A Comparison of Bilateral vs. Unilateral-Biased Strength and Power Training Interventions on Measures of Physical Performance in Elite Youth Soccer Players

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1Millwall Football Club Academy, Calmont Road, Bromley, United Kingdom; 2Return to Play Department, Sevilla Football Club, Seville, Spain; 3Department of Sport Science and Research, Nucleus of High Performance in Sport, Sao Paulo, Brazil; and 4Faculty of Science and Technology, London Sports Institute, Middlesex University, London, United Kingdom

Abstract
Stern, D, Gonzalo-Skok, O, Loturco, I, Turner, A, and Bishop, C. A comparison of bilateral vs. unilateral-biased strength and power training interventions on measures of physical performance in elite youth soccer players. J Strength Cond Res 34(8): 2105–2111, 2020—The aim of the present study was to compare the effects of bilateral and unilateral-biased strength and power training programs on measures of physical performance in male youth soccer players. Twenty-three elite youth players (age: 17.6 ± 1.2 years) were randomly assigned to either a unilateral (n = 11) or a bilateral (n = 12) group, who completed a strength and power intervention, twice per week for 6 weeks. The unilateral group completed rear foot elevated split squats (RFESS), single-leg countermovement jumps (SLCMJs), single-leg drop jumps (SLDJs), and single-leg broad jumps (SLBJs). The bilateral group intervention performed back squats, CMJs, drop jumps (DJ), and broad jumps (BJ). A 2 × 2 repeated measures analysis of variance showed no between-group differences. However, within-group differences were evident. The bilateral training group showed significant (p < 0.05) improvements in back squat strength (d = 1.27; Δ% = 26.01), RFESS strength (d = 1.64; Δ% = 23.34), BJ (d = 0.76; Δ% = 5.12), 10-m (d = −1.17; Δ% = 4.29), and 30-m (d = −0.88; Δ% = 2.10) performance. The unilateral group showed significant (p < 0.05) improvements in RFESS strength (d = 1.40; Δ% = 33.29), SLCMJ on the left leg (d = 0.76; Δ% = 9.84), SLBJ on the left leg (d = 0.97; Δ% = 6.50), 10-m (d = −1.50; Δ% = 5.20), and 505 on the right leg (d = −0.78; Δ% = 2.80). Standardized mean differences showed that bilateral training favored improvements in back squat strength and unilateral training favored improvements in RFESS strength, SLDJ on the right leg and 505 on the right leg. These results show that although both training interventions demonstrated trivial-to-large improvements in physical performance, the notion of training specificity was evident with unilateral training showing greater improvements in unilateral test measures.

Key Words: off-season, jumping, speed, change of direction speed

Introduction
Soccer is a high-intensity, intermittent sport which requires players to sprint, change direction, jump, and experience multiple physical duels during match-play (27). Time motion analysis data have shown that elite soccer players cover on average 10–11 km (22), can jump up to 15 times (18), and change direction 1,200–1,400 times (3) in a single match. Given that many of these intermittent actions are high intensity in nature, it stands to reason that strength and power training serve as useful modes of training for soccer players, to help prepare them for the demands of the game. Increases in bilateral strength and power have shown improvements in related actions such as change of direction speed (CODS) (20), linear speed (6), and jump height (8). Similarly, evidence exists showing the benefits of unilateral training for improved CODS (25), jumping (15), and linear speed (16). Thus, with both bilateral and unilateral training having been shown to improve various markers of athletic performance, it would be useful for coaches to know whether one training modality is more effective than the other, so that training programs can be prioritized accordingly.

