = 15) |
|------------------|----------------------------------|------------------------------|--------------|
| Tackling         | 6                                | 2                            | 8            |
| Being tackled    | 1                                | 0                            | 1            |
| Ground collision | 0                                | 1                            | 1            |
| Unknown          | 3                                | 2                            | 5            |

Table 3  Result of medical screening

|                  | No injury group | Injury group | p     | Effect size |
|------------------|-----------------|--------------|-------|-------------|
|                  | 54 players      | 15 players   |       |             |
|                  | (108 shoulders) | (30 shoulders)|      |             |

ROM

90 degrees of abduction

- IR (degrees)
  - New (n = 6): 74.0 ± 16.9
  - Recurrent (n = 9): 75.3 ± 18.1
  - All (n = 15): 74.2 ± 17.2
  - p = 0.71
  - Effect size = 0.08

- ER (degrees)
  - New (n = 6): 90.1 ± 12.9
  - Recurrent (n = 9): 91.2 ± 12.6
  - All (n = 15): 90.8 ± 12.4
  - p = 0.68
  - Effect size = 0.09

Horizontal adduction

- IR (degrees)
  - New (n = 6): 20.9 ± 13.8
  - Recurrent (n = 9): 24.7 ± 11.1
  - All (n = 15): 23.3 ± 12.3
  - p = 0.17
  - Effect size = 0.29

- ER (degrees)
  - New (n = 6): 95.1 ± 16.7
  - Recurrent (n = 9): 86.7 ± 8.0
  - All (n = 15): 90.9 ± 11.7
  - p = 0.00
  - Effect size = 0.55

Muscle strength

0 degrees of abduction

- IR (N/body mass)
  - New (n = 6): 3.03 ± 0.6
  - Recurrent (n = 9): 3.07 ± 0.5
  - All (n = 15): 3.05 ± 0.5
  - p = 0.76
  - Effect size = 0.07

- ER (N/body mass)
  - New (n = 6): 1.81 ± 0.4
  - Recurrent (n = 9): 1.62 ± 0.3
  - All (n = 15): 1.71 ± 0.3
  - p = 0.01
  - Effect size = 0.50

- IR/ER ratio (IR/ER)
  - New (n = 6): 1.72 ± 0.4
  - Recurrent (n = 9): 1.93 ± 0.4
  - All (n = 15): 1.88 ± 0.4
  - p = 0.00
  - Effect size = 0.53

90 degrees of abduction

- IR (N/body mass)
  - New (n = 6): 2.42 ± 0.6
  - Recurrent (n = 9): 2.66 ± 0.4
  - All (n = 15): 2.58 ± 0.4
  - p = 0.04
  - Effect size = 0.60

- ER (N/body mass)
  - New (n = 6): 2.22 ± 0.4
  - Recurrent (n = 9): 2.30 ± 0.4
  - All (n = 15): 2.26 ± 0.4
  - p = 0.38
  - Effect size = 0.20

- IR/ER ratio (IR/ER)
  - New (n = 6): 1.10 ± 0.3
  - Recurrent (n = 9): 1.18 ± 0.2
  - All (n = 15): 1.16 ± 0.2
  - p = 0.17
  - Effect size = 0.28

Questionnaire

- History of injury
  - New (n = 6): 102
  - Recurrent (n = 9): 21
  - All (n = 15): 0.00
  - Effect size = 0.32

- Joint instability
  - Apprehension sign
    - New (n = 6): 103
    - Recurrent (n = 9): 28
    - All (n = 15): 0.65
    - Effect size = 0.03

- Joint laxity
  - LAS test
    - New (n = 6): 91
    - Recurrent (n = 9): 21
    - All (n = 15): 0.07
    - Effect size = 0.15

- Sulcus sign
  - New (n = 6): 100
  - Recurrent (n = 9): 30
  - All (n = 15): 0.12
  - Effect size = 0.13

