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Article  in  The Journal of Strength and Conditioning Research · June 2017
DOI: 10.1519/JSC.0000000000001644

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Effects of Two Different Volume-Equated Weekly Distributed Short-Term Plyometric Training Programs on Futsal Players’ Physical Performance

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1Physical Education and Sport Department, University of the Basque Country, UPV/EHU, Vitoria-Gasteiz, Spain; 2Physical Education Department, State University of Londrina, Londrina, Paraná, Brazil; and 3Nucleus of High Performance in Sport Department, São Paulo, Brazil

Abstract

Yanci, J, Castillo, D, Iturricastillo, A, Ayarra, R, and Nakamura, FY. Effects of two different volume-equated weekly distributed short-term plyometric training programs on futsal players’ physical performance. J Strength Cond Res 31(7): 1787–1794, 2017—The aim was to analyze the effect of 2 different plyometric training programs (i.e., 1 vs. 2 sessions per week, same total weekly volume) on physical performance in futsal players. Forty-four futsal players were divided into 3 training groups differing in weekly plyometric training load: the 2 days per week plyometric training group (PT2D, n = 15), the 1 day per week plyometric training group (PT1D, n = 12), and the control group (CG, n = 12) which did not perform plyometric training. The results of this study showed that in-season futsal training per se was capable of improving repeat sprint ability (RSA) (effect size [ES] = −0.59 to −1.37). However, while change of direction ability (CODA) was maintained during the training period (ES = 0.00), 15-m sprint (ES = 0.73), and vertical jump (VJ) performance (ES = −0.30 to −1.37) were significantly impaired. By contrast, PT2D and PT1D plyometric training were effective in improving futsal players’ 15-m sprint (ES = −0.64 to −1.00), CODA (ES = −1.83 to −5.50), and horizontal jump (ES = 0.33–0.64) performance. Nonetheless, all groups (i.e., PT2D, PT1D, and CG) presented a reduction in VJ performance (ES = −0.04 to −1.37). Regarding RSA performance, PT1D showed a similar improvement compared with CG (ES = −0.65 to −1.53) after the training intervention, whereas PT2D did not show significant change (ES = −0.04 to −0.38). These results may have considerable practical relevance for the optimal design of plyometric training programs for futsal players, given that a 1-day-per-week plyometric training program is more efficient than a 2-day-per-week plyometric training program to improve the futsal players’ physical performance.

Keywords: strength, indoor soccer, team sports, sprint, change of direction

Introduction

Futsal is a multiple-sprints sport in which high-intensity phases are more prevalent than in soccer and other intermittent sports (1,5). It is characterized by intermittent bouts of activity during which players have to be able to perform short specific actions every 8–9 seconds (5) as an important prerequisite for successful participation (11). During the game, futsal players cover approximately 118 m·min⁻¹ (1,23), of which 13.7% is at high-intensity running speed (18.1–25.0 km·h⁻¹) and 8.9% is at sprinting speed (>25.1 km·h⁻¹) (1), involving short recovery periods of 55–63 seconds between consecutive sprints (6). Owing to these great physical demands, it is important for futsal players to be capable of sustaining forceful muscle contractions throughout the matches (11).

Due to the high demands involving short anaerobic actions and the accumulation of fatigue during futsal matches (33), performance in the countermovement jump (CMJ) and 20-m LSS very likely decreased after a 9-week preseason period in professional Brazilian players (7), others did not find a regression in jumping and acceleration performance during similar preseason periods (35). Moreover, there are reports evidencing the maintenance of performance in an RSA test (mean time) (2) and in the CMJ and 5-m sprint (36) during the in-season period. Given these
contrasting results, it would be interesting to further elucidate futsal players’ specific physical fitness evolution during the competitive season.

Plyometrics is one of the most popular and widely used training strategies to improve physical performance in team sport players (3,15,18,29). To date, some authors have demonstrated that plyometric training could be a safe, effective, and useful strategy to improve jump, sprint, and change of direction performance (24,36) in soccer. However, there is a lack of studies about the effectiveness of plyometric training in futsal players. Furthermore, it is unknown if different plyometric training load timing during the week can have different effects on futsal players’ physical performance adaptations. In this sense, it would be interesting to determine the effectiveness of different plyometric training programs (i.e., the same total volume performed in 1 or split into 2 days per week) in futsal players during the competitive period because this knowledge might help coaches and physical fitness trainers to optimize specific training strategies. Knowing if a given plyometric training distribution can affect futsal players’ physical performance can provide relevant information to improve neuromuscular training programs in this sport discipline.