Gonzalo-Skok et al. (10) compared the effects of six-week unilateral versus bilateral training interventions on single-leg output, interlimb asymmetry, bilateral deficit, CODS, linear sprinting, and jump height. The bilateral group (n = 11) completed 3 sets of back squats, with repetitions continuing until power output dropped by >10%. In addition, 2 sets of 5 repetitions were completed for bilateral drop jumps (DJ), horizontal DJ, countermovement jumps (CMJs), and broad jumps all in addition to their normal strength training program (which consisted of eccentric strength, balance and coordination exercises). The unilateral group (n = 11) completed 3 sets of rear foot elevated split squats (RFESS), with repetitions continuing until power output dropped by >10%. Two sets of 5 repetitions were completed for the same jumps, but performed unilaterally. Again, this was performed in addition to the aforementioned normal strength training program. Results showed that both groups improved in maximal power, linear sprinting, and CMJ tests; however, the bilateral group reduced the bilateral deficit 29.2% more than the unilateral group. In contrast, the unilateral group reduced asymmetry 53.0% more than the bilateral group, showed
greater improvements in CODS on the left leg (2.6%), and mean power on both limbs during the RFESS exercise (12.3–12.8%). Although not a true unilateral exercise (17), these data show that the RFESS could be a viable alternative to traditional back squat training when aiming to enhance CODS and power output unilaterally.

Speirs et al. (25) compared the effects of the back squat and RFESS only in a twice per week strength program for 5 weeks on strength, sprinting (40 m), and CODS (pro-agility) in elite international academy rugby players. Their results showed a main effect for time pre-intervention to postintervention for; back squat (ES = 0.84–0.92), RFESS (ES = 0.89–0.94), 40 m (ES = 0.47–0.67), pro-agility (ES = 0.77–0.89), but no meaningful differences between groups. These data suggest that both training methods exhibited similar benefits on strength, linear speed, and CODS, and somewhat disagree with the findings from Gonzalo-Skok et al. (10). Similar results were shown in a recent study by Appleby et al. (1), who investigated the effects of bilateral (back squat) and unilateral (step ups) resistance training groups against a control group during an 8-week training intervention and a 3-week maintenance phase in developmental rugby players. Results showed that both intervention groups improved in one-repetition maximum (1RM) strength for back squat (ES: 0.79 ± 0.40) and 1RM average steps up (ES: 0.63 ± 0.17), with neither being significantly better than the other. Given the conflicting findings in the literature, further research is warranted to establish which training modality (bilateral or unilateral) is more effective for improving athletic performance.

Bogdanis et al. (4) also compared a bilateral (n = 8) and unilateral (n = 7) plyometric training intervention performed twice per week for 6 weeks. The groups performed a range of plyometric exercises (e.g., CMJ, DJ, broad jumps, and their associated single-leg versions), and jump performance was assessed via the CMJ, DJ, and maximal isometric leg press strength and rate of force development (RFD) on each leg separately and both together. Results showed that the unilateral group improved more than the bilateral group for; CMJ (19.0 ± 7.1%, p < 0.001), maximal isometric force (23.8 ± 9.1%, p < 0.009), and RFD from 0 to 50 (34%) and 50–100 ms (36%), indicating the superiority of unilateral training for improving jumping, isometric force production, and RFD compared with bilateral training. Similar results were shown by Fisher and Wallin (9), who compared bilateral (n = 7) versus unilateral (n = 8) lower body resistance and plyometric training, performed twice per week for 6 weeks in collegiate male rugby players. Groups performed either back squats or single-leg squats as the resistance exercise and a range of plyometric exercises (e.g., forward and lateral CMJ, box jumps, or their associated single-leg versions). Results showed large improvements in CODS performance for the unilateral group (ES range = 1.48–1.86) and small-to-moderate improvements for the bilateral group (ES range = 0.23–1.16). In contrast, the bilateral group showed noticeably better improvements in 10-m sprint performance (ES = 0.7) compared with the unilateral group (ES = 0.1). Collectively, these data show the efficacy of both bilateral and unilateral training methods for the enhancement of athletic performance. However, given no clear trend exists as to whether one method is better than the other, further comparisons are warranted in an attempt to inform practitioners about the effectiveness of each method.

Therefore, the primary aim of the present study was to determine whether bilateral and unilateral strength and power training improves measures of physical performance in male youth soccer players. A secondary aim was to compare both training interventions in an attempt to determine which training method was superior at improving measures of physical performance. Given, the conflicting findings in the literature, developing a true hypothesis was challenging; however, it was believed that the unilateral strength and power training, may be more likely to transfer to unilateral test measures, supporting the notion of specificity (2,5).

