ARE CHANGES IN MAXIMAL SQUAT STRENGTH DURING PRESEASON TRAINING REFLECTED IN CHANGES IN SPRINT PERFORMANCE IN RUGBY LEAGUE PLAYERS?

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ABSTRACT

Comfort, P, Haigh, A, and Matthews, MJ. Are changes in maximal squat strength during preseason training reflected in changes in sprint performance in rugby league players? *J Strength Cond Res* 26(X): 000–000, 2012—Because previous research has shown a relationship between maximal squat strength and sprint performance, this study aimed to determine if changes in maximal squat strength were reflected in sprint performance. Nineteen professional rugby league players (height = 1.84 ± 0.06 m, body mass [BM] = 96.2 ± 11.11 kg, 1 repetition maximum [1RM] = 170.6 ± 21.4 kg, 1RM/BM = 1.78 ± 0.27) conducted 1RM squat and sprint tests (5, 10, and 20 m) before and immediately after 8 weeks of preseason strength (4-week Mesocycle) and power (4-week Mesocycle) training. Both absolute and relative squat strength values showed significant increases after the training period (pre: 170.6 ± 21.4 kg, post: 200.8 ± 19.0 kg, $p < 0.001$; 1RM/BM pre: 1.78 ± 0.27 $kg \cdot kg^{-1}$, post: 2.05 ± 0.21 $kg \cdot kg^{-1}$, $p < 0.001$; respectively), which was reflected in the significantly faster sprint performances over 5 m (pre: 1.05 ± 0.06 seconds, post: 0.97 ± 0.05 seconds, $p < 0.001$), 10 m (pre: 1.78 ± 0.07 seconds, post: 1.65 ± 0.08 seconds, $p < 0.001$), and 20 m (pre: 3.03 ± 0.09 seconds, post: 2.85 ± 0.11 seconds, $p < 0.001$) posttraining. Whether the improvements in sprint performance came as a direct consequence of increased strength or whether both are a function of the strength and power mesocycles incorporated into the players' preseason training is unclear. It is likely that the increased force production, noted via the increased squat performance, contributed to the improved sprint performances. To increase short sprint performance, athletes should, therefore, consider increasing maximal strength via the back squat.

KEY WORDS short sprints, acceleration, back squat

INTRODUCTION

Sprint performance is arguably the most universally required fitness attribute for success in team sports, where the ability to outaccelerate and outrun an opponent is crucial. During team sports, the most critical elements in a game are often determined by intermittent high-intensity sprints that rarely last >10–22 m (2,3) but when combined may account for a significant portion of the match, making up approximately 11% of game time in soccer—or a 10- to 15-m sprint every 90 seconds (2,21)—with similar findings also reported in rugby league (5,14), rugby union (8–10), and field hockey (17).

The ability to accelerate effectively, and thereby out-accelerate an opponent, over the first few meters may be far more important to achieve success in these sports than is peak running velocity. Athletes consequently dedicate large amounts of training time and effort toward improving performance within this crucial range. A number of studies have investigated the relationship between strength and sprint performance and observed that, in general, stronger athletes perform better during sprint performances (2,7,13,15,20).

When investigating the relationship between strength and sprint performance, several different methods have been used to assess strength including isokinetics (2,4), machine squats (11), and free-weight squats (2,7,13,20). The strongest correlations with speed occur when strength is assessed using free-weight squats and occur across both absolute strength ($r = -0.94$, $p < 0.05$) (20) and relative strength ($r = -0.605$, $p = 0.01$) (14). This may be explained by the fact that peak ground reaction forces and impulse have been shown to be strong determinants of sprint performance (12,18,19,22).

At present, there is limited research documenting whether changes in strength are associated with changes in sprint

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Table 1. Example of training program during strength and power mesocycles.

