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Increased anterior translation of the knee in professional rugby players following one-hour game-related training: An etiological factor for anterior cruciate ligament ruptures?

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Abstract

Brooks et al. (2005) described that most of the injuries to the cruciate ligaments in professional rugby players were most likely to occur during the third quarter of a game. It has been proposed that a short-term increase in ACL laxity would have the potential to predispose an athlete to such injury. The purpose of this investigation was to assess whether a one hour rugby training session would increase anterior tibial translation as evaluated with a KT-1000 arthrometer. 29 professional players (age range 18-32 SD; +/-3.66) were tested immediately before and immediately after a routine 60 minute rugby training session; 15 minutes warm-up consisting of agility ladders, mini hurdles, jogging, heel flicks, cariocas, side stepping and dynamic flexibility drills, followed by rugby specific sequence moves for 40 minutes and a five minute cool down. Instrumented knee laxity testing was undertaken on both legs using a KT-1000 knee ligament arthrometer. The mean anterior excursion pre-exercise with a 20 pound displacement force was 3.67mm in the left pre exercise group and 3.46mm in the right knee. The mean excursion post-exercise was 4.46mm in the left knee and 4.97mm in the right knee. This equates to a 23% increase for the left knee and a 30% increase for the right knee.

In conclusion, the study showed that a one hour rugby session significantly increased anterior tibial translation of the knee in 26 professional players. Further studies are prompted to validate this finding versus a potentially increased risk of ACL rupture.

Introduction

Anterior cruciate ligament (ACL) injury is very common in sport, especially basketball, American football, skiing and football (Griffin, 2000; Viola et al., 1999; Bjordal et al., 1997; Arendt, et al., 1995). In rugby it accounts for the longest period that a player is unavailable through injury, accounting for 29% of all days missed from playing or training, according to
the RFU injury audit, which recorded an average severity of 204 days to return from an ACL injury (Brooks et al., 2005) which equates to almost seven months absence from the game.

In rugby forwards, ACL is the highest risk injury from being tackled or twisting / turning and, in backs, the highest risk injury from a collision (Brooks et al., 2005). The ACL is frequently injured without any precipitating collision or traumatic event (Belanger et al., 2004) and up to 78% are non contact injuries (Belanger et al., 2004; Kirkendall and Garrett, 2000; Johnson, 1983). This implies that there must be intrinsic factors which lead to ACL rupture; such as excess anterior tibial translation (ATT) or rotation of the femur on the tibia (Rosene and Fogarty, 1999).

Of further interest, Brooks et al. (2005) described that most of the injuries to the cruciate ligaments were most likely to occur during the third quarter of a rugby game. This is specifically relating to injuries of the backs, with 75% of their ACL injuries occurring during this third quarter. This relates to approximately 40-60 minutes of play; the period immediately after half-time. Laxity (Steiner et al., 1986; Kirkley et al., 2001). It has been hypothesised that there may be a relationship between exercise induced laxity and subsequent ligamentous injury; an increase in anterior translation of the knee joint has been demonstrated with repetitive loading exercises (Kirkley et al., 2001), and Stoller et al. (1983), when investigating the effect of running on torsional laxity of the knee, found that there was a peak in knee laxity at ten minutes after exercise ceased. It has been proposed that a short-term increase in ACL laxity would have the potential to predispose an athlete to injury. However, it remains unclear whether knee laxity accurately reflects ATT during dynamic knee motion (Higuchi et al., 2003).

The KT-1000 arthrometer has been used extensively in clinical populations to measure relative displacement of the tibia on the femur and has been assessed for reliability and validity (Highgenboten et al., 1989; Wroble et al., 1990; Anderson et al 1991; Stratford et al., 1991), and has been accepted as the most accurate and reliable method of quantifying knee laxity when compared to other knee joint arthrometers (Daniel, 1991).

The purpose of this investigation was to assess whether a one hour rugby training session will increase anterior tibial translation as evaluated with a KT-1000 arthrometer.

