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Running Title**:** CHANGES IN TACKLING ABILITY

Changes in rugby league tackling ability during a competitive season: the relationship with strength and power qualities

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ABSTRACT

This study examined the relationship between changes in tackling ability, and muscular strength and power, during a semi-professional rugby league competitive season. Twelve semi-professional rugby league players (mean ± SD age, 23.3 ± 2.0 yr) underwent tests of upper- and lower-body strength and power during the preseason period. Tackling ability was tested using video analysis of a standardized one-on-one tackling drill. Players repeated these tests after round 15 of a 25 match competitive season. Changes in 1RM squat (r_s = 0.70; $p<0.02$) and squat relative to body mass (r_s = 0.73; $p<0.01$) were significantly related to changes in tackling ability. Players with the greatest improvements in tackling ability (i.e. "responders") retained 1RM squat (effect size, ES = 0.85, p=0.09) and squat relative to body mass (ES = 0.82, p=0.15) to a greater extent than the "non-responders". The results of this study suggest that players who retained lower-body strength were able to improve tackling ability during the competitive season, while reductions in lower-body strength were associated with decrements in tackling ability. This study highlights the importance of the development and maintenance of lower-body muscular strength for effective tackling performance throughout the rugby league season.

Keywords: tackle, defense, wrestle, contact, collision

INTRODUCTION

Rugby league is an intermittent, contact sport played internationally at junior and senior levels. The sport is physically demanding requiring players to have well-developed endurance, speed, agility, strength, and power in order to compete at an elite level (15). The sport is characterized by multiple physical contact efforts, known as the tackle contest. Gabbett et al. (11) reported that players were involved in 28 to 45 collisions per match with some players experiencing a physical contact once every 1.09 minutes during match-play. Thus, a large part of success in a contact sport such as rugby league is attributed to the ability to perform effective tackles, having a high tolerance for physical impacts, and the capacity to dominate the tackle contest (12).

In defense, players are required to make contact and tackle the opposition players in order to halt their forward progress. The number of tackles that players are required to make throughout a match is dependent on their playing position (13). During professional match-play, wide running forwards make the greatest number of tackles with players in this position making an average of 25 tackles per match, with hit-up forwards, adjustables, and outside backs performing an average of 20, 15 and 8 tackles per match, respectively (10).

Most of the research examining tackling ability in rugby league has been performed using video analysis of a standardized one-on-one tackling drill. Tackling technique, as examined by the one-on-one tackle drill has been found to be strongly associated with the proportion of missed tackles (negative) and proportion of dominant tackles (positive) performed in rugby league match-play

(12,19). Studies examining the physiological and anthropometric correlates of tackling ability in rugby league players have concluded that high levels of acceleration (over a 10-metre sprint) and lower-body muscular power are associated with superior tackling ability in elite junior and professional rugby league players (7-9). Lower- and upper-body strength, as well as upper-body power have been shown to be significantly related to tackling ability in semi-professional rugby league players (18). Furthermore, it has been shown that the enhancement of lower-body muscular strength, and to a lesser extent muscular power, contribute to improvements in tackling ability in semi-professional rugby league players (20).

In a sport where it is essential that players physically dominate their opposition, well-developed muscular strength and power is critical (2). During the preseason, training frequency and volume is relatively high to optimally develop muscular strength and power, as well as speed, agility, and aerobic capacity (17). During the competitive phase of the rugby league season, there is a reduction in volume and frequency of resistance training to allow a greater emphasis on recovery and skill-based training, with strength and conditioning programs aiming to maintain the muscular strength and power that were developed during the preseason phase of training (2). Studies examining changes in muscular strength and power during the competition phase have reported varied results (1,2,16). In a study examining professional rugby league players it was concluded that maximal strength and power could be maintained over the course of a 29-week season (2). Argus et al. (1) examined changes in strength and power over a professional rugby union season and found that players were able to improve lower-body strength by 8.5% but experienced slight decrements in upper-body strength (-1.2%), and lower- (-3.3%) and upper-

body (-3.4%) power, respectively. Mitchell et al. (16) found that in the collision sport of international rugby sevens, players experienced decreases in lower-body strength (4 to 9%) but were able to maintain or improve upper-body strength during the course of a 28-week competitive season. Interestingly, it was also found that forwards experienced moderate decrements in lower-body muscular power during the season, whereas the backs experienced moderate improvements (16).