Data above shows average value ± standard deviation; ROM, range of motion; IR, internal rotation in shoulder; ER, external rotation in shoulder; N, newton; LAS, load and shift; (−), negative; (+), positive; p value, unpaired t-test or chi-square test for difference between groups; *p < 0.05; Effect size by d family or φ coefficient
Table 4  Result of logistic regression analysis

| Variables                        | B (S.E.) | Wald  | OR (95%CI)      | p    |
|----------------------------------|----------|-------|-----------------|------|
| [x1] History of injury           | 1.88 (0.59) | 10.03 | 6.56 (2.04-20.98) | 0.00 |
| [x2] Positive LAS test           | 0.94 (0.52) | 3.25  | 2.55 (0.92-7.06)  | 0.07 |
| [x3] IR/ER muscle strength ratio | 0.33 (0.13) | 6.77  | 1.39 (1.08-1.77)  | 0.00 |
| Constant                         | -4.61 (1.19) | 15.07 | 0.01  | 0.00 |

Probability of the shoulder injuries = $1/1 + \exp (-(-4.61 + 1.88x1 + 0.94x2 + 0.33x3))$; Omnibus test of model coefficients (p = 0.0001); Hosmer and Lemeshow test (p = 0.35); Cox & Snell $R^2 = 0.14$; Nagelkerke $R^2 = 0.22$; Predictive value = 79.4%; Variance inflation factor as follows; past history of injury = 1.012, positive LAS test = 1.005, IR/ER muscle strength ratio = 1.009.

than that of players without such a history. Players with positive LAS test result had a shoulder injury rate 2.55 times higher than that of players with negative findings. An increase in the IR/ER muscle strength ratio by 1.0 point was associated with a 1.39-fold higher risk of shoulder injury.

The regression equation was $1/1 + \exp (-(-4.61 + 1.88x1 + 0.94x2 + 0.33x3))$. The omnibus test of model coefficients have a significant result (p = 0.0001) (p ≤ 0.05). The result of the Hosmer and Lemeshow test was not significant (p = 0.35) (p > 0.05). The model of contributing rate was 0.14-0.22 form Cox & Snell $R^2$ and Nagelkerke $R^2$. The predictive value was 79.4%. Variance inflation factors were: history of injury = 1.012, positive LAS test result = 1.005, IR/ER muscle strength ratio = 1.009 (Table 4).

4. Discussion

This prospective cohort study collected findings of preseason medical screening examinations and subsequent occurrence of shoulder injuries to clarify the potential risk factors for shoulder injury among collegiate rugby union players. The study identified three risk factors using logistic regression analysis: history of injury, a positive LAS test result, and the IR/ER muscle strength ratio. Therefore, for evaluation of shoulder injury risk, it is necessary to confirm an individual's history of injury, and to perform the LAS test and determine the IR/ER muscle strength ratio by medical screening.

Among the latter three factors, the IR/ER muscle strength ratio is one of the key factors that has to be considered for both intervention and prevention of shoulder injuries. A 1.0-point increase in the IR/ER muscle strength ratio was associated with a 1.39-fold increase in the risk of shoulder injury. The subscapularis is one of the prime movers of IR motion, while the infraspinatus is a prime mover of ER motion. As these muscles affect the stability of the gleno-humeral joint, it is essential to maintain a balance in their strength—in other words the the IR/ER muscle strength ratio—for prevention of shoulder injuries. Furthermore, to maintain stability and ensure permanent centering of the humeral head, a balanced IR/ER muscle strength ratio is essential (Codine et al., 1997). Improvement of the IR/ER muscle strength ratio might therefore help to decrease the incidence of shoulder injuries among rugby players. While the present study showed that IR muscle strength was greater than ER muscle strength (Table 3), our evaluation of rotator cuff injuries showed results similar to those reported by Edouard et al. (2009). Therefore, increasing the ER muscle strength might help to improve the IR/ER muscle strength ratio in rugby players.

