Title: Changes in Adductor Strength Following Competition in Academy Rugby Union Players.

ABSTRACT

This study determined the magnitude of change in adductor strength following a competitive match in academy rugby union players and examined the relationship between locomotive demands of match-play and changes in post-match adductor strength. A within-subject repeated measures design was used. Fourteen academy rugby union players (age 17.4±0.8 years; height 182.7±7.6 m; body mass 86.2±11.6 kg) participated in the study. Each player performed 3 maximal adductor squeezes at 45° of hip flexion pre- and immediately, 24, 48 and 72 hours post-match. Global positioning system was used to assess locomotive demands of match-play. Trivial decreases in adductor squeeze scores occurred immediately (-1.3±2.5 %; ES = -0.11±0.21; likely, 74 %) and 24 hours post-match (-0.7±3 %; ES = -0.06±0.25; likely, 78 %) while a small but substantial increase occurred at 48 hours (3.8±1.9 %, ES = 0.32±0.16, likely, 89 %) before reducing to trivial at 72 hours post-match (3.1±2.2 %, ES = 0.26±0.18, possibly, 72 %). Large individual variation in adductor strength was observed at all time-points. The relationship between changes in adductor strength and distance covered at sprinting speed (V_{max}≥81 %) was large immediately post-match (p=0.056, r=-0.521), moderate at 24 hours (p=0.094, -0.465) and very large at 48 hours post-match (p=0.005, -0.707). Players who cover greater distances sprinting may suffer greater adductor fatigue in the first 48 hours following competition. The assessment of adductor strength using the adductor squeeze test should be considered post-match in order to identify players who may require additional rest before returning to field-based training.

Key Words: Football, muscle strength, groin, fatigue

INTRODUCTION

Groin injury is one of the top six most frequently cited injuries in rugby union (3) and is the fourth most common injury sustained during rugby union training (20). Groin injuries are prevalent in field-based sports such a rugby union, due to the specific biomechanical demands of match-play (10). The adductor muscles are constantly contracting during running, acting to stabilise the thigh (with respect to the pelvis) during the swing phase and the pelvis (with respect to the thigh) during stance (22). Moreover, actions such as twisting and kicking while running place increased load on the numerous anatomical structures local to the groin area (10).

In order to prevent groin injuries in field-based sport athletes, research has been undertaken to identify the modifiable risk factors associated with these injuries. One of the most prominent intrinsic risk factors is weakness of the hip adductor muscles (28). Various methods for assessing adductor muscle strength have been described in the literature including isokinetic dynamometry (1), hand held dynamometry (13, 30) and the adductor squeeze test (8, 21). The latter, is a simple, low-cost, reliable (9) and valid measure (8) of adductor muscle strength. Furthermore the adductor squeeze test exhibits discriminative capacity whereby it can differentiate symptomatic from asymptomatic players (21, 26)

In sport, the monitoring and screening of athletes is common practice in order to detect and thus avoid the development of fatigue and injury (12). The adductor squeeze test is a screening tool commonly used to identify changes in adductor strength, which may precede the onset of groin pain and injury. By monitoring an athlete’s adductor squeeze on a regular basis, it is hoped that the early identification of potential groin pain can be made, and thus the progression to full injury can be prevented (6). The importance of such monitoring has been suggested in a study assessing adductor strength in 86 junior Australian Rules football players on a weekly basis over the course of a 9-week pre-season period using a hand held dynamometer (7). Twelve (14 %) players developed groin pain during the study period and experienced decreases in adductor strength, two weeks (1.99±4.28%, ES=0.26) and one week (5.83±5.16 %, ES=0.55) prior to the onset of groin pain. These decreases became more pronounced during the week of groin pain onset (11.75±2.5 %, ES=0.98), thus it is suggested that the onset of groin pathology may be detected prior to the onset of symptoms through regular screening of adductor strength (7).