Although tackling is a fundamental skill in rugby league there is very limited research into the effect that training, and match-play has on tackling performance. Only one study has examined the influence of specific coaching on tackling technique (12). Gabbett and Ryan (12) found that there was a small (non-significant) improvement in tackling technique following a 3-month skills training program in professional rugby league players. The authors found that the greatest improvements in tackling technique occurred in the players with the lowest initial tackling technique (12). Following the 3-month training program, players more frequently made initial contact with their shoulder, made contact with the target's centre of gravity, and kept their centre of gravity in front of their base of support (12). The aforementioned study was conducted during the preseason phase of training, therefore the influence of match-play exposure on tackling ability was not examined. To date no study has examined the impact of match-play on tackling ability.

Previous research has found that an improvement in lower-body muscular strength during the preseason phase of training, contributes to improvements in tackling ability in semi-professional rugby league players (20). To date no study has examined the influence of changes in muscular strength and power on tackling ability during a competitive season. The purpose of this study was to investigate changes in tackling ability during a competitive season, and determine if these changes were associated with changes in muscular strength and power. It was hypothesized that players who were able to retain or improve muscular strength and power would experience the greatest improvements in tackling ability.

METHODS

Experimental Approach to the Problem

A repeated measures experimental design was used to evaluate changes that occurred in muscular strength and power qualities as well as tackling ability from the end of preseason training phase to mid-way through the competition season. The players underwent tests for upper- and lower-body strength and power, as well as an assessment of tackling ability before the commencement of round 1 of the season, and after week-16 (round 13) of the competitive season. Using a median split technique, players were divided into either “responders” or “non-responders” based on the changes in the assessment of tackling ability.

Subjects

Twelve senior semi-professional rugby league players (mean ± SD age, 23.3 ± 2.0 yr; mass, 96.5 ± 10.3) participated in this study. All players were over the age of 18 years. All players were from the same rugby league club, and were competing in the Queensland Cup competition. The Queensland Cup is a 'feeder' competition to the elite National Rugby League competition. Players were classified as semi-professional as they received remuneration for playing rugby league but also relied on other forms of income. Players were free from injury and in week eight of a fifteen week preseason training program when they undertook the initial muscular strength and power testing, and the tackling assessment. Throughout the entire preseason the players completed three training sessions per week which consisted of strength and conditioning elements as well as skill based training. All players received a detailed explanation of the study, including information on the risks and benefits, and were advised that they were free to withdraw from the study at any time. Written informed consent was obtained before the start of the study. All the procedures for this study were preapproved by the Australian Catholic University Ethics Reviewing Panel.

Strength Testing

Upper- and lower-body muscular strength was assessed using a one repetition maximum (1RM) bench press and squat test, respectively. The players were familiar with the tests as they were part of routine testing. The tests were conducted 72 hours after the previous training session and players were instructed to refrain from excessive exercise 24 hours prior to the testing session. The testing occurred in the evening. Players were instructed to maintain their normal diet and hydration as they would for normal training sessions. For the 1RM test the players were

instructed to perform progressively heavier loads using a standard 20 kg Olympic barbell, with 3 to 5 minutes rest between sets, until they attempted a load that they could lift for a maximum of one full range repetition. A strength and conditioning specialist familiar with the players, supervised and guided the players through the strength tests. Players were required to perform the squats to a below parallel thigh position (i.e. they descended to a position where the hip crease dropped below the knee). Bench press was performed in a controlled manner for the bar to touch the chest and press the bar upwards until arms were fully extended. The intraclass correlation coefficients for test-retest reliability and typical error of measurement were 0.98 and 2.8% for the 1RM bench press and, 0.96 and 3.0% for the 1RM squat. Relative upper- and lower-body strength were calculated by ratio scaling, dividing the 1RM of the bench press and squat by the player's body mass. Rugby league research has shown that ratio scaling is as effective as other more complex methods, such as allometric scaling for the calculation of relative strength (5).