A history of joint dislocation/instability or rotator cuff injuries also increased the incidence of recurrence of similar shoulder injuries. In general, joint dislocation and/or instability causes a decreased joint range of motion, weak muscle strength and/or joint instability (Pagnani et al., 1995; McMahon et al., 2004). In addition, Edouard et al. (2011) have pointed out that rotator cuff injuries lead to muscular dysfunction. Accordingly, these factors could increase the risk of recurrent joint dislocation/instability. In fact, two of the studied players with a history of rotator cuff injury suffered shoulder dislocation during the period of research. These events suggest that the rotator cuff is partially responsible for the dynamic stability of the gleno-humeral joint.

Some subjects who were recruited for the present study had a previously injured shoulder, and we also found that a history of shoulder injury was one of the risk factors for recurrent injury. Therefore,
preventive strategies against recurrent shoulder injury are also essential. In addition to weak muscle strength and/or joint instability, special attention should be paid to players with joint laxity. Cheng et al. (2012) suggested that rugby players who have suffered a dislocated shoulder previously should be given care to reduce the chance of them dislocating the other shoulder, because of the possibility of bilateral anterior shoulder joint. The present findings seemed to reflect this possibility. However, if a history of injury reflects joint laxity, further examination will be required to clarify the relationship between joint dislocation/instability.

Players who have a history of injury and an increase of joint instability might have a poor sense of joint position. Herrington et al. (2010) evaluated shoulder joint position sense in professional rugby players, and found that previously injured rugby players who had sustained injury had a decreased joint position sense. Therefore, any of the present players who had a history of injury might have had a poor joint position sense, and this might have affected the risk of injury.

Of the 15 players who sustained shoulder injuries during the two seasons, the most common timing of injury was during tackling. Our findings are consistent with the results of previous studies such as those of Bathgate et al. (2002) and Headey et al. (2007), who found that shoulder injuries were manifested as gleno-humeral instability and/or rotator cuff injuries, and almost always occurred during tackling. These findings were similar to those of a study of American football (Kelly et al., 2004).

Weak muscle strength would remain after dislocation and/or rotator cuff injuries (Edouard et al., 2009). The present injured group included 9 subjects who had a history of traumatic injury (dislocation in 4, and rotator cuff injury in 5). Therefore, as a history of injury may be a confounding factor, further data collection is required to clarify the IR/ER ratio.

Shoulder dislocation, instability and rotator cuff injuries, which we defined as shoulder injuries in this study, were usually caused by tackling (Headey et al., 2007). Rugby union players receive tremendous direct force on their shoulder while tackling and during impact with the ground. To resist external force and increase the stability of the shoulder joint, the rotator cuff muscle plays an important role. Therefore, prehabilitation and specific strengthening exercise should reduce the risk of shoulder injuries.

Four steps for the prevention of sports injuries are included in the “sequence of prevention” that was proposed by van Mechelen et al. (1992): (1) The extent of the injury problem is identified and described; (2) The factors and mechanisms involved in the occurrence of sports injuries are identified; (3) Appropriate intervention that is likely to reduce the risk and/or severity of sports injuries is applied; and (4) The effects of the measures are evaluated by revisiting the first step. Since the present study has contributed to the identification of risk factors corresponding to the second step, the third step, “appropriate intervention” should be implemented.

There were several limitations to the present study. First, it investigated a single rugby team, and potential risk factors might differ according to team or competition grade. Second, only risk factors for shoulder injuries, defined as shoulder dislocation, shoulder instability, and rotator cuff injury, were studied. These types of injuries are frequently encountered among sports injuries, especially in hard contact sports. However, other risk factors that were not addressed here might also need to be considered. Other potential variables (exposure, tackle technique, position, joint position sense) may warrant further study to gain an overall picture of the factors related to shoulder injuries in rugby union players.

5. Conclusion

This study examined the association of potential risk factors assessed by preseason medical screening with subsequent shoulder injuries in collegiate rugby union players. It was found that a history of injury, a positive LAS test result, and the IR/ER muscle strength ratio are important risk factors for recurrent injury.

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