85–90% 1RM	Strength mesocycle (sets [reps]) Heavy day	Strength mesocycle (sets [reps]) Light day	85% 1RM	Power mesocycle (sets [reps]) Heavy day	Power mesocycle (sets [reps]) Light day
Exercise			Exercise		
Back squats	4 (4–6)	2 (2–4)	Hang power clean	4 (3–4)	4 (2)
Midthigh clean pull	4 (4–6)†	2 (2–4)	Squat jumps	4 (3–4)‡	4 (2)
Romanian Deadlift (RDL)	4 (4–6)	2 (2–4)	Back squats	2 (3–4)	2 (2)
Nordic curls	4 (4–6)	2 (2–4)	Nordic curls	3 (4–6)	2 (3)

*1RM = 1 repetition maximum.
†Hundred percent 1RM power clean.
‡Forty percent 1RM back squat.

performance (6,11,16). Ronnestad et al. (16) demonstrated that 7 weeks of strength and plyometric training in professional soccer players resulted in significant increases in half squat strength (pre: 173 ± 4 kg, post: 215 ± 4 kg) and squat jump (pre: 29.3 ± 0.9 cm, post: 31.7 ± 1.2 cm) performance along with significant ($p < 0.05$) improvements in 10-m (pre: 1.78 ± 0.02 seconds, post: 1.75 ± 0.01 seconds) and 40-m (pre: 5.43 ± 0.05 seconds, post: 5.37 ± 0.05 seconds) sprint performances. Similarly Chelly et al. (6) found a significant improvement in squat strength, leg power, and jump height and sprint performances in young male soccer players. Harris et al. (11) demonstrated that squat jump training, using both high loads (80% 1 repetition maximum [1RM]) and lower loads (individual maximal power loads, 30–50% 1RM) resulted in similar improvements in maximal squat strength and 30-m sprint performance.

The aim of this investigation was to identify whether changes in maximal squat strength during preseason training are reflected in changes in sprint performance, in rugby league players. Because of the strong correlations previously reported between squat strength and sprint performance (2,7,13,20), it was hypothesized that increases in squat strength would be reflected by a concurrent decrease in sprint times over 5, 10, and 20 m.

Methods

Experimental Approach to the Problem

To determine whether increases in maximal squat strength were reflected in concurrent increases in sprint performance, a squad of elite Rugby league players were tested (1RM squat and 5-, 10-, and 20-m sprint), before and after 8 weeks of preseason training, using a within-subject design.

The aim of the investigation was to determine if an increase in squat strength is associated with an increase in sprint performance, not to determine the effects of either strength or power training on increased sprint performance. Although we recognize that testing at the end of each mesocycle would have pinpointed whether the improvements in sprint speed were attributable to the strength or power mesocycle, the practical issues of limited access to an elite rugby team, prevented this testing. The fact that agility and plyometric training was performed throughout the entire period further blurs the boundaries between mesocycles, and although it is acknowledged that additional plyometric and agility sessions may have affected sprint performance, the aim of this investigation was to determine if an increase in squat strength is associated with an increase in sprint performance, not to determine the effects of training particular fitness attributes. Because this is an observational study of what actually happens within a club-training environment, to attempt to alter this would have impacted the ecological validity of the study. It is also worth noting that it would not be possible to remove such sessions from the training of a professional squad of athletes. This highlights some of the issues experienced by the UK-based clubs where they are attempting to develop multiple fitness attributes over a relatively short preseason period.

Table 2. Changes in body mass and strength.

	Pre	Post*
Body mass	96.2 ± 11.11	97.7 ± 11.13
Absolute strength (kg)	170.6 ± 21.4	200.8 ± 19.0
Relative strength ($kg \cdot kg^{-1}$)	1.78 ± 0.27	2.05 ± 0.21

*Significantly greater than pretraining values ($p < 0.001$), power > 0.90.