**Methods**

**Experimental Approach to the Problem**

This study used the preseason period in the build up to the 2019–2020 soccer season, to conduct 2 strength and power training interventions for academy soccer players, at a professional soccer club in the UK. With a randomized crossover design, players were either selected to be part of a bilateral or RFESS training group, investigating the effects on bilateral and unilateral strength and jumps, and linear and CODS performance. All players performed a standardized warm-up procedure, consisting of a single set of 10 repetitions of bodyweight squats, 5 repetitions on each leg of linear and lateral lunges, spiders, and inchworms mobility exercises. After this, 3 practice trials were provided for each jump, sprint, and CODS test, at 50, 75, and 100% of perceived maximal effort. For testing, day 1 consisted of the CMJ, single-leg CMJ (SLCMJ), DJ, single-leg DJ (SLDJ), speed (10 and 30 m), and CODS (505) tests. Seventy-two hours later, day 2 consisted of predicted 1RM strength for back squats and RFESS, with the same process conducted during postintervention testing. Subjects were instructed to refrain from any exercise for 24 hours before testing at both time points. After pre-intervention testing, subjects were randomly assigned to one of 2 groups: either a unilateral (n = 11) or a bilateral (n = 12) group, consisting of either bilateral or unilateral strength and power exercises twice per week for 6 weeks. All measurements were then repeated after the completion of the 6-week intervention.

**Subjects**

Twenty-three level academy male football players (mean ± SD: age: 17.6 ± 1.2 years, body mass: 77.3 ± 7.91 kg, height: 179.6 ± 7.27 cm) were recruited and provided written informed consent to take part in this study. Guardians also provided written consent where necessary. All subjects were from a category 2 soccer academy and participated in structured technical soccer training, on average, 6 times per week and structured strength and power training in the weight room twice per week (Table 1). Inclusion criteria required subjects to have a minimum of 2 year’s resistance training experience, be free from any injuries for a minimum of 4 weeks before pretesting and attend all training sessions throughout their respective intervention. This study was approved by the London Sport Institute Research and Ethics Committee.

**Procedures**

**Training Intervention.** Training was conducted during a typical academy level football preseason preparation phase (Table 1), which normally involves 6 football sessions per week (60–90 minutes of duration, including football position specific drills, technical, tactical and physical sessions), 2 lower body resistance training sessions per week in which the subjects completed a periodized, volume-load-matched strength and power program of back squats or RFESS (bilateral or unilateral group,
respectively), alongside DJ, CMJ, and broad jumps, again, either bilaterally or unilaterally, depending on the group (Table 2). Subjects completed their interventions under the guidance of at least one accredited strength and conditioning coach to assist with technique and performance monitoring. Barbell loads were prescribed as a percentage of the IRM obtained at baseline testing.

**One Repetition Maximum Testing.** After completion of a barbell warmup (2 sets of 8 repetitions with just the bar), the PUSH 2.0 Band was placed on the barbell before the subject performed 5 sets of 3 repetitions of self-selected submaximal loads with each set increasing in load (e.g., 3 reps at 40, 60, 70, 85, and 100 kg). Subjects were instructed to move in a controlled manner during the eccentric phase of the lift and then move as fast as possible during the concentric phase of the exercise, with a 3-minute rest period between sets. The recorded metric was mean concentric velocity, with the best repetition per set subsequently used for further analysis, to determine predicted IRM loads. All subjects were required to achieve a 90° angle between the femur and the tibia while performing the both RFESS and back squat testing (23), which was controlled with a resistance band being tied to either side of the squat rack and subjects were required to touch the band to complete the required depth for a successful repetition.

**Bilateral and Unilateral Countermovement Jumps.** Subjects performed the jumps using a contact mat (Just Jump system, Probotics, Huntsville, AL). They were instructed to step off the box and land on the contact mat below, with either both legs or one leg depending on the test measure in question. Upon landing, subjects were then instructed to “jump as high as you can, while spending as little time on the ground as possible” in line with previous research (13,14). Each trial was separated by 45-second rest, with the recorded metric being reactive strength index (RSI), quantified using the equation: flight time/ground contact time (14). Two trials were performed for each test and the trial with the greatest jump height was subsequently used for further analysis.

**Bilateral vs. Unilateral Training (2020) 34:8**

**Table 1**

Typical training week for during preseason in elite academy soccer players.