**Methodology**

A convenience sample of 29 subjects volunteered for this study. All subjects were full-time professional rugby players with no previous history of knee injury. All participants had been
playing rugby at a professional level for a minimum of three years and were aged between 21 and 38 years old.

Ethical approval was obtained from the University of Sheffield.

A Power Analysis was conducted using G*Power 3.0 software, calculated a sample size of 27 to be statistically significant.

Subjects were tested immediately before and immediately after a routine 60 minute rugby training session; 15 minutes warm-up consisting of agility ladders, mini hurdles, jogging, heel flicks, cariocos, side stepping and dynamic flexibility drills, followed by rugby specific sequence moves for 40 minutes and a five minute cool down.

Instrumented knee laxity testing was undertaken on both legs using a KT-1000 knee ligament arthrometer (MedMetric Corporation, California). Subjects were tested in the supine position to ensure that there was no activity in the hamstrings. All subjects were tested wearing shorts to ensure the arthrometer had direct contact with the skin. Testing was carried out in accordance with the manufacturer’s recommendations. A thigh support positioned under the knee joint ensured a consistent amount of knee flexion for testing. A foot support controlled limb rotation which was kept at $15^\circ$ – $25^\circ$ of external rotation. Three readings were taken for each leg at maximal force.

**Results**

<table>
<thead>
<tr>
<th>Descriptive</th>
<th>Left Pre</th>
<th>Left Post</th>
<th>Right Pre</th>
<th>Right Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.67</td>
<td>4.46</td>
<td>3.46</td>
<td>4.97</td>
</tr>
<tr>
<td>Median</td>
<td>3.67</td>
<td>5.08</td>
<td>3.17</td>
<td>4.75</td>
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<tr>
<td>SD</td>
<td>1.27</td>
<td>1.15</td>
<td>1.16</td>
<td>1.20</td>
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<td>1.17</td>
<td>2.83</td>
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<td>Maximum</td>
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<td>6.83</td>
<td>5.50</td>
<td>6.83</td>
</tr>
<tr>
<td>Range</td>
<td>4.33</td>
<td>4.16</td>
<td>4.33</td>
<td>4.00</td>
</tr>
</tbody>
</table>

*Table 1* Results of Anterior draw assessment
The mean anterior excursion pre-exercise with a 20 pound displacement force was 3.67mm in the left pre exercise group and 3.46mm in the right knee. The mean excursion post-exercise was 4.46mm in the left knee and 4.97mm in the right knee. This equates to a 23% increase for the left knee and a 30% increase for the right knee.

Table 2: Paired Samples Statistics

<table>
<thead>
<tr>
<th>Pair</th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Pre</td>
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<td>26</td>
<td>1.16098</td>
<td>.23698</td>
</tr>
<tr>
<td>Right Post</td>
<td>4.9721</td>
<td>26</td>
<td>1.20218</td>
<td>.24539</td>
</tr>
<tr>
<td>Left Pre</td>
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<td>26</td>
<td>1.26675</td>
<td>.25858</td>
</tr>
<tr>
<td>Left Post</td>
<td>4.9729</td>
<td>26</td>
<td>1.15446</td>
<td>.23565</td>
</tr>
</tbody>
</table>

Table 3: Paired Samples Correlations

<table>
<thead>
<tr>
<th>Pair</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Pre &amp; Post</td>
<td>26</td>
<td>.798</td>
<td>.000</td>
</tr>
<tr>
<td>Right Pre &amp; Post</td>
<td>26</td>
<td>.633</td>
<td>.001</td>
</tr>
</tbody>
</table>

Table 4: T-Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>Mean difference</th>
<th>SD</th>
<th>Standard Error</th>
<th>Sig.</th>
</tr>
</thead>
</table>
The results of the T-test showed that, for both knees, there was a significance of 0.00. As the P value was set at 0.05 this identified a perfect correlation between a laxity increase and the effect of the one hour rugby session for both knees (P<0.01).