Although the development of groin pain has been attributed to the biomechanical demands of match-play, to date no studies have reported changes in adductor strength following competitive match-play. However, recent research has evaluated changes in global lower-limb neuromuscular function, via the vertical jump test, demonstrating significant reductions in the first 24-48 hours post-game in junior collision-sport athletes (18, 32). Based on these findings, it has been recommended that activities that may compound these deficits, such as repeated high velocity movements be avoided during this period to facilitate recovery (23). Equally, there is potential for the adductor muscles to exhibit similar post-match fatigue and thus may require a period of recovery before returning to field-based training. Ensuring full recovery of adductor muscle strength prior to returning to training post-game may reduce the likelihood of adductor injury. However, currently no literature exists which investigates this phenomenon. Therefore, the purpose of the current study was to investigate the magnitude of change in adductor strength following match-play in academy rugby union players using the adductor squeeze test. A second purpose was to examine the relationship between locomotive match-play demands and changes in adductor strength.

METHODS

Experimental Approach to the Problem

A within-group repeated measures design was used in this study. To examine the magnitude of change in adductor strength following a competitive match, adductor squeeze test scores were collected from academy rugby union players pre-match and immediately, 24, 48 and 72 hours post-match. Testing was conducted at the same time of day in order to avoid the potential effects of circadian rhythm on performance.

Subjects

Fourteen players (age 17.4±0.8 years; height 182.7±7.6 m; body mass 86.2±11.6 kg) were recruited from a professional rugby union academy. Players were excluded if they had a history of groin pain within the previous 3 months or had sustained a lower-limb injury during the match. Ethical approval was granted by the University ethics board and written informed consent was acquired from all participants along with parental consent.

Procedures:

Following a day of complete rest, players underwent baseline adductor strength testing at 11.00 am, approximately 2 hours prior to kick-off. Further testing was undertaken immediately post-match, and at 24, 48 and 72 hours following baseline testing. All testing was undertaken at the same time of day. During the testing period, players did not engage in any training or strenuous activity in the days following the match. Players were advised on nutritional intake but no recovery protocol was undertaken. Further adductor strength measurements were taken six days apart in order to determine the between-day reliability of the test.

Adductor Strength Testing: Adductor strength was assessed using the adductor squeeze test (8). The adductor squeeze test was performed with the participant supine on a plinth with hips at 45° and feet flat on the plinth. This position has the lowest standard error of measurement

(1.6 %), minimal detectable difference (10.62 mmHg), highest reliability (ICC=0.92)(9) and greatest EMG activation of the adductor muscles (8). The position of the hip joint was confirmed using a goniometer. A sphygmomanometer (Welch Allyn Disytest, Skaneateles, New York, USA) was pumped to 10 mmHg and allowed to settle of 30 s before being placed between the knees of the participant at the most prominent points of the medial condyles. The hip joints were positioned in neutral rotation. Participants were instructed to squeeze the sphygmomanometer as hard as possible. Participants performed 3 maximal efforts separated by 30 s, and the highest pressure achieved was recorded (9).

Internal Match Load: Subjective internal game load was obtained via the session rating of perceived exertion method (sRPE) (11) within 30 minutes of the match on a modified Borg scale, which has been previously validated in collision sport athletes (29). This rating was then multiplied by the time spent playing to give a game load in arbitrary units (AU).

External Match Load: External load was measured using Minimax x4 global positioning systems (GPS) units (Catapult Innovations, Melbourne, Australia) with 10Hz sampling to analyse the locomotive demands of the match. Each player wore a specialised vest designed to house and position a GPS unit in the upper-back region between the shoulder blades. The GPS units were turned on prior to the warm-up and turned off following the match. GPS data was downloaded to a laptop and analysed using Catapult Sprint software (Catapult Innovations, Melbourne, Australia). The GPS units also contained gyroscopes, magnetometers and tri-axial accelerometers sampling at 100Hz, which provided information regarding collisions, accelerations and decelerations.

In order to individualise the velocity bands used to categorise locomotive demands of the match, individual maximum velocities were established from speed testing undertaken a week prior to the match. Each player performed three maximal 40 m sprints with 3 min rest in between each sprint while wearing the same Minimax x4 GPS unit that they wore during the match. The highest velocity (Vmax) achieved was used to classify locomotive match demands for each player as follows: walking and standing (<20 % Vmax), jogging (20-50 % Vmax), striding (51-80 % Vmax), sprinting (81-95 % Vmax) and maximum sprinting (96-100 % Vmax) (5, 31). However, as little distance was covered at maximum sprinting speed (1.43±4.01 m), the sprinting and maximum sprinting categories were aggregated to form one sprinting category (81-100 % Vmax).