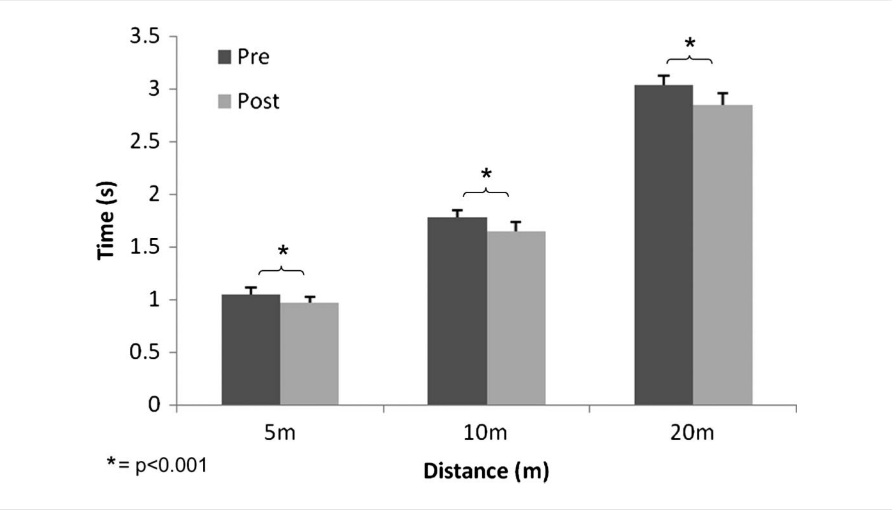

Figure 1. Changes in sprint performance after 8 weeks of strength and power training.

Subjects

Nineteen, well-trained, professional rugby league players (height = 1.84 ± 0.06 m, body mass [BM] = 96.2 ± 11.11 kg, 1RM = 170.6 ± 21.4 kg, and 1RM/BM = 1.78 ± 0.27) participated in this study, during preseason training. The participants had previously completed an 8-week, off-season, hypertrophy training program. The Institutional Review Board approved the project, and all the participants provided written informed consent.

Maximal Strength Testing

One repetition maximum back squat was assessed via a standardized protocol (1), with warm-up loads approximated via individual training loads. During all the attempts, the participants were required to squat to a position where a 90° knee angle was achieved. Before the start of the warm-up, this knee angle was assessed using a goniometer while the participant was squatting. A bungee was placed at the appropriate height so that the participant's buttocks touched the bungee once the required squat depth was achieved; this was also reinforced with verbal commands. All the participants achieved their 1RM within 4 attempts.

Strength performances were reported as both absolute (kilograms) and relative strength (kilogram per kilogram of BM) to take into account the changes in the BM over the 8-week training period.

Sprint Performances

The participants performed three 20-m sprints on an indoor track (Mondo, SportsFlex–10 mm, Mondo America Inc., Conshohocken, PA, USA), wearing standard training shoes. Sprints were interspersed with a 1-minute rest period. Time to 5, 10, and 20 m was assessed using infrared timing gates (Brower, Speed Trap 2, Wireless Timing System, UT, USA). All the subjects began with their front foot positioned 0.5 m behind the start line and were instructed to perform all the sprints with a maximal effort.

Training

This consisted of 8 weeks of preseason strength (4-week Mesocycle) and power (4-week Mesocycle) training, with lower body strength and conditioning sessions performed twice a week (Table 1), along with 2 additional plyometric and agility sessions.

Testing

Maximal strength and sprint performances were assessed on separate days, 72 hours apart, at the beginning and end of the preseason training. Both maximal strength and sprint performances were reassessed after the protocols identified above were completed, 8 weeks after initial testing, at the same time of the day, and with 48 hours of rest between both the assessments.

Statistical Analyses

Intraclass correlation coefficients were measured to assess the reliability between sprints, both preintervention and postintervention. Paired sample *t*-tests were performed to identify the differences in performance pre and post 8 weeks of training, with observed power >0.90.

All statistical analyses were performed using SPSS software (Version 16.0, SPSS, Inc., IL, USA). A priori power calculations, using G-Power statistical software (version 3.03), determined that a minimum sample size of $n = 14$ was required for 90% power with a significance level of $p \leq 0.05$.

RESULTS

Intraclass correlations demonstrated a high level of reliability between repetitions for the 5-, 10-, and 20-m sprints during pretraining ($r = 0.96, p < 0.001$; $r = 0.97, p \leq 0.001$; $r = 0.97, p < 0.001$; respectively) and posttraining ($r = 0.98, p < 0.001$; $r = 0.97, p \leq 0.001$; $r = 0.96, p < 0.001$; respectively).

Body mass showed a small but significant increase after the 8-week training period (pre: 96.2 ± 11.11 kg, post: 97.7 ± 11.13, $p < 0.001$). Similarly, both absolute and relative strengths showed significant increases after the training period (pre: 170.6 ± 21.4 kg, post: 200.8 ± 19.0 kg, $p < 0.001$; 1RM/BM pre: 1.78 ± 0.27 $\text{kg}\cdot\text{kg}^{-1}$, post: 2.05 ± 0.21 $\text{kg}\cdot\text{kg}^{-1}$, $p < 0.001$; respectively) (Table 2).