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>Soccer training</td>
<td>Gym + soccer training</td>
<td>—</td>
<td>Gym + soccer training</td>
<td>Soccer training</td>
<td>Match</td>
<td>—</td>
</tr>
<tr>
<td>Afternoon</td>
<td>—</td>
<td>Technical soccer skills</td>
<td>—</td>
<td>Technical soccer skills</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Table 2**

Periodized strength and power interventions for the bilateral and unilateral training groups.*

<table>
<thead>
<tr>
<th>Bilateral training group</th>
<th>Unilateral training group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weeks 1–2</strong></td>
<td></td>
</tr>
<tr>
<td>Back squat (4 × 6 at 75% 1RM)</td>
<td>Rear foot elevated split squat (4 × 6 each leg at 75% 1RM)</td>
</tr>
<tr>
<td>Drop jump (4 × 3 from 30 cm box)</td>
<td>Single-leg drop jump (4 × 3 each leg from 15 cm box)</td>
</tr>
<tr>
<td>Countermovement jump (4 × 3)</td>
<td>Single-leg countermovement jump (4 × 3 each leg)</td>
</tr>
<tr>
<td>Broad jumps (4 × 3)</td>
<td>Single-leg broad jump (4 × 3 each leg)</td>
</tr>
<tr>
<td><strong>Weeks 3–4</strong></td>
<td></td>
</tr>
<tr>
<td>Back squat (4 × 6 at 80% 1RM)</td>
<td>Rear foot elevated split squat (4 × 6 each leg at 80% 1RM)</td>
</tr>
<tr>
<td>Drop jump (4 × 3 from 30 cm box)</td>
<td>Single-leg drop jump (4 × 4 each leg from 15 cm box)</td>
</tr>
<tr>
<td>Countermovement jump (4 × 4)</td>
<td>Single-leg countermovement jump (4 × 4 each leg)</td>
</tr>
<tr>
<td>Broad jumps (4 × 4)</td>
<td>Single-leg broad jump (4 × 4 each leg)</td>
</tr>
<tr>
<td><strong>Weeks 5–6</strong></td>
<td></td>
</tr>
<tr>
<td>Back squat (4 × 6 at 85% 1RM)</td>
<td>Rear foot elevated split squat (4 × 6 each leg at 85% 1RM)</td>
</tr>
<tr>
<td>Drop jump (4 × 5 from 40 cm box)</td>
<td>Single-leg drop jump (4 × 5 each leg from 20 cm box)</td>
</tr>
<tr>
<td>Countermovement jump (4 × 5)</td>
<td>Single-leg countermovement jump (4 × 5 each leg)</td>
</tr>
<tr>
<td>Broad jumps (4 × 5)</td>
<td>Single-leg broad jump (4 × 5 each leg)</td>
</tr>
</tbody>
</table>

*1RM = repetition maximum.
landing from horizontal jumps, the use of an arm swing was allowed during all trials. Subjects were instructed to bend their knees to a self-selected depth before accelerating horizontally and explosively as far as possible. Distance was measured from the start line to the point of the landing heel, with subjects required to “stick the landing” for 3 seconds. If these criteria were not adhered to, the trial was deemed void and retaken after a 45-second rest period. Two trials were performed for each test and the trial with the greatest was used for further analysis.

10- and 30-m sprints. Dual beam electronic timing games (Brower Timing Systems, Draper, UT) were positioned at a height of 1 m on the start line, 10 and 30 m, enabling multiple splits to be measured during a single sprint. Players started the test in a staggered 2-point stance with toes positioned 30 cm behind the start line, to not break the beam of the timing gates before the initiation of the test. When ready, subjects sprinted all the way through the final set of timing gates, allowing 10- and 30-m split times to be recorded to the nearest 100th of a second. Two trials were performed on an outdoor 4 G synthetic surface and separated by a 3-minute rest period, with the fastest trial considered for further analysis.

505 Change-of-Direction Speed Test. A distance of 15 m was measured out and electric timing gates (Brower Timing Systems) positioned at the 10-m mark, whereas the 15-m point was positioned on the goal line to ensure that players had an obvious target as they approached the turning point. Players sprinted 15 m on the 4 G synthetic and performed a 180° turn, off both right and left legs, with a total of 2 trials completed for each leg. Time started when players broke the electronic beam at the 10-m mark and finished after sprinting back through the timing gates, having completed the 180° turn. Subjects were required to place the outside foot passed the goal line for a successful trial. Two trials were performed for each test with a 3-minute rest period and the fastest trial was used for data analysis. The COD deficit was also calculated for each leg using the formula: fastest 505 time—fastest 10-m time, suggested to provide a more accurate representation of each player’s true COD ability (19).