Statistical Analysis

All data were managed using Microsoft Excel 2011. Between-day reliability statistics of intraclass correlation coefficient (ICC), typical error (TE) and coefficient of variance (CV) were calculated for the adductor squeeze test using a Microsoft Excel spreadsheet (14). Pre- and post-match scores following the match were log transformed to reduce bias as a result of non-uniformity error. Data were then analysed for practical significance using magnitude-based inferences (2). This statistical approach was chosen because the current study was concerned with magnitudes of change, which traditional hypothesis testing does not provide. The threshold for a change to be considered practically important (the smallest worthwhile change, SWC) was set at 0.2 x between subject standard deviation (SD), based on Cohen's *d* effect size (ES) principle. The probability that the magnitude of change was greater than the SWC was rated as <0.5 %, almost certainly not; 0.5-5 %, very unlikely; 5-25%, unlikely; 25-75 %, possibly; 75-95 %, likely; 95-99.5 %, very likely; >99.5 %, almost certainly (15). The magnitude of increase or decrease in adductor squeeze scores was described as substantial when the probability of the effect being equal to or greater than the SWC (ES≥0.2) was ≥75%.(2) Those that were less than the SWC (ES≤0.2) were described as trivial (2). Where the 90 % Confidence Interval (CI) crossed both the upper and lower boundaries of the SWC (ES±0.2), the magnitude of change was described as unclear (2). Data was tested for normality using Shapiro-Wild test and the relationships between locomotive demands of match-play and changes in adductor strength were examined using Pearson's product-moment correlation coefficient using SPSS for Mac (version 21). The correlation coefficient was ranked as trivial (<0.1), small (0.1-0.29), moderate (0.3-0.49), large (0.5-0.69), very large (0.7-0.89) and nearly perfect (0.9-0.99) (15).

RESULTS

The total length of the match was 1 hour13 minutes and 28 seconds. The first and second halves lasted 36 minutes and 30 seconds and 37 minutes and 7 seconds, respectively. The average match load (RPE x time) was 334±121AU. Locomotive demands of the match are presented in table 1.

Table 1: Locomotive demands of the match; meters per minute, total distance, walking / standing, jogging, striding, sprinting. Data are expressed as mean±standard deviation.

Meters per Minute	Total Distance	Walking / Standing	Jogging	Striding	Sprinting
74±6 m/min	4691±878 m	1771±436 m	2215±461 m	663±238 m	41±40 m

Reliability

For the between-day reliability calculations, the mean and standard deviation for testing day one and two were 297.4±34.2 mmHg and 304.9±31.7 mmHg respectively. The typical error TE was 7.5 mmHg [90% CI=5.70-11.11] and the SWC (0.2 x between subject SD) was 6.5 mmHg (2.1%) while the CV was 2.7 [90% CI = 2.1–4.1%] and the ICC was 0.95 [90% CI= 0.88–0.98].

Adductor Squeeze Test

Results for the magnitudes of change in adductor squeeze scores based on Cohen's *d* principle are presented in figure 1. Trivial decreases in adductor squeeze strength scores occurred immediately (-1.3±2.5 %; ES = -0.11±0.21; possibly, 74 %) and 24 hours post-match (-0.7±3%; ES=-0.06±0.25; likely, 78 %), while a small but substantial increase occurred at 48 hours (3.8±1.9%, ES = 0.32±0.16; likely, 89 %) before reducing to trivial at 72 hours post-match (3.1±2.2%, ES = 0.26±0.18 possibly, 72 %).

As the TE of the adductor squeeze was greater than the threshold set for the SWC (0.2 x between athlete SD), a separate analysis was conducted using the TE as the threshold (4) in order to determine whether the changes in adductor strength were also greater than the TE of the test. The standardised typical error (TE, based on Cohen's *d* effect size principle) was calculated as 0.24 and is presented in figure 1. Small changes to the probabilities occurred for all measurements but the inferences stayed the same. Trivial decreases in adductor squeeze strength scores occurred immediately (-1.3±2.5 %; ES = -0.11±0.21; likely, 84 %) and 24 hours post-match (-0.7±3 %; ES = -0.06±0.25; likely, 86 %), while a small but substantial increase occurred at 48 hours (3.8±1.9 %, ES = 0.32±0.16; likely, 79 %) before reducing to trivial at 72 hours post-match (3.1±2.2 %, ES = 0.26±0.18 possibly, 58 %). Individual changes in adductor strength are shown in figure 2.

