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Original citation:
Morgan, R. and Herrington, L. (2014) The effect of tackling on shoulder joint positioning sense in semi-professional rugby players. Physical Therapy in Sport, volume 15 (3): 176-180

http://dx.doi.org/10.1016/j.ptsp.2013.10.003

Publisher:
Elsevier

Accepted Manuscript

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PII: S1466-853X(13)00104-1

DOI: 10.1016/j.ptsp.2013.10.003

Reference: YPTSP 580

To appear in: *Physical Therapy in Sports*

Received Date: 23 April 2013

Revised Date: 22 August 2013

Accepted Date: 24 October 2013

Please cite this article as: Morgan MSc MSST, R., Herrington PhD MCSP, L., The Effect of Tackling on Shoulder Joint Positioning Sense in Semi-Professional Rugby Players, *Physical Therapy in Sports* (2013), doi: 10.1016/j.ptsp.2013.10.003.

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Key Words: Rugby Union, Tackling, Shoulder, Joint Positioning Sense.

Word Count: 3,168

Abstract

Objective: To assess the effect of a tackling task replicating the force magnitudes and directions seen in a competitive game or training session, on a players shoulder joint position sense.

Design: Repeated measures design.

Setting: Field based.

Participants: Nineteen, senior, male, semi-professional rugby union players.

Main outcome measures: Two criterion angles of 45° and 20° off maximal range of shoulder external rotation in the 90° angle of abduction, were assessed for reproduction accuracy prior to, and following a field based tackling task against an opponent. A comparison between dominant and non-dominant side accuracy was also obtained.

Results: Prior to the tackling task, joint positioning sense was poorer at the 45° criterion angle than for 20° off the athletes' maximal range angle. Following the tackling task, error scores were significantly increased from baseline measures at the outer range criterion angle for both dominant and non-dominant sides. In contrast to previous research the detrimental effect of the task was also greater. In addition, there was a significant decrease in accuracy at the 45 ° criterion angle for the players' non-dominant side.

Conclusions: This study found a significant decrease in accuracy of joint position sense following the tackling task. It also found this decrease to be greater than previous research findings. In contrast to previous studies that found no effect at the 45 ° criterion angle, this study found significant changes for the players' non-dominant side occurred at this angle. A possible explanation for this is that the sensory motor system is negatively affected by fatigue and consequently shoulder

dynamic stability is reduced. This fatigue element explains the trend for increased injury frequency in the third quarter of the game and would provide a rationale for the inclusion of conditioning programmes that address fatigue resistance and motor co-ordination in the region.

1. Introduction

Rugby union is a vigorous contact sport, which due to the physical nature of the game exposes players to a high frequency of contact events, which leads to one of the highest risk for injuries of any sport (Bottini, Poggi & Luzuriga, 2000). Although the lower limb is the most common site of injury (Brooks, Fuller, & Kemp, 2005), injuries to the shoulder are particularly costly in terms of time lost (Brooks & Kemp, 2008; Headey, Brooks, & Kemp, 2007), with 35-60% of injuries resulting from the tackle (Fuller, Brooks, & Cancea, 2007; McIntosh, Savage, & McRory, 2010; Quarrie & Hopkins, 2008). Although physical contact has been linked to the vast majority of injury mechanisms to the shoulder region, what has not been explained are the potential risk factors which may increase the susceptibility to shoulder injury during contact events.

Normal shoulder joint function is dependent upon both static and dynamic stabilising mechanisms (Janwantanakul et al., 2001). A combination of bony, capsular, ligamentous and muscular systems, serve to provide stability to the shoulder region in varying degrees. The bony constraint system has minimal influence (Lee et al., 2003), whereas the capsuloligamentous system contributes to stability at extreme positions of movement. In mid ranges of motion, it is the muscular system that provides the principal support, muscles contributing to joint stabilisation through activation of protective contraction reflexes, and adjustment of muscle stiffness (Carpenter, Blasier & Pellizzon, 1998).