Power Testing

Lower- and upper-body peak power were assessed with the players performing a countermovement jump (CMJ) and plyometric push-up on a force platform with a sampling rate of 500 Hz (Kistler 9290AD Force Platform, Kistler, Switzerland). To perform the CMJ, players were required to keep their hands on their hips for the duration of the movement. When instructed, the players dipped to a self-selected depth before explosively jumping as high as possible. Players had two attempts with their highest power output used for analysis. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for

CMJ peak power were 0.81 and 3.5% respectively. For the plyometric push-up (PPU), players were instructed to place their hands on the force platform while in the push-up position with their arms at full extension. When indicated, players lowered their body before performing an explosive push-up that caused their hands to leave the platform. The players had two attempts with their highest power output recorded. All testing occurred at the start of a regular training session to limit fatigue-related interference. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the plyometric push-up were 0.97 and 3.8%, respectively.

Tackling Technique

The protocol used to examine tackling ability through the video analysis of a standardized 1-on-1 defensive drill has been previously described (7-9). The drill was conducted in a 10 metre grid with video cameras (Sony AX100, Sony, Japan) on the left, right and rear of the drill. The participants performed six consecutive tackles, three on the right shoulder and three on the left shoulder, on another participant of similar height and mass. The drill was performed at the start of a training session so that the participants were in a non-fatigued state. Tackling ability was assessed by a sport scientist using standardized technical criteria described previously (7-9).

168 The technical criteria included:

169 1. Contact made at the centre of gravity
170 2. Initial contact made with the shoulder
171 3. Body position square and aligned
172 4. Leg drive on contact
173 5. Watch the target onto the shoulder
174 6. Centre of gravity forward of the base of support

175

176 Each tackle received a score out of 6 (arbitrary units). Players were awarded 1 point for each
177 criteria they achieved or 0 points if they failed to meet the criteria while performing a tackle. The
178 players received an aggregate score (arbitrary units) from all 6 tackles, which was then converted
179 to a percentage. The intraclass correlation coefficient for test-retest reliability and typical error of
180 measurement for tackling ability were 0.88 and 3.9%, respectively.

181

182 Muscular strength and power, and tackling ability were retested in the week following the round
183 fifteen match. During this period the team were involved in thirteen matches over a sixteen week
184 period. Individual players competed in an average of 8 games (range: 3 to 13) in the period
185 between round 1 and round 15.

186

187

Statistical Analysis

Data were tested for normality using a Shapiro-Wilk test. Due to the non-normal distribution of the data, non-parametric tests and magnitude based inferences were used. Pre- to post-training changes in strength, power, and tackling ability for the entire group were first analysed using a Wilcoxon signed rank test. Spearman's correlation coefficients (r_s) and 95% confidence intervals (CI) were used to determine the relationships among changes in muscular strength and power and tackling ability. The level of significance was set at $p \leq 0.05$. Based on changes in tackling ability over the season, players were then divided into "responders" (n=6) or "non-responders" (n=6) using a median split. Mann Whitney-U test was used to test for differences in muscular strength and power, and tackling ability between the "responders" and "non-responders". A Wilcoxon signed rank test was used to examine the within group differences in muscular strength and power, and tackling ability in the "responders" and "non-responders". Cohen's effect size (ES) statistic was also used to determine the magnitude of any differences in pre-season and in-season testing between groups (4). Effect sizes of ≤0.2, 0.2-0.6, 0.61–1.2 1.21-2.0, and >2.0 were considered trivial, small, moderate, large, and very large, respectively (3).