Statistical Analyses
All data were initially recorded as mean ± SD in Microsoft Excel. Thereafter, the data were transferred to SPSS (version 25.0; SPSS, Inc., Armonk, NY). All data were checked for normality using the Shapiro-Wilk test, and within-session reliability of test measures computed using an average measures two-way random intraclass correlation coefficient (ICC) with absolute agreement, inclusive of 95% confidence intervals (relative reliability), and the coefficient of variation (CV) (absolute reliability). Interpretation of ICC values was in accordance with previous research by Koo and Li (12), where values >0.9 = excellent, 0.75–0.90 = good, 0.5–0.74 = moderate, and <0.5 = poor. Coefficient of variation values were considered acceptable if <10% (7). Differences from pre-intervention to post-intervention were determined through a paired samples t-test for each group individually and a 2 × 2 (group × time) repeated measures analysis of variance (ANOVA) was conducted to quantify whether the bilateral or unilateral training intervention was significantly different across 2 time points, with statistical significance set at $p \leq 0.05$. Magnitude of change was quantified using Cohen’s $d$ effect sizes: ($\text{Max}_{\text{pre}} - \text{Max}_{\text{post}})/\text{SD}_{\text{pooled}}$, with values interpreted in line with a suggested scale by Hopkins et al. (11) where <0.20 = trivial; 0.20–0.60 = small; 0.61–1.20 = moderate; 1.21–2.0 = large; and >2.01 = very large.

Results
A Shapiro-Wilk test revealed that all data were normally distributed ($p > 0.05$). Reliability data are presented for both time points in Table 3. Relative reliability ranged from moderate to excellent for all metrics at both time points, and all CV values were <10% and therefore, deemed acceptable (7). The repeated measures ANOVA showed no meaningful between-group differences. Descriptive data, accompanying effect sizes and percentage change are presented in Table 4 for the bilateral group, and Table 5 for the unilateral group. For the bilateral group, significant improvements were seen for 1RM back squat, 1RM RFESS, BJ, 10 and 30 m, with no significant differences found for the other performance measures. For the RFESS group, significant improvements were found for 1RM RFESS, SLCMJ left leg, single-leg broad jump (SLBJ) left leg, 10 m and 505 right leg. No other significant differences were found. Standardized mean differences between groups are presented in Figure 1 and show that bilateral training favored greater improvements in back squat strength, while unilateral training favored improvements in RFESS strength, SLDJ, and 505 performance on the right leg.

Discussion
The aims in the present study were 2-fold: (a) to determine whether either modality were superior for performance in elite youth male soccer players. Results showed that both training modalities improved various markers of athletic performance with the unilateral group significantly improving in 6 different testing measures (1RM BS, 1RM RFESS, SLCMJ left, SLBJ left, CMJ, and 505).