Optimal muscle action is under the control of accurate feedback into the central nervous system from the proprioceptive system (Tripp, Boswell & Gansneder, 2004). In relation to the active stabilisers (muscular) around the shoulder, the passive tension generated in the muscle fibres of the internal rotators during the outer ranges of external rotation, would result in enhanced activity of the muscle spindles and further input into the central nervous system. Tension in the tendinous part of the internal rotators would also be increased, although research suggests that this structure is influenced more by tension generated through muscle fibre contraction, than by a slow passive stretch (Stephens, Rienking & Stuart, 1975: Moore, 1984). It appears that greater positional awareness occurs toward the outer ranges of external rotation, as a result of this increased neural input. Positional acuity in the mid-ranges of external rotation may be less accurate, due to a reduced level of sensory input from the surrounding structures (Janwantanakul et al., 2001). Any deleterious effects to this system could be linked to a reduction in efficiency of the active stabilisers, leading to an increased risk of injury and /or decrease in performance (Carpenter et al., 1998; Herrington, Horsley & Whitaker, 2008).

Takarada (2003) and Suzuki, Umeda, and Nakaji (2004) found biomechanical evidence of serious structural muscle damage following a competitive rugby match, due to tackling requiring the head, neck and shoulder area to experience significant forces. A co-ordinated muscular recruitment pattern must then serve to develop rapid deceleration forces to stabilise the region at the point of impact. Previous research by Herrington et al., (2008) has shown a reduced ability to determine joint position at the outer ranges of joint motion following a tackling task, with no significant change in repositioning errors at the mid ranges.

What this supports is changes in the sensory motor system having a negative effect on joint stability in the outer ranges and potentially leaving a joint vulnerable to injury due to a decrease in muscle co-contraction co-ordination (Pederson et al., 1999)**.** Although the research (Carpenter et al., 1998; Herrington et al., 2008) suggests a decrease in joint position sense, it is its extent that is not clear, as the methods utilised in the studies are not likely to have exposed the players to the magnitudes of force encountered during a competitive game or training environment. One of the principal factors affecting tackle injuries in rugby union is momentum, with either the tackled or tackling player running or sprinting prior to the tackle taking place (Garaway, Lee, & Macleod, 1999). Pain, Tsui, and Cove (2008) reported a maximum impact force of 819N when a tackle is executed from a crouched position, with Usman, McIntosh, and Frechede (2011) finding maximal forces of 1660N in a laboratory setting, and 1997N during field testing using a 45kg tackle bag. The higher impact forces seen in the field setting may be a reflection on the type of surface and the purchase a player can obtain when wearing studded boots, in contrast to training shoes worn in a laboratory setting.

Despite the growing number of studies examining the epidemiology of injuries in rugby union, and the general acceptance that injuries to the shoulder region are primarily as a result of the tackle, information on the intrinsic risk factors is lacking and does not necessarily replicate the true force magnitudes and directions likely to be encountered during a game. The aims of this study therefore looked at the effect of tackling in a field based setting on shoulder joint position sense in rugby players at mid and outer ranges, comparing the effect on the dominant and non-dominant side.

2. Method

2.1 Participants

Nineteen semi-professional rugby union players, from a first team squad of 28, at a single level 5 club were recruited for the study. Players were included if they either reported no previous history of shoulder injury, or were passed medically fit to return to training and competition at least 2 months previously. Players were aged between 22 and 32 (mean 26.7 (± 3.2 years)) . Their mean height was 1.71m (± 0.13m), and mean mass was 94 kg (± 8.6 kg), with a mean BMI of 32.7 (± 5.7). Players had an average playing experience of 13.3 years (± 2.7 years). Data collection took place 48 hours after the last training session or match to allow sufficient recovery, whilst not impeding team preparations. The study was given ethical approval by Salford University research ethics committee, and all participants gave informed consent to participate in the research.

2.2 Procedures

Prior to baseline measurements, players completed a 10 minute warm-up consisting of active range of motion exercises of shoulder flexion to 90°, and potentiating drills of press-ups and passing drills that players would normally undertake pre match /training before any contact or unit specific drills. The player's dominant side was then determined by ascertaining which side the player would prefer to tackle with.