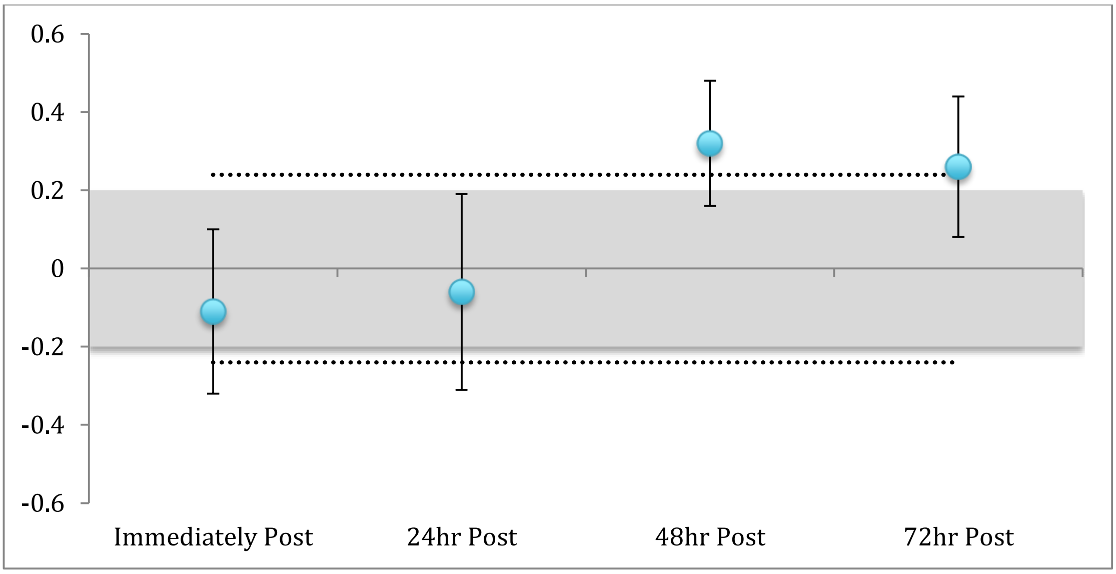

Figure 1: Change in adductor squeeze scores from pre-match. Data are Cohen's effect size statistics (± 90% confidence intervals) with the shaded area representing the smallest worthwhile change (ES≥0.2) and the dotted line representing the standardised typical error (ES≥0.24).

Large, moderate and very large relationships were observed between the change in adductor strength and the distance covered at sprinting speed immediately post-match (p=0.056, r=-0.521), 24 hours post-match (p=0.094, -0.465) and 48 hours post-match (p=0.005, -0.707) respectively. All other relationships between locomotive variables and changes in adductor strength were non-significant and small to moderate (p>0.05, r=-0.373 to 0.249).

