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Comparing the Effectiveness of a Short-Term Vertical Jump vs. Weightlifting Program on Athletic Power Development

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Abstract

Efficient training of neuromuscular power and the translation of this power to sport-specific tasks is a key objective in the preparation of athletes involved in team-based sports. The purpose of this study was to compare changes in center of mass (COM) neuromuscular power and performance of sport-specific tasks after short-term (6-week) training adopting either Olympic-style weightlifting (WL) exercises or vertical jump (VJ) exercises. Twenty-six recreationally active men (18–30 years; height: 178.7 ± 8.3 cm; mass: 78.6 ± 12.2 kg) were randomly allocated to either a WL or VJ training group and performance during the countermovement jump (CMJ), squat jump (SJ), depth jump (DJ), 20-m sprint, and the 5-0-5 agility test—assessed pre and posttraining. Despite the WL group demonstrating larger increases in peak power output during the CMJ (WL group: 10% increase, $d = 0.701$; VJ group: 5.78% increase, $d = 0.328$) and SJ (WL group: 12.73% increase, $d = 0.854$; VJ group: 7.27% increase, $d = 0.382$), no significant between-group differences were observed in any outcome measure studied. There was a significant main effect of time observed for the 3 VJs (CMJ, SJ, and DJ), 0- to 5-m and 0- to 20-m sprint times, and the 5-0-5 agility test time, which were all shown to improve after the

training (all main effects of time $p < 0.01$). Irrespective of the training approach adopted by coaches or athletes, addition of either WL or VJ training for development of power can improve performance in tasks associated with team-based sports, even in athletes with limited preseason training periods.

Key Words: speed; agility; exercise; sport; strength; hang power clean

Introduction

Muscular power is an important component of dynamic athletic performance (2) and has therefore become integral to the physical preparation of athletes (29). However, competing demands on training time in team-based sports concomitant with the short period (typically less than 6 weeks) dedicated to training phases results in limited opportunity to adequately develop power in a nonprofessional athlete. Therefore, the efficient training of muscular power (29) and the transfer of training improvements to performance improvements become paramount.

The classical model of training power development in team sports is based around vertical jump (VJ) movements (27). This type of training results in significant gains in muscle power (16,17) due to the high rate of force development and the peak force achieved during the concentric phase of movement (23). An additional benefit of this type of training is the ability to mimic sport-specific movements and thereby enhance intermuscular coordination (29). The weighted jump squat (20,21), a variant of VJ training using external resistance, was found to improve VJ height to a greater degree than nonweighted jump training in elite male and female volleyball players (24). Currently, variations of resisted VJ exercises can be performed with customized exercise machines such as the Cormax jump squat machine which uses a lever arrangement to allow for external resistance to be added (19). This training allows for the development of power by increasing both maximal strength (force), rate of force development and force production under rapid velocity of muscle shortening by varying across heavy and lighter training loads. One potential limitation of the Cormax jump squat machine is that the athlete and coach are limited in the sport-specific movement patterns that can be applied.

Olympic-style weightlifting (WL) movements and their derivatives are now widely adopted in team sports for neuromuscular power development and athletic performance enhancement (14). The WL movements and derivatives are considered specific to sport performance because (a) they involve large muscle mass, multijoint movements, and fast movement velocity (13,26), (b) biomechanical comparisons between WL movements and sport-related performance measures (e.g., VJ) reveal a high degree of similarity (15), and (c) speed intention is always maximal in WL movements, which may induce greater motor unit synchronization and allow for an increase in the rate of force development (30). Indeed, a study by Tricoli et al. (27) demonstrated a greater improvement in jumping and sprinting performance with WL compared with VJ training 3 times per week over an 8-week period. One potential limitation of WL movements and derivatives relates to the amount of training required to improve technique. Given the limited time allocated to off-field conditioning in nonprofessional team sport athletes, much of the allocated time may consequently be spent training the WL movement technique and not focusing on the development of neuromuscular power.

The importance of power development in team-sport athletes is well recognized; however the limited availability in time to train the development of power in nonprofessional athletes makes implementation of this type of training difficult. The purpose of this study, therefore, was to compare changes in power development after completion of 2 training programs previously shown to improve peak power development, but with different degrees of mastery. Specifically, changes in center of mass (COM) peak power output, speed, and change of direction (COD) were assessed after a 6-week program adopting either resisted VJ training (considered low in difficulty to master) or WL training (considered moderate-high in difficulty to master) in individuals currently participating in team sports. We hypothesized that the WL intervention training group would demonstrate greater improvements, and these improvements would be greatest during the VJ-based activities.