Table 3

<table>
<thead>
<tr>
<th>Fitness test</th>
<th>Pre-intervention CV (%)</th>
<th>ICC (95% CI)</th>
<th>Postintervention CV (%)</th>
<th>ICC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMJ</td>
<td>2.01</td>
<td>0.95 (0.89–0.98)</td>
<td>2.45</td>
<td>0.95 (0.89–0.98)</td>
</tr>
<tr>
<td>SLCMJ-L</td>
<td>2.51</td>
<td>0.96 (0.91–0.98)</td>
<td>2.89</td>
<td>0.81 (0.90–0.91)</td>
</tr>
<tr>
<td>SLCMJ-R</td>
<td>2.52</td>
<td>0.96 (0.89–0.98)</td>
<td>3.38</td>
<td>0.77 (0.53–0.89)</td>
</tr>
<tr>
<td>BJ</td>
<td>2.99</td>
<td>0.82 (0.64–0.92)</td>
<td>2.85</td>
<td>0.82 (0.63–0.92)</td>
</tr>
<tr>
<td>SLBJ-L</td>
<td>3.14</td>
<td>0.78 (0.43–0.91)</td>
<td>2.00</td>
<td>0.88 (0.72–0.95)</td>
</tr>
<tr>
<td>SLBJ-R</td>
<td>2.22</td>
<td>0.88 (0.75–0.94)</td>
<td>2.49</td>
<td>0.85 (0.68–0.94)</td>
</tr>
<tr>
<td>RSI</td>
<td>7.69</td>
<td>0.74 (0.50–0.88)</td>
<td>7.41</td>
<td>0.73 (0.46–0.87)</td>
</tr>
<tr>
<td>SLRSL-L</td>
<td>6.27</td>
<td>0.64 (0.33–0.82)</td>
<td>8.49</td>
<td>0.59 (0.21–0.82)</td>
</tr>
<tr>
<td>SLRSL-R</td>
<td>6.38</td>
<td>0.74 (0.50–0.88)</td>
<td>7.23</td>
<td>0.78 (0.54–0.89)</td>
</tr>
<tr>
<td>10m</td>
<td>1.41</td>
<td>0.78 (0.30–0.92)</td>
<td>1.56</td>
<td>0.64 (0.31–0.83)</td>
</tr>
<tr>
<td>30m</td>
<td>0.63</td>
<td>0.92 (0.50–0.98)</td>
<td>0.74</td>
<td>0.86 (0.69–0.94)</td>
</tr>
<tr>
<td>505-L</td>
<td>1.09</td>
<td>0.80 (0.48–0.95)</td>
<td>2.31</td>
<td>0.57 (0.21–0.79)</td>
</tr>
<tr>
<td>505-R</td>
<td>1.06</td>
<td>0.87 (0.55–0.97)</td>
<td>2.02</td>
<td>0.59 (0.25–0.80)</td>
</tr>
</tbody>
</table>

*CMJ = jump; SLCMJ = single-leg countermovement jump; SLRSL = single-leg broad jump; RSLRSL = reactive strength index; SLRSL = single-leg reactive strength index.
10 m, and 505 right), and the bilateral group significantly improving in 5 test measures (back squat, RFESS, BJ, 10 and 30 m). Therefore, these data suggest that both interventions were effective at improving certain performance markers, with specificity of intervention often showing greater benefit for comparable test protocols.

Pre-intervention and postintervention data for the bilateral group are displayed in Table 4. Strength measures displayed a large magnitude of change and percentage improvement both bilaterally and unilaterally; 1RM back squat (ES = 1.27; confidence interval (CI) = 0.39 to 2.15; Δ% = 26.01) and RFESS (ES = 1.64; CI = 0.72 to 2.57; Δ% = 23.34). Although challenging to fully explain, previous research by Speirs et al. (25) has shown similar results, with elite academy rugby athletes. Training interventions required players to undertake 2 strength training sessions per week, for 5 weeks, with one group (n = 9) performing back squats and the second group (n = 9) the RFESS. Results showed that both training methods were equally effective at improving both back squat and RFESS 1RM loads. Thus, it would seem that bilateral strength training may have a positive carryover to more than just bilateral strength alone. Linear speed also showed significant