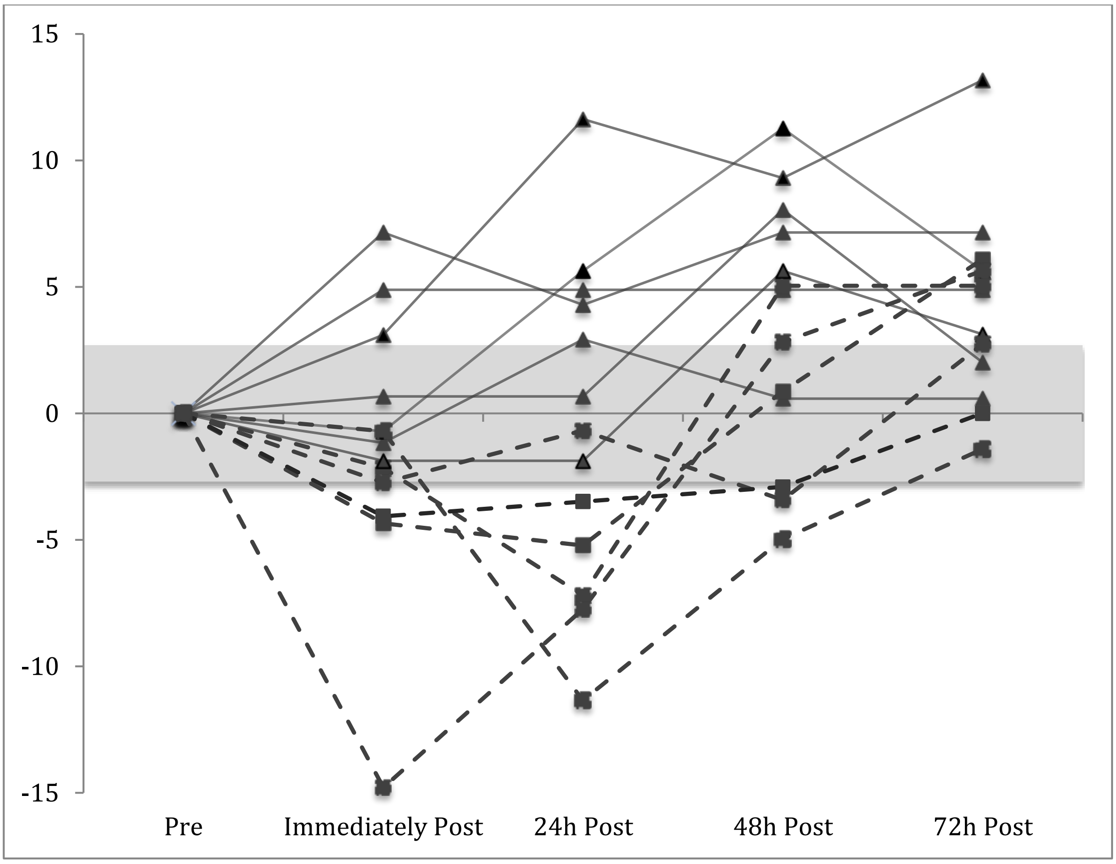

Figure 2: Individual changes in adductor squeeze scores from pre-match. Data are percentage change with dotted lines representing players who presented with decreases below the SWC as 24 and 48 hours post-match, and the shaded area representing the smallest worthwhile change as the typical error (2.7%).

DISCUSSION

The aims of the current study were to determine the magnitude of change in adductor strength following a competitive match in academy rugby union players using the adductor squeeze test, and to examine any relationships that may exist between locomotive demands of match-play and changes in post-match adductor strength. Trivial reductions were observed immediately and 24 hours post-match, while there was a small but a substantial increase in adductor strength at 48 hours before reducing to trivial at 72 hours post-match. To the author's knowledge, this is the first study to report changes in adductor strength following a competitive match in field-based sport athletes, despite anecdotally its wide use in practice. A previous study by Paul et al (27) examined the acute effect of match-play on hip adductor strength and flexibility in junior football players, although only changes in flexibility were reported, thus making it impossible to compare changes in hip adductor strength with the present study.

In order to use the adductor squeeze test as a monitoring tool, it must be reliable within a given athletic population. In the present study, the adductor squeeze test demonstrated low TE (7.5 mmHg [90% CI=5.7-11.1]), a low CV (2.7% [90% CI = 2.1–4.1%]), and an the ICC of 0.95 [90% CI= 0.88–0.98] which is similar to other adductor squeeze reliability studies (9). However it must be pointed out that the TE was greater than the threshold set for the SWC (0.2 x between subject SD), preventing the adductor squeeze test from detecting potentially important changes. When the threshold for the SWC was changed to the TE, minimal changes occurred in the results, potentially due to the small difference between the two thresholds (6.5 mmHg versus 7.5 mmHg). Nevertheless, when using the adductor squeeze as a monitoring tool in academy rugby union players, it may be prudent to use the TE as the SWC threshold in order to ensure that changes are real and not the result of testing error.

The magnitude of decrease in adductor strength immediately and 24 hours post-match was trivial and did not reach the changes previously observed by Crow and colleagues in the weeks preceding the onset of groin pain (7). Furthermore, adductor strength increased by a small but substantial amount at 48 hours. Based on the findings of the present study, and the previous findings of Crow and colleagues, players who present with substantially reduced adductor strength at 24-48 hours post-game may require additional rest before returning to field-based training. Furthermore, it has been suggested that an athlete presenting with substantial reductions in adductor strength at this time-point should be referred to the medical staff to determine if any intervention is required (25).