Methods

Experimental Approach to the Problem

This study was designed to compare the short-term effects of 2 training programs (WL and VJ) on the development of COM peak power output, horizontal speed, and COD. To address this issue, we selected 2 exercises for the WL intervention that were deemed relatively easy to master with correct instruction, and efficient for developing neuromuscular power; and 2 VJ exercises that were considered to be closely related to sports movements. A repeated-measures design was used to assess changes in outcome measures in response to both 6-week training interventions. We selected physically active male subjects with limited (<6 months continuous) experience in resistance training and no experience in WL exercises to more accurately reflect the target population which was the nonprofessional athletes.

Subjects

The sample comprised 26 subjects (age: 24.2 ± 1.11 years; (range: 20–28 years) height: 178.7 ± 8.31 cm; mass: 78.6 ± 12.16 kg) that met the inclusion and exclusion criteria of the study and were in the preparatory phase of their training cycle. The study inclusion criteria were (a) recreationally active men (defined as participating in at least 2 organized training sessions per week), (b) limited (<6 months continuous) experience with resistance training, and (c) over the age of 18 years. The study exclusion criteria were (a) any injuries or conditions which may be exacerbated with exercise (assessed through the Exercise and Sports Science Australia (ESSA) preexercise screening tool), (b) individuals using any type of nutritional supplement (e.g., performance enhancement/aids), and (c) over the age of 44 years. Nutritional intake was not controlled, but subjects were asked to maintain their normal diet during the study. All subjects were informed of the benefits and risks of the investigation and signed the institutional approved informed consent document before participating in the study. All aspects of the study were approved by the University's Human Research Ethics Committee in accordance with National Statement on Ethical Conduct in Human Research, 2007.

Procedures

Before the 6-week intervention, all subjects were required to complete a familiarization session and 2 preintervention testing sessions. The familiarization session was strictly used to (a) provide the subjects with an overview of the tests and training procedure, and (b) allow subjects to master the techniques that were required during testing. Thereafter, subjects were required to complete 2 preintervention testing sessions during which data were collected for reliability purposes and subsequently used as the subjects' preintervention baseline results. The time interval between sessions was at least 48 hours but not more than 7 days. After the completion of these initial sessions, subjects were then randomly assigned to the 2 intervention groups. After the completion of these initial sessions, subjects were then randomly assigned to the 2 intervention groups (WL and VJ) before commencing their respective 6-week training intervention. The allocation to the training groups was completed in a blinded fashion using a computer-generated numbered list consisting of 1 s and 2 s which represented the WL and VJ groups, respectively. The blinding was achieved by forwarding the subject's unique id code to an independent researcher, who then allocated each code to either the WL or VJ group (represented by 1 s and 2 s) and then sending the list back to the student researcher. The composition of the intervention group after the randomly allocation process was equal (WL: $n = 13$; VJ: $n = 13$). By the end of the 6-week training intervention, the final composition remained the same.

Training program

All subjects in the WL and VJ groups attended a total of 18 training sessions conducted over 6 weeks with each session lasting approximately 45 minutes. The criterion for noncompliance was established as missing more than 25% of the training sessions (i.e., >4 sessions). Along with the specific training protocol (outlined below), the subjects in both intervention groups had their training complemented by 4 sets of 6 repetitions maximum (6RM) of the half-squat exercise. This exercise was selected because it was considered a safe and effective strength training exercise for the lower-body muscle groups directly involved in the criterion tasks investigated in the study (1). A heavy-load, low repetition paradigm was used for this exercise because this was deemed most likely to increase strength, impulse, and movement speeds (1) in traditional exercises.

Weightlifting Group

Training consisted of 2 WL exercise derivatives (hang power clean and power snatch) performed using a cluster set approach (Table 1). The volume remained consistent for the first 3 weeks (weeks 1–3) of training followed thereafter by an increase in volume for the final 3 weeks (weeks 4–6). The intensity for the 2 WL exercises was set at 70% of 1RM as this intensity has been found to maximize peak power output (9).

Vertical Jump Group

Training consisted of 2 different VJ variations (weighted double leg jumps and 40 cm depth jumps [DJs]) performed using a cluster set approach (Table 1). The weighted double leg jumps were performed using a hydraulic system (Isotronic System; Fitness Technology, Skye, SA, Australia). This system allowed the researchers to individually adjust the concentric load, while reducing the impact of landing and impulse that needed to be absorbed eccentrically. Similar to the WL group, the volume was increased in the final 3 weeks (weeks 4–6) of the intervention (Table 1).