The olecranon and ulna styloid process were marked using 1cm square adhesive tape. The joint angle was captured and measured by obtaining a digital photograph (Samsung Digimax A7 digital camera, 7 megapixel resolution) on two reference lines; one horizontal line parallel to the treatment bed the player is lying supine on , and one line connecting the points marked on the olecranon and ulna styloid process. Pre and post tackling measurements were taken replicating the method of Herrington et al., (2008). The active repositioning sequences were repeated until the player had three attempts at 45° and further repeated for an angle 20° short of the athlete's maximal range of external rotation in 90° abduction. The mean was calculated for the three attempts of each respective range. Similar research by Herrington et al., (2008) support this method, and have produced good test-retest reliability (r=0.92). For this study the between session test – retest reliability was obtained by testing a group of six separate players. The error scores for both target angles (45° and 20° off maximum external rotation) were determined and then reassessed 30 minutes later. Intraclass correlation coefficient comparison of first and second measurements revealed a correlation of 0.81 (p=0.001), with a mean difference between measurements of 1.7° (± 0.8°) with a 95% confidence interval of 0 - 3.3°. All setting angles were measured by digital inclinometer (Saunders Group, Minnesota, USA), which has been shown to have a high degree of intra and inter-tester reliability (r = 0.91 – 0.97) (Venturni et al., 2006). To avoid visual clues, players were blindfolded during the testing procedure. The error score was then calculated by subtracting the baseline angle from the reproduction angle. The order of testing was block ordered (45° or 20° off max) for each subject, and the sequence reversed post tackling drill. Following the baseline measurements the players then undertook an opposed tackling session. The course was set up as in figure 1.

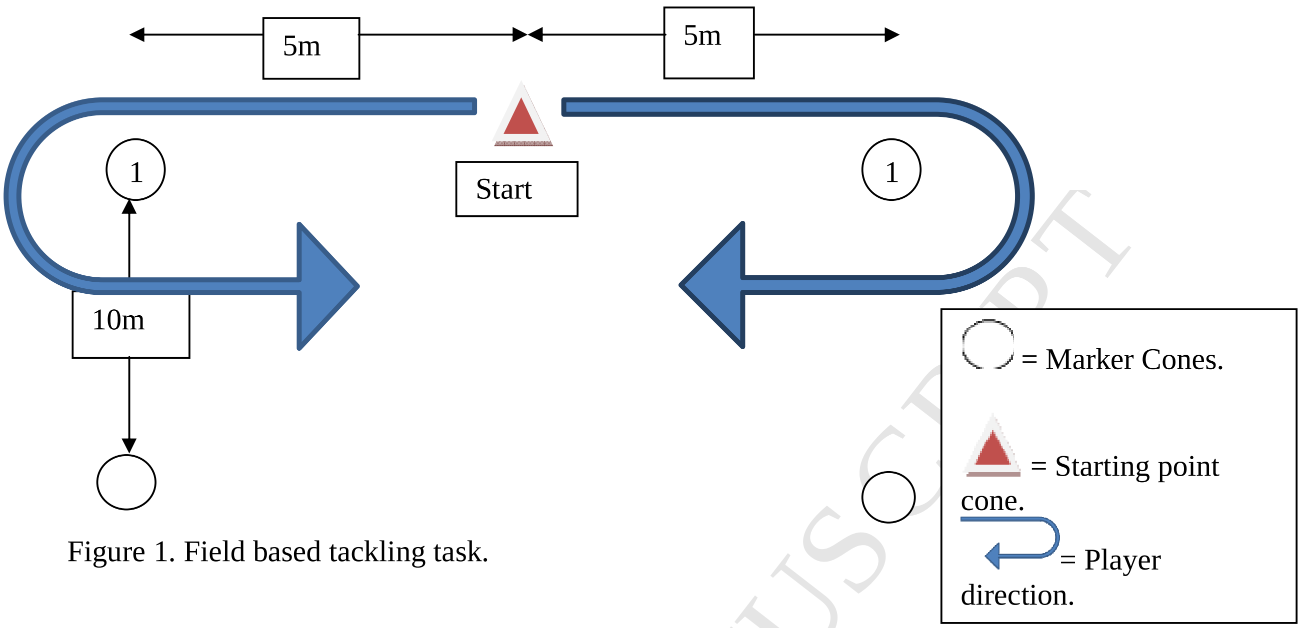

Figure 1. Field based tackling task.

Attacker and defender went in opposite directions around marker 1 before turning toward each other in the 10m channel. The defending player performed 10 tackles with their dominant side. Players were instructed to tackle around the legs and utilise the arms; as is common practice in a game, and consistent with guidance from coaching manuals. After each tackle, attacker and defender had 10 seconds to return to the start before repeating the drill. In total the defender made 10 tackles on each shoulder. After 10 tackles off one shoulder, the joint positioning sense was immediately re-measured, with the reproduction angle block order being reversed. The player then completed another 10 tackles off the non-dominant shoulder, with position sense re-measured immediately after.