<table>
<thead>
<tr>
<th>Table 4</th>
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<tbody>
<tr>
<td><strong>Mean ± SDs data for the bilateral training group, with accompanying effect sizes (95% confidence intervals) and percentage changes between pre-intervention to postintervention.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fitness test</th>
<th>Pre-intervention</th>
<th>Postintervention</th>
<th>Effect size (95% CI)</th>
<th>Percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1RM back squat (kg)</td>
<td>113.75 ± 28.85</td>
<td>143.33 ± 15.93†</td>
<td>1.27 (0.39 to 2.15)</td>
<td>26.01</td>
</tr>
<tr>
<td>1RM RFESS (kg)</td>
<td>81.96 ± 12.15</td>
<td>101.08 ± 11.12†</td>
<td>1.64 (0.72 to 2.57)</td>
<td>23.34</td>
</tr>
<tr>
<td>CMJ (cm)</td>
<td>56.37 ± 5.14</td>
<td>58.13 ± 4.50</td>
<td>0.36 (−0.44 to 1.17)</td>
<td>3.12</td>
</tr>
<tr>
<td>SLCMU-L (cm)</td>
<td>35.73 ± 5.70</td>
<td>38.46 ± 2.33</td>
<td>0.63 (−0.19 to 1.45)</td>
<td>7.62</td>
</tr>
<tr>
<td>SLCMU-R (cm)</td>
<td>34.89 ± 4.08</td>
<td>36.11 ± 1.76</td>
<td>0.39 (−0.42 to 1.20)</td>
<td>3.49</td>
</tr>
<tr>
<td>BJ (cm)</td>
<td>224.67 ± 14.20</td>
<td>236.17 ± 16.10†</td>
<td>0.76 (−0.07 to 1.59)</td>
<td>5.12</td>
</tr>
<tr>
<td>SLBJ-L (cm)</td>
<td>197.00 ± 17.59</td>
<td>203.58 ± 10.45</td>
<td>0.45 (−0.36 to 1.27)</td>
<td>3.34</td>
</tr>
<tr>
<td>SLBJ-R (cm)</td>
<td>192.92 ± 15.66</td>
<td>202.58 ± 8.32</td>
<td>0.77 (−0.06 to 1.60)</td>
<td>5.01</td>
</tr>
<tr>
<td>RSI</td>
<td>2.67 ± 0.45</td>
<td>2.76 ± 0.39</td>
<td>0.21 (−0.59 to 1.02)</td>
<td>3.53</td>
</tr>
<tr>
<td>SLRSI-L</td>
<td>1.16 ± 0.09</td>
<td>1.23 ± 0.11</td>
<td>0.70 (−0.13 to 1.52)</td>
<td>5.74</td>
</tr>
<tr>
<td>SLRSI-R</td>
<td>1.18 ± 0.20</td>
<td>1.19 ± 0.21</td>
<td>0.05 (−0.75 to 0.85)</td>
<td>0.70</td>
</tr>
<tr>
<td>10 m (s)</td>
<td>1.71 ± 0.06</td>
<td>1.64 ± 0.06†</td>
<td>−1.17 (0.30 to 2.03)</td>
<td>4.29</td>
</tr>
<tr>
<td>30 m (s)</td>
<td>4.09 ± 0.10</td>
<td>4.01 ± 0.08†</td>
<td>−0.88 (0.05 to 1.72)</td>
<td>2.10</td>
</tr>
<tr>
<td>505-L (s)</td>
<td>2.34 ± 0.07</td>
<td>2.33 ± 0.07</td>
<td>−0.14 (−0.66 to 0.94)</td>
<td>0.36</td>
</tr>
<tr>
<td>505-R (s)</td>
<td>2.33 ± 0.06</td>
<td>2.32 ± 0.09</td>
<td>−0.13 (−0.67 to 0.94)</td>
<td>0.61</td>
</tr>
<tr>
<td>CODD-L (s)</td>
<td>0.63 ± 0.08</td>
<td>0.70 ± 0.08†</td>
<td>−0.87 (−1.71 to −0.04)</td>
<td>10.30</td>
</tr>
<tr>
<td>CODD-R (s)</td>
<td>0.62 ± 0.08</td>
<td>0.68 ± 0.10</td>
<td>−0.66 (−1.48 to 0.16)</td>
<td>9.52</td>
</tr>
</tbody>
</table>

*CI = confidence intervals; RFISS = rear foot elevated split squat; 1RM = repetition maximum; CMJ = countermovement jump; SLCMU = single-leg countermovement jump; L = left; R = right; BJ = broad jump; SLBJ = single-leg broad jump; RSI = reactive strength index; SLRSI = single-leg reactive strength index.†Significantly different to pre-intervention (p < 0.05).
improvement from pre to post in the bilateral group, with a moderate ES across both the 10-m (ES = 1.17; CI = 0.30 to 2.03; Δ% = 4.29) and 30-m (ES = 0.88; CI = 0.05 to 1.72; Δ% = 2.10) tests. This does not seem surprising given prior research has shown that increases in maximal strength are associated with improvements in sprint times (6,24). Thus, it seems somewhat likely that increases in force production would transfer to improvements in linear speed, as seen in the present study for both training groups.