Testing

The following tests were performed during both preintervention and postintervention testing sessions: countermovement jump (CMJ), squat jump (SJ), 45 cm DJ, 20-m sprint test, and a 5-0-5 COD test. All testing sessions, both pre and postintervention testing sessions, were completed in the evening between 1700 PM and 1900 PM, in an attempt to eliminate any possible diurnal variability in short-term power output performance. In addition, all subjects completed their testing sessions between the months of July and September (i.e., first of July 2014 till ninth of September 2014). During the VJ tests (CMJ, SJ, and DJ), all test trials were performed with the subjects either standing or landing on a force plate (AMTI, Watertown, MA, USA) with the sampling rate set at 50 Hz for the collection of vertical ground reaction force. Subjects were required to perform all jump tests with their hands on their hips for the duration of each attempted jump. Each subject provided 3 attempts of each type of jump with a 1-minute passive recovery between attempts and 3 minutes passive recovery between the 3 different types of jump tests. All data collected from the jumps were then converted into ASCII files

before being analyzed using a MATLAB program (The Mathworks, Natick, MA, USA) which was developed by one of the study investigators. Peak concentric power was then calculated using custom MATLAB script using the approaches described by Harman for the CMJ and SJ (18), and Walsh for the DJ (28). For the DJ, the velocity of the COM at the initial contact with the force plate was calculated by treating the participant as a projectile using the following formula:

This approach assumed that participants stepped directly off the 40 cm stem with no vertical rise of their COM. The 20-m sprint test was performed using 4 pairs of timing gates (Speedlight; Swift, Wacol, QLD, Australia) placed at the start (0 m), 5 m, 10 m, and 20 m. Every subject provided 3 maximum attempts with a 2-minute passive recovery between attempts. Finally, each subject performed 3 attempts at the 5-0-5 COD test (8) with 2-minute recovery between each attempt. The result for the 5-0-5 test is the return time recorded with timing gates positioned 5 m before the turn.

Statistical Analyses

Differences in COM muscular power (VJ tests; power) and performance during the speed (early acceleration, 0–5 m; late acceleration, 10–20 m; total sprint time) and agility tests (total time) were assessed using a 2-way (group \times time) analysis of variance. The “group” and “time” factors consisted of 2 levels; “WL and VJ” and “pre and posttraining,” respectively. Significant differences were examined using Tukey's post hoc analysis. Cohen's effect size (d; where 0.2 = small, 0.5 = medium, and 0.8 = large) was used to report the magnitude of the within-group effects (i.e., percentage-change). An intraclass correlation coefficient (ICC) was calculated with 95% CIs (lower, upper) for each of the tests adopted in this study from the data collected during the preintervention testing sessions. Statistical analyses were conducted using SPSS statistical software (v.18 Chicago, IL, USA) with significance set at $p \leq 0.05$. All data are presented as mean \pm SD unless noted otherwise.

Results

There was no significant difference in age ($p = 0.113$; WL: 24.72 ± 1.27 years; VJ: 23.70 ± 1.49 years), weight ($p = 0.438$; WL: 80.49 ± 12.51 kg; VJ: 76.70 ± 11.99 kg), or height ($p = 0.415$; WL: 178.42 ± 10 cm; VJ: 178.96 ± 7.03 cm) between groups. The adopted tests demonstrated a high level of test-retest reliability in this subject group; 20-m sprint test ICC = 0.83 (0.66, 0.92); 5-0-5 agility test ICC = 0.96 (0.92, 0.98); CMJ ICC = 0.99 (0.99, 0.99); SJ ICC = 0.99 (0.99, 0.99); and DJ ICC = 0.982 (0.95, 0.99). All subjects completed the intervention with no differences in attendance between groups ($p = 1.00$; both groups averaged 93% [$\sim 16/18$ sessions]; minimum attendance of 88%). The adopted tests demonstrated a high level of test-retest reliability in this subject group; 20-m sprint test ICC = 0.83 (0.66, 0.92); 5-0-5 agility test ICC = 0.96 (0.92, 0.98); CMJ ICC = 0.99 (0.99, 0.99); SJ ICC = 0.99 (0.99, 0.99); and DJ ICC = 0.982 (0.95, 0.99).