2.3 Analysis

For each player the target angle was subtracted from the reproduced angle to find the resultant repositioning error, with an average being taken from the three trials for each angle. The difference in the mean error scores pre and post tackle drill for 45° and 20° from maximal lateral rotation were analysed with repeated measures ANOVA, with Greenhouse-Geisser adjustment applied. Within group differences in joint position sense between limbs (dominant and non-dominant) were also evaluated. All statistical analysis was conducted using the SPSS statistical package, version 16 (SPSS Inc., Chicago, IL, USA).

3. Results

Mean range of motion values for the 20° off maximal external rotation range were 72.7° (± 11.8°) on the left arm, and 79.4° (± 13.9°) on the right arm.

Figure 2 illustrates mean absolute error score for both non-dominant and dominant sides pooled together before the tackling drill was 4.0° (± 1.9°) at the 45 degree criterion angle, and 2.6° (± 1.8°) at the 20 degrees off maximal external shoulder rotation angle. Post tackling, the mean pooled non-dominant and dominant error scores were 6.3° (± 3.7°) at 45 degree criterion and 7.8° (± 3.4°) at the 20 degree off maximal range criterion.

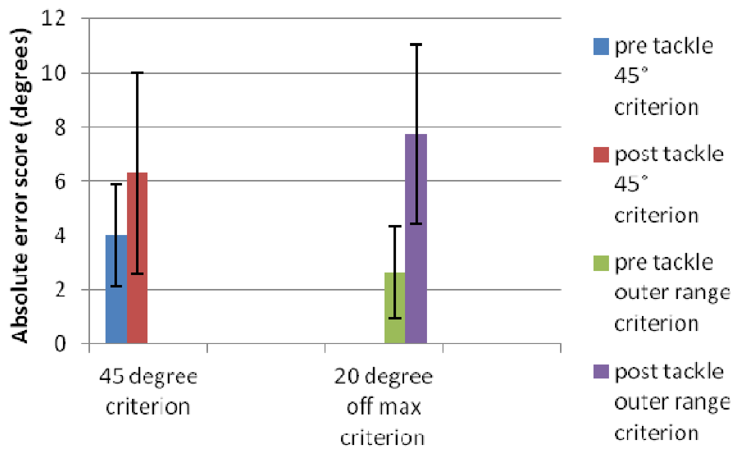

Figure 2. Pooled dominant and non-dominant mean error scores with standard deviations.

When non-dominant and dominant shoulders are considered separately (figure 3 and figure 4), the mean pre tackle error score at 45 degree criterion was 4.5° (± 1.9°) on the non-dominant and 3.5° (± 1.8°) on the dominant. At the 20 degrees off maximum criterion the mean pre tackle error scores were 3.1° (± 2.1°) for the non-dominant, 2.2° (± 1.3°) on the dominant. Post tackling the score at the 45 degree angle was 7.8° (± 4.2°) for the non-dominant, and 4.8° (± 2.5°) on the dominant. At the 20 degree off maximum, the mean error scores post tackle were 7.9° (± 2.0°) and 7.6° (± 4.2°) on the non-dominant and dominant side respectively.

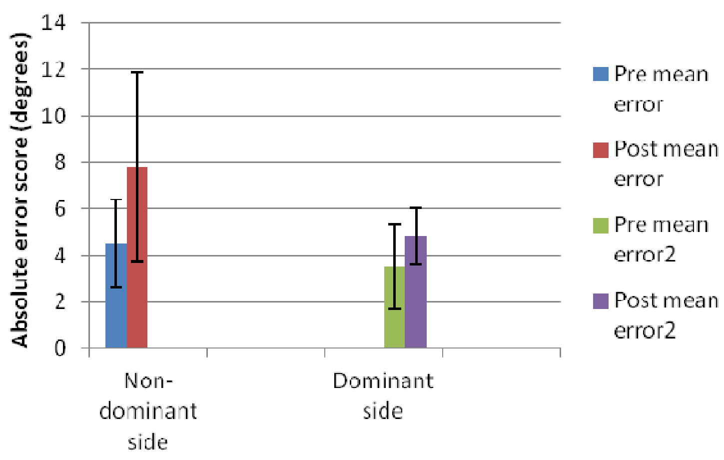

Figure 3. 45° criterion mean error scores pre and post tackle with standard deviations.