When analysing whether the pre- and post- exercise measurements could be matched, an 80% correlation was identified for the right knee and a 63% correlation in the left knee, indicating a medium to high probability of the knee laxity increasing by the same percentage each time.

**Discussion**

The percentage increases in ATT were 23% for the left knee and 30% for the right. This correlates with previous studies on basketball players and 10k runners where 18% and 20% increases were found respectively. Weisman et al. (1980) also found a 20% increase in MCL compliance post-exercise. The greater increase found in rugby may be attributed to the nature of the game involving contact and more strenuous dynamic exercise.

The results of the current study show that although there is a significant increase in the anterior laxity they are smaller than the 5mm to 8mm increases recorded after an ACL injury (Kochen et al., 1984). No definitive research has stated whether the increased laxity from exercise puts the ligament nearer its maximum available capacity and therefore less able to withstand forces exerted upon it. Statistical tests for both legs show an exercise induced increased ATT. This supports the hypothesis that rugby increases knee joint laxity. This may be relevant when reviewing the incidence of ACL injury. Although it is proposed that a short-term increase in ACL laxity would have the potential to predispose an athlete to injury, it remains unclear whether knee laxity accurately reflects ATT during dynamic knee motion (Higuchi et al., 2003).

Research has shown that most ACL injuries occur in the third quarter of the game (Brooks et al., 2005) and this piece of research was planned to replicate 60 minutes of rugby. It should be taken in to consideration that the intensity of a game cannot be replicated in training and
ultimately the volume of work may differ by playing positions from training to match situation. On this basis it is possible that there is an even greater increase in ATT during a match situation. Fatigue has been identified to play a significant part in knee control. Future research may evaluate the relationship between fatigue, ACL laxity and the subject’s ability to dynamically stabilise the joint. It is hypothesised that increased ATT coupled with muscular fatigue may place the knee at increased risk of injury.

**Limitations**

The level of subject relaxation is considered critical to accurate measurements in laxity testing (Sailors et al., 1995). For this study, verbal encouragement was used to obtain relaxation of the quadriceps and hamstrings. This had been the method of choice in previous studies. There was no method of assessing the quality of relaxation. To encourage relaxation, testing was performed in a quiet room without distraction. This was consistent with previous research. A questionnaire may be a potential method of assessing status of relaxation but was not deemed necessary for this study.

The exercise performed was designed to closely simulate a rugby game. It included acceleration, deceleration and cutting phases from an agility perspective but also tackling, line-out, rucks and mauls to make the exercise rugby specific. However, as with all training events it is never possible to re-create the intensity of an actual game.

Error may arise from the equipment, the tester or the patient. As all measurements were taken by the same person, if there was an element of tester error then this would be apparent through the whole set of data. The methodology was followed precisely each time to minimise error. A test-retest was undertaken by the tester a week prior to testing the subjects to minimise tester error.

**Recommendations for Future Research**

The increase in laxity shown after 60 minutes of rugby may adversely affect the neuromuscular control of the knee. It is unknown whether the muscles work to full capacity when there is increased joint movement from what they are accustomed. This poses the question whether stability rehabilitation and training should be carried out after exercise when the knee is potentially fatigued and more at risk of injury. It may be beneficial to train the muscles surrounding the knee joint to protect the knee when the ligamentous laxity is increased in addition to the standard injury prevention protocols which are usually enforced during strength training sessions.
It is widely apparent that at half time during a rugby game players return to the changing room and generally sit and rest. The obvious suggestion to prevent ACL injury would be to conduct a brief perturbation session during the break to ensure that the muscles surrounding the knee joint are working synergistically to stabilise in all risk situations.

**Conclusion**

The current study evaluated the effect of a one hour rugby training session on ATT as measured by a KT-1000 arthrometer in 26 professional players. The study showed that a one hour rugby session significantly increased anterior tibial translation.

**References**