Countermovement Jump

There was no significant time by group interaction ($F_{(2, 24)} = 2.427$, $p = 0.132$) observed for peak COM power performance during the CMJ. However, a significant effect of time ($F_{(2, 24)} = 52.614$, $p < 0.01$) was observed between pre and postintervention CMJ results, with greater peak power outputs recorded after the 6-week intervention program (Table 2). Although no significant between-group differences were identified, there was a medium to large effect of the WL intervention on power output and only a small to medium effect after the VJ training (WL group = 10%, $d = 0.701$; VJ group = 5.78%, $d = 0.328$).

Squat Jump

Despite the WL group having greater absolute improvement in power (WL group = 12.73%, $d = 0.854$; VJ group = 7.27%, $d = 0.382$), no significant time by group interaction ($F_{(2, 24)} = 1.171$, $p = 0.290$) was observed in the performance of the SJ. A significant main effect of time ($F_{(2, 24)} = 30.922$, $p < 0.01$) was observed, with higher power outputs achieved after the 6-week intervention program (Table 2).

Depth Jump

Similarly, no significant time by group interaction ($F_{(2, 24)} = 3.747$, $p = 0.065$) was observed in the peak COM power performance of the DJ. However, a significant main effect of time ($F_{(2, 24)} = 38.545$, $p < 0.01$) did exist, with greater power outputs measured after the 6-week intervention (Table 2). There were only small effects noted in the overall peak power output after each intervention (WL group = 4.72%, $d = 0.229$; VJ group = 7.88%, $d = 0.349$).

Sprint Test

No significant time by group interaction was observed for the total 20-m sprint ($F_{(2, 24)} = 2.225$, $p = 0.149$), 0- to 5-m sprint time ($F_{(2, 24)} = 0.969$, $p = 0.335$), or the 10- to 20-m sprint time ($F_{(2, 24)} = 0.348$, $p = 0.561$). However, there was a significant main effect of time, with the 20-m sprint time ($F_{(2, 24)} = 35.592$, $p < 0.01$) and the 0- to 5-m sprint time improving from pretraining to posttraining ($F_{(2, 24)} = 95.927$, $p < 0.01$) in both groups (Table 3).

5-0-5 Agility Test

There was no significant time by group interaction ($F_{(2, 24)} = 0.125$, $p = 0.727$) for the 5-0-5 agility test. However, a significant main effect of time ($F_{(2, 24)} = 14.234$, $p = 0.01$) was evident (Table 3) with both interventions demonstrating moderate improvements in agility times (WL group = 2.75%, $d = 0.476$; VJ group = 3.32%, $d = 0.439$).

Discussion

The purpose of this study was to identify and compare changes in peak COM muscular power, and speed and agility after 2, 6-week interventions designed for power development (WL and VJ training). The main findings of the study were (a) both training interventions resulted in significant increases in peak power output during jump testing, (b) both training interventions improved sprint and COD performance, and (c) contrary to the hypothesis, there were no significant differences between training programs on any outcome measure.

Both training groups (WL and VJ) demonstrated significant improvements in peak COM power output during the VJ testing (CMJ: 5.78%; SJ: 7.27%; and DJ: 7.88%). The increase in power output after the VJ training may be explained on the basis of training specificity because the training used plyometric jumping (vertical) exercises. The use of plyometric exercises enhances the ability to use the stretch-shorten cycle and increases overall neural stimulation of the muscle (29). Results in this study are consistent with previous research (12,13,22). For example, Fotini et al. (13) reported an increase in concentric power output during the CMJ and SJ (5.85% and 9.09%, respectively) after an 8-week plyometric training program which is comparable with those observed in our 6-week intervention (CMJ: 5.78%; SJ: 7.27%). Mihalik et al. (22) also showed an approximate 4.8% increase in mean power output ($3,865 \pm 874$ W to $4,060 \pm 896$ W) for the CMJ after a 4-week complex training program alternating between resistance exercises and biomechanically similar plyometric exercises within a single session in college-age club volleyball players. The improvements in peak COM power output during the jump testing of the WL group (CMJ: 10%; SJ: 12.73%; and DJ: 4.72%) are consistent with findings from previous studies (9,13,24) and may be explained by the similarities in kinetics and kinematics between the jumping tasks and WL exercises (6). As such, peak power during VJ performance is strongly correlated with WL ability (7), and the ground reaction force during the snatch is similar to that of the CMJ (15). It is not surprising that DJ performance demonstrated the lowest improvement after WL training, given that WL training does not target eccentric loading.