Reductions in global lower-limb neuromuscular function have been reported following competition in field-based collision sport athletes. Decreases in countermovement jump peak power production have been reported for between 24-48 hours following competition. (18, 23) However, decrements in peak force have only been observed immediately post-match (24) or not at all (17, 19). Given that the adductor squeeze test measures isometric force, the trivial post-match reductions in the present study are similar to those found in the aforementioned studies measuring global lower-limb force production (17, 19).

However, the results of the present study demonstrate the individual nature of muscular recovery following match-play. Although the mean decreases in adductor strength did not reach substantial levels, it can be seen from figure 2 that there was large variation in individual responses in the first 48 hours post-match. Of particular note are the players that remained below the SWC at 24 and 48 hours post-game. In order to investigate potential causes of such variation, the relationships between locomotive demands of match-play and changes in adductor strength were examined, of which the majority were small to moderate. However, the relationship between changes in adductor strength and distance covered at sprinting speed (Vmax≥81%) was large immediately post-match, moderate at 24 hours and very large at 48 hours post-match. Although this finding should be interpreted with caution due to the small sample size, this relationship suggests that players involved in a greater amount of sprinting during match-play have greater deficits in adductor strength post-match. For example, the player who covered the greatest distance at sprinting speed during the match still demonstrated a reduction of 10 mmHg at 48 hours post-game, a deficit that was greater than the smallest worthwhile change (6.5 mmHg) and typical error (7.5 mmHg).

Nevertheless, future research involving larger sample sizes is needed to investigate this relationship further.

The increase in adductor strength 48 hours following match-play observed in the present study is difficult to explain. Previous findings by Jensen et al (16) showed increases in adductor muscle strength 24 hours after specific football kicking practices, indicating a potentiation or increased activation of these muscles following adductor related activity. Furthermore, vertical jump performance has been shown to increase 72 hours following completion in elite rugby league players (24). However, further research involving multiple matches is needed to investigate this phenomenon further.

A limitation of the present study was the use of adductor squeeze in only one test position. The testing position was chosen to elicit maximal activation of the adductor muscles (8), with the greatest reliability (9), and to reduce the testing time prior to the match. However, due to the multi-planar function of the adductor muscles, it has been recommended that testing positions should also include 0 and 90 degrees of hip flexion to determine if strength deficits occur in different functional ranges (6). Future research is therefore needed to ascertain if acute changes in adductor strength occur following competition in different adductor squeeze test positions. A further limitation of the present study was the analysis of only one competitive match, without also examining the load accumulated during training and other competitive matches. Such data would have provided context regarding the load amassed during this match with respect to the typical load accumulated by this group of players in both training and competition. However, total distance covered in the current study (4847±682 m) was similar to the average distance reported from five games (4470±292 m) by Venter et al (31) in under-19 provincial players, suggesting this may represent academy rugby match demands. Nevertheless, future research investigating adductor strength responses to match-play following multiple matches is needed to fully establish the changes in strength that occur in this muscle group following competition.

In conclusion, findings from the present study identified trivial reductions in adductor strength immediately and 24 hours following competition in academy rugby union players when measured with the adductor squeeze test at 45° hip flexion. The distance covered sprinting influenced adductor fatigue in the first 48 hours post-match. Future research is needed to ascertain whether changes occur in adductor strength occur following competition when different adductor squeeze positions (0° or 90°) are used and to further understand the effect of sprinting on changes in post-match adductor strength. The adductor squeeze test is a reliable tool for assessing adductor strength in academy rugby union players.

PRACTICAL APPLICATIONS

Practitioners can reliably monitor adductor strength in academy rugby union players using the adductor squeeze test and can be confident that the changes in adductor strength are the result of real changes and not due to testing error. The findings from the present study highlight the importance of monitoring adductor squeeze strength in the days following competition in academy rugby union players. Players who present with substantial decreases in adductor strength beyond 24 hours may require additional rest or referral to medical staff prior to returning to field-based training. In addition, players who cover greater distances sprinting may experience greater adductor fatigue in the first 48 hours post-game and should be monitored accordingly.

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