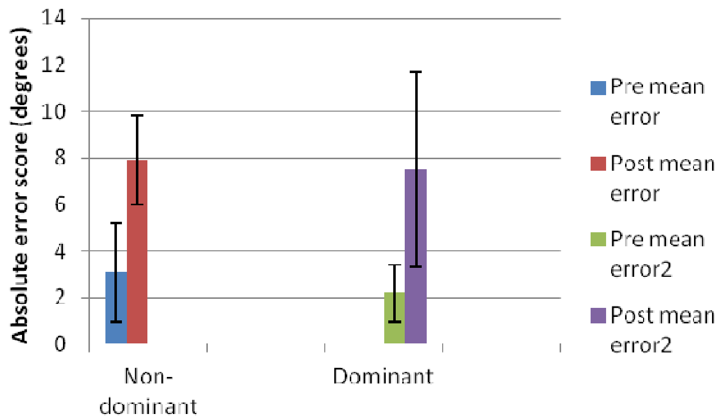

Figure 4. 20° off max external rotation criterion mean error scores with standard deviations.

A factorial ANOVA indicated a significant difference in mean pre and post tackle error scores for the 45° criterion on the non-dominant shoulder (F = 28.063, 1,36, p = < 0,001). There were no significant changes in error pre and post tackle at the 45° criterion for the dominant shoulder (F = 5.1, 1,36, p = > 0.03). At the 20 degree off maximal angle, there were significant differences in the pre and post tackle mean error scores for both non-dominant and dominant shoulders (F = 82.669, 1,35, p = <

0.001) and no significant differences in the margin of error between sides (F = 0.219, 1,35, p = > 0.05).

4 Discussion

The study supports previous work (Carpenter et al., 1998; Janwantanakul et al., 2001; Lee et al., 2003; Herrington et al., 2008) of a more accurate awareness of joint position towards the outer range of shoulder external rotation. The error scores for the 20° from maximum external rotation show a lower mean error score than the 45° criterion angle. The absolute error score when comparing dominant and non-dominant sides suggests a greater margin of error on the non-dominant side. A vast majority of the participants were right side dominant, i.e. they preferred to tackle on their right shoulder. Although the right sided players were more accurate toward the end of range on both sides, the data suggests they had poorer positional sense on their non-dominant sides for both the 45° and 20° off maximum external rotation range criterion angles. Analysis of the left side players revealed a similar trend; however, only two of the subjects were left side dominant

Following the tackling task, this study found the players joint position sense to be reduced significantly. This finding supports that of other projects investigating the effect of tackling, (Herrington et al., 2008) and also the effects of fatigue on joint position sense (Carpenter et al., 1998; Pederson et al., 1999; Lee et al., 2003; Tripp et al., 2004). This study also found that, not only was there a reduction in joint positional sense at the outer-range criterion, but also at the 45° criterion angle on the players non-dominant side. There was no significant difference for the 45° criterion angle on the dominant side. The previous study by Herrington et al., (2008) that only tested the right shoulder, reported a mean increase in error score pre to post test of 4° (± 1.5°) rising to 4.7° (± 1.9°) at the 45 degree criterion angle. In comparison, this study showed a mean pre-test error of 3.5° (± 1.8°), rising to 4.8° (± 2.4°) on the right (dominant) shoulder. This comparative mean increase in error margin is similar to that found by the previous research. However, when looking at the pre and post error scores for the non-dominant side the decrease in accuracy is much higher (4.5° (± 1.9°) and 7.8° (± 4.1°)) respectively.

It does support work by Usman et al., (2011) into forces generated at the contact point between the players shoulder and tackle bag, of a tendency for players to be able to generate greater force on their dominant side. Bagestiero and Sainburg, (2002) found a greater positional awareness on the dominant arm of subjects, and this awareness may afford the player more co-ordination and confidence when preparing for the impact. This would suggest that the increased force encountered with this particular research project has had a greater detrimental effect upon joint positioning sense at this angle for the players' non-dominant side. This may go some way into explaining why statistically players are more likely to injure their non-dominant shoulder. In a total of 166 incidences, right shoulder dominant players requiring reconstruction for anterior instability injured their left side in 94 (57%) instances, and their right in 72 cases (43%). Whilst left sided players in a total of 15 instances were left 5 (33%), and right 10 (67%) (Sundaram, Bokor, & Davidson, 2011).