Although no significant between-group differences were observed in the 20-m sprint testing, there was a significant improvement in the 0- to 5-m sprint and the total (0–20 m) sprint time in response to both training interventions. Considering there were no differences in the 10- to 20-m sprint time of either group (Table 3), it is likely the observed improvement in 0- to 20-m sprint time is solely attributable to the significant improvement in the sprint performance in the first 5 m (WL: 5.44%, $d = 0.466$; VJ: 7.64%, $d = 0.745$). The results are partly in agreement with those of Tricoli et al. (27), who observed an improvement in 10-m sprint speed but not 30-m sprint speed after 8 weeks of WL training. However in contrast to the findings in our study, no improvements in sprint capacity were

observed by Tricoli et al. after VJ training. This may in part be attributable to differences in subject number, with only 8 participants completing the VJ training protocol in the study of Tricoli et al. This is supported on the basis of the VJ training having a medium effect ($d = 0.47$) on 10-m sprint speed in the study of Tricoli et al., which is a comparable effect to that observed in the 5-m sprint time in this study after VJ training. The findings of improved 0- to 5-m and 0- to 20-m sprint times, but not 10- to 20-m sprint times, are in agreement with previous training studies demonstrating large improvements in sprint performance over short distances such as 10–20 m, but smaller improvements in maximum running velocity (5). Time-motion analyses of various field sports indicate sprints rarely exceed 3 seconds in duration or 20 m in length in rugby union (11), soccer (3), field hockey (25), or Australian Rules football (10), therefore the significant 0- to 5-m and 0- to 20-m sprint time improvements in this study have important practical relevance.

There were no between-group differences in the 5-0-5 agility times in response to the 6-week training intervention, but there were significant within-group differences with both the WL and VJ groups improving their 5-0-5 agility time (WL: 2.75%; VJ: 3.32%). The improvements in the COD time showed only modest effects (WL: $d = 0.476$; VJ: $d = 0.439$), which are consistent with the work of Tricoli et al. (27), and are likely a reflection of these tasks relying more heavily on motor control and coordination (31) than other outcome measures in this study. Indeed the improvements in the COD task is important, considering both training groups adopted primarily bilateral exercises in the vertical plane, whereas the COD movements in the agility tasks require unilateral movements along the horizontal plane with considerable anterior-posterior (braking and propulsive) and mediolateral force production (4).

Although findings from this study add to the growing body of knowledge in this area, we do acknowledge limitations in data collection and interpretation that may impact our findings. All participants in this study were randomized into 1 of 2 training groups. The decision to use an experimental design which did not include a control group was based on previous evidence demonstrating a clear benefit of supplementing existing training with either WL or VJ training; whereas, the difference in performance gains between WL and VJ training had not been previously

explored in this training time frame or population. However, the absence of a control group is a potential limitation given that, in particular, participants may demonstrate an improvement in performance solely due to a “learning effect.” To minimize this potential confounder, participants completed multiple familiarizations of each test before conducting the initial testing session; additionally a learning effect is unlikely to have contributed given the 6-week time lag between the pre and posttraining testing sessions. Second, the use of a force platform may have restricted jumping performances because of the limited surface area available for landing. Finally, subjects participating in the study were recreational level athletes training at least twice a week. Subjects were required to continue training in addition to the training requirements of this study. Although this training did not include resistance training, this training may still have affected the results of this study because of the completion of the additional training volume.

In summary, the findings of this study demonstrate 6 weeks of VJ, and WL training is sufficient to significantly improve performance in tasks associated with team-based sports in a group of recreational athletes. These improvements, however, were not different between individual training programs. It remains to be elucidated whether combining WL and VJ training with more specific type training will result in optimal adaptations in both power output and sports performance measures. Furthermore, studies could also investigate whether it is better to combine resistance training that uses either WL or VJ exercise training and sport-specific training in the same block of training as seen in traditional periodization designs or divide them into separate blocks as used in the conjugate sequence model and coupled successive system (21).

Practical Applications

Although Olympic-style WL exercises may require more time to acquire the specific skills due to the technical nature of the exercises, this type of training seems to be as beneficial for improving COM power output, speed, and COD when compared with traditional VJ training programs in recreationally active individuals who participate in sports. The greater skill complexity required for the Olympic WL

exercises may help facilitate the development of a broader physical ability spectrum, which could allow for greater force and impulse capacity in the longer (>6 weeks) term (27). Based on the findings of this study, it seems that WL is an appropriate modality even in individuals with limited previous resistance training exposure.