Pre-intervention and postintervention data for the unilateral group is displayed in Table 5. Significant improvements in strength were evident, but only for the RFESS, which showed a large increase from pre to post (ES = 1.40; CI = 0.47 to 2.34; Δ% = 33.29). In contrast, only a small improvement in IRM back squat strength was evident for the unilateral training group. These results can likely be explained by the notion of specificity, which is increasingly becoming acknowledged as a fundamental factor when prescribing training exercises (2,5). Thus, in the present study, it seems likely that the unilateral group made substantially better improvements during the RFESS compared with the bilateral group, because they trained this way for 6 weeks. These results are in part supported by previous research, whereby Appleby et al. (1) showed that training unilaterally for 8 weeks (using the barbell step up exercise) resulted in greater improvements in IRM step up strength for the unilateral group compared with the bilateral group (ES = 0.36–0.41). Another significantly large improvement which occurred in the unilateral training group was a reduction in acceleration times; 10 m (ES = 1.50; CI = 0.55 to 2.45; Δ% = 5.20). In addition, significant improvements in 505 time were evident, but only on the right limb (ES = 0.78; CI = −0.09 to 1.64; Δ% = 2.80) and for the SLBJ, but only on the left limb (ES = 0.97; CI = 0.08 to 1.85; Δ% = 6.50). Although not all unilateral test measures significantly improved, these data do support the notion that unilateral strength and power training, may be more likely to transfer to unilateral test measures. This further supports the notion of specificity (2,5) and serves as useful information for practitioners who need to develop physical competency unilaterally. This seems especially relevant for team sport athletes, who often perform movement patterns unilaterally (e.g., sprinting, changing direction, and kicking).

When viewing the standardized mean differences (Figure 1), it is hard to clearly identify which training modality is better for improving measures of athletic performance, because most confidence intervals overlap the gray shaded area (indicating positive and negative trivial results). However, one key take home message from these results, is that strength seems to be dependent on training specificity, which is in line with previous research (26,28,29). In addition, the SLDJ and 505 (on the right limb) seem to be more positively influenced by unilateral training, which again falls in line with the notion of training specificity. However, bilateral and unilateral vertical and horizontal jumping seem to be influenced to the same degree from both training interventions. Thus, it is suggested that both bilateral and unilateral strength and power training are as equally effective at improving CMJ and broad jump performance (noting that small % improvements were made for both test measures, bilaterally and unilaterally), and is also in agreement with previous comparable research (10,25). In addition, mean body mass was 77.3 kg across the sample and the mean load for the RFESS was 100 kg, before the training intervention. Thus, the athletes undertaking the unilateral training intervention, showed reasonable strength levels (1.29 per kg of body mass) during the RFESS exercise. Although somewhat anecdotal, if athletes are unable to demonstrate high levels of strength unilaterally, then similar results to the present study should likely not be expected. In such a scenario, it is still suggested that unilateral training is integrated into programming (especially for team sport athletes), and that practitioners recognize that the adaptive response from unilateral training methods are likely to take longer.

There are a couple of limitations to the present study which should be acknowledged. First, a third group which used a combination of bilateral and unilateral would have served as useful comparison to determine whether there were any meaningful advantages over singling out bilateral or unilateral training methods. Thus, future research should aim to compare 3 different training approaches, where possible. Second, the current investigation only lasted 6 weeks, which may have potentially been too short to exhibit meaningful improvements in some of the test measures. Although the opportunity for consistent and prolonged training in the off-season is somewhat restricted in professional soccer clubs, future research should aim to investigate training interventions over a longer period (e.g., 8–12 weeks), whereby...
players are tested across different phases of training with different intensity and workloads.

**Practical Applications**

The present study shows that both bilateral and unilateral strength and jump training programs are effective at improving measures of physical performance, which provides 2 key take-home messages for practitioners. First, these findings demonstrate the significant improvements that academy soccer players can obtain when following a structured strength and jump program during the short preseason period. It may seem prudent to recommend that strength training (in particular) should be prioritized during this part of the offseason, which should help to improve players’ robustness. Second, these data support previously published literature, indicating that both bilateral and unilateral training methods provide similar benefits for athletic performance enhancement. Knowing this provides practitioners with a wider variety of options when programming for enhanced physical adaptation, which may offer increased variety when designing training programs over time.

**References**