Sprint performances were significantly faster for 5 m (pre: 1.05 ± 0.06 seconds, post: 0.97 ± 0.05 seconds, $p < 0.001$), 10 m (pre: 1.78 ± 0.07 seconds, post: 1.65 ± 0.08 seconds, $p < 0.001$), and 20 m (pre: 3.03 ± 0.09 seconds, post: 2.85 ± 0.11 seconds, $p < 0.001$, Figure 1) posttraining.

Discussion

Preseason training resulted in significant (17.7%, $p < 0.001$) improvements in maximal squat strength from pretraining (170.6 ± 21.4 kg) to posttraining (200.8 ± 19.0 kg), along with significant (7.6, 7.3, and 5.9%; $p < 0.001$) increases in sprint performance over 5 m (pre: 1.05 ± 0.06 seconds, post: 0.97 ± 0.05 seconds), 10 m (pre: 1.78 ± 0.07 seconds, post: 1.65 ± 0.08 seconds), and 20 m (pre: 3.03 ± 0.09 seconds, post: 2.85 ± 0.11 seconds). These changes in sprint times appear to reflect the changes in maximal squat strength, with the greatest improvements in sprint performance during the 5-m sprint (7.6%) and smaller improvements as the sprint distance increased (10 m = 7.3%; 20 m = 5.9%). The greater improvement in sprint performance over the initial 5 m is likely because of the higher forces required during the initial acceleratory phase of sprinting.

Whether the improvements in sprint performance came as a direct consequence of increased strength or whether both are a function of the strength and power mesocycles incorporated into the players' preseason training is unclear. Based on the fact that peak ground reaction forces and impulse are strong determinants of sprint performance (12,18,19,22), it is likely, however, that the increased force production noted via the increased squat performance contributed to the improved sprint performances. The findings of this study are in line with those of previous research by Ronnestad et al. (16) wherein professional soccer players demonstrated significant ($p < 0.05$) increases in half squat strength (pre: 173 ± 4 kg, post: 215 ±4 kg) and squat jump (pre: 29.3 ± 0.9 cm, post: 31.7 ± 1.2 cm) performance, and 10-m (pre: 1.78 ± 0.02 seconds, post: 1.75 ± 0.01 seconds) and 40-m (pre: 5.43 ± 0.05 seconds, post: 5.37 ± 0.05 seconds) sprint performances, after 7 weeks of strength and plyometric training. Similarly, Chelly et al. (6) found a significant improvement in squat strength, leg power, vertical jump height, and sprint performances after a period of strength training in young male soccer players.

These findings are important for multiple sprint team sports, such as soccer, rugby union, rugby league, and field hockey, where the most critical elements in a game are often determined by brief, intermittent, high-intensity sprints, which account for 10–15% of the duration of the game (3,5,8–10, 14,17,21). It is recommended that lower body strength development be prioritized during preseason training, with a focus on power development and maintenance of strength during the competitive season for multiple sprint sports.

The results of this investigation also demonstrate that a relatively short period (8 weeks) is sufficient to elicit significant ($p < 0.001$) improvements in both maximal squat strength and sprint performance over 5 , 10, and 20 m, in well-conditioned athletes. Because no interim testing was performed, it is not possible, from the results of this investigation, to determine whether these changes take place in a linear fashion or primarily occur during the initial weeks. It is, therefore, suggested that strength and conditioning coaches maximize squat strength to aid with acceleration during short-sprint performance, in line with the findings of McBride et al (13) who demonstrated a stronger relationship between squat strength and sprint performance in athletes with higher relative strength values. It is also suggested that future research investigate the time course of these adaptations.

Practical Applications

Prior research has demonstrated a clear association between maximum squat strength and short sprint (5-, 10-, and 20-m) ability. Given the relatively long ground contact times associated with accelerating over the short distances required by team sports, the ability to generate high forces is a determining factor in acceleration. This study highlights the importance of increasing strength to improve sprint performance over short distances. It is, therefore, suggested that strength and conditioning coaches focus on maximizing squat strength to aid acceleration during short-sprint performance.

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