At the outer range criterion position, previous research (Herrington et al., 2008) showed a 2.8° (± 1°) pre tackle and a 4.6° (± 1.3°) post tackle absolute error score. In comparison, this study resulted in a pre-tackle average error score of 3.1° (± 2.0°)

non-dominant and 2.2° (± 1.3°) dominant side error. Post tackle the error scores increased significantly, non-dominant side mean error rising to 7.9° (± 1.9°), dominant side, rising to 7.6° (± 4.2°). Whilst this supports the previous research of a decreasing ability following tackling, it does also show a greater effect of the tackling task set up in this project. This may be a result of increased force required to execute the tackle task, due to a greater momentum generated by the attacking and defending players as they are moving at a greater speed compared to previous studies.

The shoulders inherent lack of stability, particularly in the position commonly encountered during tackling, re-enforces the need for precise neuromuscular control and joint stability when attenuating high forces. Functional stability of the shoulder joint is dependent upon interlinked, accurate control of scapulothoracic stabilisation, glenohumeral stabilisation and humeral control, with all of these elements mediated, in part, by the neuromuscular mechanisms (Lephart & Henry, 1996). Any condition that alters the synchronised balance between the dynamic and static mechanisms can therefore potentially lead to dysfunction and injury. Interventions that are geared toward increasing the dynamic stabilisers resistance to fatigue would logically improve joint stability, and consequently reduce injury predisposition, as such deficits have been implicated in susceptibility to shoulder injury (Lephart & Henry, 1996). However, given the delicate balance between mobility and stability that exists in the shoulder region, it is essential to address the sensorimotor elements that contribute to stability of the region.

The data from this and other studies (Carpenter et al., 1998; Lee et al., 2003; Herrington et al., 2008; MacQueen & Dexter, 2010) goes some way in providing an explanation behind the increase in frequency of shoulder injury seen in the game (Brooks and Kemp, 2008). The increasing intensity, frequency of impact and consequent effect upon joint stability may be the underlying rationale behind the tendency for increasing injury occurrence in the game as a whole, and the distribution of injury occurrence biasing toward the final quarter of the game (Bathgate et al., 2002). With such information, coaches and medical teams can begin to address the modifiable factors, with consideration to sensory motor function training at the outer and inner ranges, and not just morphological orientated training.

There are limitations to the study that should be considered. Firstly, the intensity of having to conduct ten consecutive 'hits' in a game scenario, is highly unlikely. The recovery permitted between tackles was adequate enough to allow players to return to the start position, but may not necessarily be representative of the work to rest ratio encountered in a game. Players tackled with their dominant side first, and it is not known what effect 'assisting' in the tackle had on the non-dominant side. However, it was considered that as an anaerobic activity, the recovery time during re-measuring of the dominant arm would be sufficient to allow the non-dominant arm to recover. It should however, be born in mind that other game events probably contribute to muscle damage and fatigue (Takarada, 2003). Although Takarada (2003) did not differentiate between damage caused by specific activity, it is logical that other game related activities, such as sprinting, lifting and rucking would also cause some degree of muscle fatigue. The effect of recovery between tackles is therefore unknown. It is also difficult in a training scenario to fully replicate the aggressive, dominating attitude toward the tackle seen in match play. Further research could include specific analysis of speed variability, with the use of accelerometry or GPS, which this study did not utilise. Some players may be more aggressive in their tackling technique, looking to knock a player back, whilst others might be more passive in nature. Based on Usman et al., (2011), the true magnitudes of force seen in match play may be higher than those encountered here, and it would prove interesting to conduct similar studies pre and post a competitive match.

5. Conclusions

Not only were decreases in joint positional sense found at the outer ranges, as in previous research (Herrington et al., 2008), but the extent of these changes was also greater than that previously cited. Deleterious effects were also not confined to just the outer ranges, as significant changes were observed in the mid-range position on the athletes non-dominant side. These outcomes go some way in providing a rationale to the underlying mechanism behind the increasing prevalence of injury to the region occurring in the latter stages of the game, particularly the third and fourth quarters at the professional level of the game (Headey and Kemp, 2007)**.**

It would therefore appear prudent to consider the inclusion of conditioning programmes that address increasing the fatigue resistance, especially on the non-dominant side, and formation of accurate and engrained motor co-ordination, as these elements are crucial to obtaining stability of the region (Lee et al., 2003). The format of training and conditioning sessions should also be carefully considered, so as not to load the shoulder excessively when in a fatigued state, and consider correct technique a key component.

Conflict of interest statement

No financial support was received in undertaking this study. The authors had no conflicts of interest when undertaking this study.

Ethics

Ethical approval was obtained from Salford University prior to commencing the data collection.

Funding Statement.

This research received no specific grant from any funding agency in the public, commercial or not – for- profit sectors

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