RESULTS

Changes in Strength, Power and Tackling Ability

Table 1 shows the changes in muscular strength and power, and tackling ability following 15 rounds of competition. There was a significant decrease in upper-body power (ES = -0.68, $p<0.01$). There was no significant ($p>0.05$) change in upper or lower-body muscular strength, or

lower-body power. There was a small, insignificant increase in tackling ability (ES = 0.24, p=0.38).

Table 1 near here

Relationship between Strength and Power Qualities and Tackling Ability

Table 2 shows the relationships between the changes in strength and power qualities and changes in tackling ability. Change in 1RM squat (r_s = 0.70 [0.14-0.89]; $p<0.05$) and change in squat relative to body mass (r_s = 0.73 [0.25-0.92]; $p<0.01$) were significantly related to change in tackling ability.

Table 2 near here

Responders *vs.* Non-responders

The responders and non-responders were exposed to a similar number of games, 8.0 ± 3.8 and 8.3 ± 3.9 respectively. The changes in strength and power in the responders and non-responders are displayed in Table 3. Players with the greatest improvements in tackling ability (i.e. "responders") retaineded 1RM squat (ES = 0.86, p=0.09) and squat relative to body mass (ES =

227 0.82, p=0.15) more than the “non-responders”. “Responders” showed a larger decrement in CMJ
228 than the “non-responders” (ES = -0.84, p=0.26).

229

230 ***Table 3 near here***

231

232 Table 4 illustrates the changes in tackling ability between “responders” and “non-responders”.
233 From preseason to mid-season testing, the “responders” had greater improvements in the
234 regularity that they maintained a square and aligned position (p=0.87; ES = 0.61) and produced
235 leg drive on contact (p=0.14; ES = 0.97) than the “non-responders’. The “non-responders”
236 experienced decrements in the two aforementioned technical criteria.

237

238 ***Table 4 near here***

239

240 **DISCUSION**

241 This is the first study to examine changes in tackling ability and its relationship with changes in
242 muscular strength and power during a competitive season. The results of this study are in partial
243 agreement with our hypothesis that players who were able to retain or improve muscular strength
244 and power would experience the greatest improvements in tackling ability, as measured by the
245 standardized one-on-one tackling drill. In the present study, players who retained lower-body

maximal strength during the competitive season also elicited improvements in tackling ability, while the players who experienced reductions in lower-body strength experienced decrements in tackling ability. Changes in upper-body strength or muscular power were not related to changes in tackling ability.

Previous research has shown that enhancements in lower-body muscular strength contribute to improvements in tackling ability in semi-professional rugby league players (20). In the present study, we found that the players who retained lower-body maximal strength also experienced the greatest improvements in tackling ability (i.e. “responders”) whereas the “non-responders” had a 4.0% and 3.4% decrement in 1RM squat and squat relative to body mass, respectively. The results of this study demonstrate that tackling ability can be improved in the absence of improvements in lower-body strength. It would appear that the stimulus of match-play, training and coaching is sufficient to elicit improvements in tackling ability if lower-body strength can be retained. Conversely, this study also found that decrements in lower-body strength were associated with a reduction in tackling ability.

During the mid-season testing, the “responders” moderately improved the regularity of leg drive upon contact compared to preseason testing. In comparison, the “non-responders” showed a reduction in this technical criterion. It is possible that a decrement in lower-body strength may have a negative influence on a players’ ability to exert force in the tackle through leg drive, thereby adversely affecting tackling ability.

The strongest correlates of changes in tackling ability were changes in 1RM squat and squat relative to body mass. The coefficient of determination (r^2) for the 1RM squat and squat relative to body mass were 49% and 53%, respectively. Therefore, 49-53% of the variance in the change in tackling ability is explained by changes in lower-body strength. However, while this study provides an important step in explaining how changes in lower-body strength influence changes in tackling ability, it must be acknowledged that additional factors, such as changes in technical or perceptual skill may further explain a proportion of the change in tackling ability.