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Table 1. Training volume, training intensities, and recovery periods for the 6-week training period for both the WL and VJ intervention groups.

WL group		
Exercises	Weeks 1–3	Weeks 4–6
Hang power clean	4 sets × 4 reps at 70% of 1RM (15-s rest between reps) (3- to 5-min rest between sets)	6 sets × 4 reps at 70% of 1RM (15-s rest between reps) (3- to 5-min rest between sets)
Power snatch	4 sets × 4 reps at 70% of 1RM (15-s rest between reps) (3- to 5-min rest between sets)	6 sets × 4 reps at 70% of 1RM (15-s rest between reps) (3- to 5-min rest between sets)
Half Squat	4 sets × 6 reps × 6RM (15-s rest between reps) (3- to 5-min rest between sets)	4 sets × 6 reps × 6RM (15-s rest between reps) (3- to 5-min rest between sets)
VJ Group		
Exercises	Weeks 1–3	Weeks 4–6
Weighted double leg jumps	4 sets × 4 reps at 30% of 1RM (15-s rest between reps) (3- to 5-min rest between sets)	6 sets × 4 reps at 30% of 1RM (15-s rest between reps) (3- to 5-min rest between sets)
45 cm depth jumps	8 sets × 10 reps at body weight (15-s rest between reps) (3- to 5-min rest between sets)	8 sets × 12 reps at body weight (15-s rest between reps) (3- to 5-min rest between sets)
Half squat	4 sets × 6 reps × 6RM (15-s rest between reps) (3- to 5-min rest between sets)	4 sets × 6 reps × 6RM (15-s rest between reps) (3- to 5-min rest between sets)

*WL = weightlifting; VJ = vertical jump; RM = repetition maximum.

Table 2. Vertical jump (VJ) test performance during pre and postintervention testing.

Test	Olympic weightlifting			VJ		
	Pre, mean ($\pm SD$)	Post, mean ($\pm SD$)	Mean change (post – pre) (95% CI)	Pre, mean ($\pm SD$)	Post, mean ($\pm SD$)	Mean change (post – pre) (95% CI)
CMJ (W)	4,358.475 (± 658.818)	4,815.894 (± 646.337)	457.419 (298.7–616.1)	5,116.380 (± 892.699)	5,412.065 (± 910.974)	295.685 (168.3–423.0)
SJ (W)	3,965.267 (± 543.954)	4,470.169 (± 634.382)	504.903 (271.3–738.5)	4,685.086 (± 867.774)	5,025.508 (± 913.232)	340.422 (155.2–525.3)
DJ (W)	3,397.103 (± 675.033)	3,557.497 (± 723.827)	160.393 (65.3–255.5)	3,878.079 (± 894.451)	4,183.805 (± 855.435)	305.725 (193.4–418.0)

*CMJ = countermovement jump; SJ = squat jump; DJ = depth jump.

Table 3. Performance in 20-m sprint (total, 0–5 m, 10–20 m) and 5-0-5 COD test during pre and postintervention testing.

Test (s)	Olympic weightlifting			Vertical jump		
	Pre, mean ($\pm SD$)	Post, mean ($\pm SD$)	Mean change (pre – post) (95% CI)	Pre, mean ($\pm SD$)	Post, mean ($\pm SD$)	Mean change (pre – post) (95% CI)
20-m sprint	3.28 (± 0.143)	3.22 (± 0.129)	0.058 (0.014 to 0.102)	3.19 (± 0.115)	3.10 (± 0.122)	0.096 (0.072 to 0.121)
0- to 5-m sprint	1.14 (± 0.065)	1.078 (± 0.072)	0.065 (0.046 to 0.085)	1.127 (± 0.047)	1.047 (± 0.055)	0.08 (0.059 to 0.101)
10- to 20-m sprint	1.377 (± 0.076)	1.385 (± 0.058)	0.008 (–0.013 to 0.029)	1.318 (± 0.052)	1.318 (± 0.051)	0.001 (–0.012 to 0.013)
5-0-5 COD	2.43 (± 0.120)	2.37 (± 0.159)	0.067 (0.014 to 0.120)	2.41 (± 0.192)	2.33 (± 0.175)	0.081 (0.026 to 0.136)

*COD = change of direction.