This study highlights the importance of maintaining and developing lower-body muscular strength for effective tackling performance throughout the rugby league season. It would be misleading however, to suggest that lower body strength is the most important physical quality for rugby league players as tackling is only one element of the game. However, it has been shown that players with superior lower-body strength are involved in more repeated high-intensity effort bouts and collisions (6), and also demonstrate accelerated post-match recovery (14). Coupled with the results of the present study, these findings support the importance of developing lower-body strength in rugby league players.

Players who improved their tackling ability experienced a larger decrement in lower body power than the "non-responders" during the course of the competitive season. These results are unexpected given that previous rugby league research has found a positive association between vertical jump and tackling ability (8,9,18). It is also interesting that the "responders" had inferior

lower-body strength compared to the “non-responders”. Research conducted by Johnston et al. (14) found that post-match fatigue was reduced in players with well-developed lower body strength. Although we performed all testing 72 hours post intense exercise, it is possible that the inferior lower-body strength contributed to an increased carryover of fatigue from matches, potentially explaining the decreases in muscular power found in the “responders” groups. The results of this study suggest that improvements in muscular power do not play a significant role in eliciting improvements in tackling ability in semi-professional rugby league players.

Previous research has found that tackling ability, as examined using the standardized one-on-one tackle drill is strongly associated with match-play tackling performance, in particular the proportion of missed tackles and dominant tackles that players perform (12,19). Given that this study has found that tackling ability does change (both positively and negatively) in individual players throughout the competitive season, one would assume that it would also affect the player’s match-play tackling performance. It is recommended that future studies examine the influence of changes in tackling ability on match-play tackling performance throughout a competitive season.

PRACTICAL APPLICATIONS

This study highlights the importance of developing and maintaining lower-body muscular strength for effective tackling performance throughout the rugby league season. It has been demonstrated in this study that exposure to match-play, training and coaching is sufficient to

elicit improvements in tackling ability during the competitive season if lower-body strength can be retained. Although there are significant reductions in frequency and volume in the strength training during the competitive season it is imperative for strength and conditioning specialists to implement an appropriate and adequate strength training stimulus in order to retain muscular strength in rugby league players during this phase.

Of particular note to rugby league coaches, this study has shown that players can experience changes in tackling ability (both positive and negative) over the course of the competitive season. Given that previous research has found that tackling ability as examined by a one-on-one tackling drill has been found to be strongly associated with the proportion of missed tackles (negative) and the proportion of dominant tackles (positive) that players are involved in during match-play, one could assume that any changes in taking ability will affect match-play tackling performance (12,19). Therefore the standardized one-on-one tackle drill may be a useful test to evaluate players tackling ability throughout the competitive season.

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Table 1. Changes in body mass, muscular strength and power, and tackling ability †

	Pre-season	Mid-season	Δ	Effect Size
Body Mass (kg)	97.0 ± 10.6	96.5 ± 10.3	-0.5 ± 1.6	-0.04
Squat (kg)	157.9 ± 19.4	155.4 ± 18.5	-2.5 ± 11.3	-0.13
Bench Press (kg)	121.9 ± 21.4	123.8 ± 17.9	1.9 ± 6.3	-0.10
Relative Squat ($kg \cdot kg^{-1}$)	1.63 ± 0.16	1.62 ± 0.19	-0.01 ± 0.10	-0.08
Relative Bench Press ($kg \cdot kg^{-1}$)	1.26 ± 0.20	1.29 ± 0.16	0.03 ± 0.07	0.14
CMJ Peak Power ($W \cdot kg^{-1}$)	60.6 ± 7.2	56.6 ± 5.5	-4.1 ± 6.9	-0.64
PPU Peak Power ($W \cdot kg^{-1}$)	20.8 ± 3.4	18.4 ± 3.9[#]	-2.4 ± 1.5	-0.68
Tackling Ability (%)	68.2 ± 0.1	70.1 ± 0.1	1.9 ± 7.5	0.24

Squat = 1RM squat; Bench = 1RM bench press; CMJ = counter movement jump; PPU = plyometric push up.
Δ = change in body mass, strength, power and tackle ability from pre-season to mid-season.
† Data are means ± SD.
Effect size of changes from pre-season to mid-season, <0.2 = trivial; 0.2-0.6 = small; 0.61–1.2 = moderate; 1.21–2.0 = large; >2.0 = very large.
[#] Significant difference ($p<0.01$) between pre-season and mid-season.

Table 2. Relationship among changes in physical qualities and tackling ability in semi-professional rugby league players †

	Body Mass	Squat	Bench	Rel Squat	Rel Bench	CMJ	PPU	Tackle
Body Mass	1.00							
Squat	-0.38 (-0.86 to 0.35)	1.00						
Bench	-0.24 (-0.79 to 0.38)	-0.37 (-0.81 to 0.24)	1.00					
Rel Squat	-0.62 (-0.66 to 0.62)	0.91# (0.80 to 0.99)	-0.37 (-0.84 to 0.26)	1.00				
Rel Bench	0.10 (-0.56 to 0.61)	-0.48 (-0.87 to 0.07)	0.89# (0.54 to 1.00)	-0.34 (-0.83 to 0.27)	1.00			
CMJ	0.37 (-0.32 to 0.85)	-0.32 (-0.81 to 0.33)	-0.30 (-0.77 to 0.29)	-0.28 (-0.83 to 0.35)	-0.26 (-0.72 to 0.37)	1.00		
PPU	0.24 (-0.57 to -0.80)	0.04 (-0.60 to 0.79)	-0.10 (-0.72 to 0.49)	0.10 (-0.61 to 0.77)	-0.16 (-0.75 to 0.47)	0.40 (-0.16 to 0.77)	1.00	
Tackle	-0.30 (-0.82 to 0.38)	0.70* (0.21 to 0.92)	-0.01 (-0.63 to 0.68)	0.73# (0.17 to 0.98)	0.07 (-0.56 to 0.65)	-0.38 (-0.80 to 0.24)	-0.15 (-0.71 to 0.55)	1.00

Squat = change in 1RM squat; Bench = change in 1RM bench press; Rel Squat = change in 1RM squat relative to body mass; Rel Bench = change in 1RM bench press relative to body mass; CMJ = change in counter movement jump peak power; PPU = change in plyometric push up peak power; Tackle = change in tackling ability.

† Data are reported as Spearman's rank order correlation coefficients, r_s and 95% confidence interval (in parentheses).

* Significant at $p<0.05$.

Significant at $p<0.01$.

Table 3. Changes in body mass, strength, power and tackling ability in responders and non-responders†

	Responders		Non-Responders				
	Pre-season	Mid-season	Pre-season	Mid-season	Δ Responders	Δ Non-responders	Effect Size
Body Mass (kg)	96.5 ± 9.8	96.6 ± 10.6	97.5 ± 12.2	96.4 ± 11.1	0.1 ± 1.4	-1.1 ± 1.8	0.74
Squat (kg)	148.3 ± 20.6	150.4 ± 11.0	167.5 ± 13.7	160.4 ± 23.9	2.1 ± 11.2	-7.1 ± 10.2	0.86
Bench (kg)	117.5 ± 8.9	120.0 ± 10.5	126.3 ± 29.6	127.5 ± 23.6	2.5 ± 5.9	1.3 ± 7.2	0.19
Relative Squat ($kg \cdot kg^{-1}$)	1.55 ± 0.16*	1.57 ± 0.20	1.72 ± 0.11	1.67 ± 0.18	0.03 ± 0.12	-0.06 ± 0.08	0.82
Relative Bench ($kg \cdot kg^{-1}$)	1.22 ± 0.10	1.25 ± 0.10	1.30 ± 0.28	1.33 ± 0.21	0.02 ± 0.05	0.03 ± 0.08	-0.03
CMJ Peak Power ($W \cdot kg^{-1}$)	61.3 ± 7.5	54.4 ± 3.0	60.0 ± 7.5	58.7 ± 6.9	-6.9 ± 8.7	-1.3 ± 3.4	-0.84
PPU Peak Power ($W \cdot kg^{-1}$)	21.6 ± 2.8	18.9 ± 2.3‡	20.1 ± 4.1	17.8 ± 5.0‡	-2.6 ± 1.4	-2.3 ± 1.7	-0.25
Tackling Ability (%)	64.4 ± 10.6	71.8 ± 8.5‡	72.2 ± 3.9	68.5 ± 4.2‡	7.4 ± 7.0#	-3.7 ± 1.4	2.21

Δ Responders = change in body mass, strength, power and tackling ability from pre-season to mid-season in "responders".
Δ Non-responders = change body mass, in strength, power and tackling ability from pre-season to mid-season in "non-responders".
† Data are means ± SD.
Effect size of changes between groups, <0.2 = trivial; 0.2-0.6 = small; 0.61–1.2 = moderate; 1.21–2.0 = large; >2.0 = very large.
* Significant difference ($p<0.05$) between groups.
# Significant difference ($p<0.01$) between groups.
‡ Significant difference ($p<0.05$) within groups.

Table 4. Changes in tackling ability of "responders" and "non-responders"†

	Responders		Non-responders				
	Pre-season	Mid-season	Pre-season	Mid-season	Δ Responders	Δ Non-responders	Effect Size
Contact centre of gravity (AU)	4.8 ± 2.4	5.7 ± 0.8	5.8 ± 0.4	5.8 ± 0.4	0.8 ± 1.6	0.2 ± 0.4	0.57
Initial contact with shoulder (AU)	5.3 ± 1.2	5.8 ± 0.4	5.7 ± 08	5.7 ± 08	0.5 ± 1.4	-	0.51
Square and aligned (AU)	1.5 ± 1.4	2.3 ± 2.0	2.2 ± 1.7	2.5 ± 1.1	0.8 ± 2.0	-0.2 ± 1.2	0.61
Leg drive on contact (AU)	4.2 ± 1.0	4.8 ± 1.2	4.8 ± 1.8	3.7 ± 1.6	0.7 ± 1.4	-1.0 ± 2.0	0.97
Watch target onto shoulder (AU)	1.8 ± 2.1	2.3 ± 1.4	1.5 ± 1.8	1.3 ± 2.0	0.5 ± 2.9	0.0 ± 1.8	0.21
Centre of gravity over base (AU)	5.5 ± 0.8	4.8 ± 1.9	6.0 ± 0.0	5.7 ± 0.5	-0.7 ± 1.2	-0.3 ± 0.5	-0.36
Tackling Ability (AU)	23.2 ± 1.5	25.8 ± 3.1‡	26.0 ± 1.4	24.7 ± 1.5‡	2.7 ± 2.5#	-1.3 ± 0.5	2.21
Tackling Ability (%)	64.4 ± 10.6	71.8 ± 3.9‡	72.2 ± 3.9	68.5 ± 4.2‡	7.4 ± 7.0#	-3.7 ± 1.4	2.21

Δ Responders = change in tackling ability technical criteria from pre-season to mid-season in "responders".
Δ Non-responders = change in tackling ability technical criteria from pre-season to mid-season in "non-responders".
† Data are means ± SD.
Each variable represents a score from a possible score of 6 (i.e. the sum of 6 trials). Tackling ability score represents the total score from a possible score of 36 (i.e. the sum of the technical criteria), and is also expressed as a percentage.
Effect size of changes between groups, <0.2 = trivial; 0.2-0.6 = small; 0.61–1.2 = moderate; 1.21–2.0 = large; >2.0 = very large.
Significant difference ($p<0.01$) between groups.
‡ Significant difference ($p<0.05$) within groups.