Therefore, the aim of the present study was to analyze the effect of 2 different short-term plyometric training programs (i.e., 1 vs. 2 days per week), during the competitive season, on performance in the LSS, CODA, RSA, and bilateral and unilateral (D, dominant and ND, non dominant) vertical jump (VJ) and horizontal jump (HJ) capacity in futsal players.

**METHODS**

**Experimental Approach to the Problem**

Relevant fitness tests such as LSS, CODA, RSA, VJ, and HJ have been previously undertaken in futsal players (2,4,7,11,19). However, the present cluster randomized study was designed to determine the effects of 2 different 6-week plyometric training programs in amateur futsal players. In this sense, this study was conducted over 6 consecutive weeks during the competitive period. The testing procedures were carried out at the beginning of the second phase of the competition fixture (Pretest, in January) and at the end of the 6-week training program (Posttest, in March). The tests were performed after 48 hours of rest and on 2 consecutive days. No strenuous exercises were performed within the 48 hours immediately before the training sessions, and the study was supervised by the researchers at all times.

**Subjects**

Forty-four male futsal players (age = 22.5 ± 5.0 years, body mass = 69.3 ± 9.8 kg, height = 1.7 ± 0.1 m, body mass index = 22.4 ± 2.7 kg·m⁻²) volunteered to participate in this study. They were all amateur players from the Spanish national league. Their experience in futsal and in strength training was of at least 6 months and more than 2 years, respectively. All players regularly performed endurance, sprint, and futsal-specific training 2–3 days per week as well as playing an official weekly match during the competitive period. All players belonged to different teams from the same futsal club. The same physical trainer supervised all training sessions, applying a similar total weekly training load on all 3 groups. Five players withdrew from the study because they were injured (n = 2, traumatic injury during futsal matches) or did not complete the full intervention program (n = 3). Players were divided into 3 training groups (teams acting as units of randomization) differing in weekly plyometric training load as a result of random assignment made by drawing lots. The 2-day plyometric training group (PT2D; n = 15, 71.1 ± 8.6 kg, 1.7 ± 0.1 m, 23.6 ± 2.2 kg·m⁻²) performed 2 plyometric sessions per week; the 1-day plyometric training group (PT1D; n = 12, 71.7 ± 11.6 kg, 1.8 ± 0.1 m, 22.6 ± 3.4 kg·m⁻²) performed 1 plyometric session per week; and the control group (CG; n = 12, 65.1 ± 8.6 kg, 1.8 ± 0.1 m, 21.0 ± 2.1 kg·m⁻²) did not perform plyometric training. PT1D and PT2D performed the same weekly plyometric training volume. Written informed consent was obtained from each of the participants after a detailed written and oral explanation of the potential risks and benefits resulting from this study participation. The study was conducted according to the Declaration of Helsinki (2013) and was approved beforehand by the local ethics committee.

**Procedures**

The testing procedures were carried out in 2 consecutive days in the Pretest and in the Posttest. All the futsal players were familiar with the procedures undertaken in this study, as they were part of their follow-up measures. During the first day, LSS (5 and 15 m), CODA (505 test), and RSA were assessed. On the second day of testing, players were assessed for VJ and HJ. Tests were preceded by a standard warm-up consisting of 7 minutes of slow jogging followed by 4 progressive sprints with and without change of direction.

**Training Program**

The 6-week intervention period consisted of performing 2 (PT2D group) weekly sessions or 1 (PT1D group) weekly session of plyometric programs. Before the training program, the futsal players performed a standardized warm-up similar to that completed during testing. Training volume (sets × repetitions) was the same for both groups, and the sessions lasted 15–30 minutes each. Table 1 shows in detail the exercises, weekly frequency, number of repetitions, and number of sets in the 2 training programs. All the futsal players were supervised by one of the investigators during the whole training intervention. The CG did not perform any specific plyometric training.

**Measures**

*Straight Sprint Test.* Straight line sprint time over 5 and 15 m was measured using infrared photoelectric cells (Microgate Polifemo Radio Light, Bolzano, Italy). The starting position
**Table 1.** Short-term plyometric training programs (exercises, weekly frequency, number of repetitions, and number of sets) for the 2-day (PT2D) and 1-day (PT1D) per week plyometric training group.*

<table>
<thead>
<tr>
<th>Training</th>
<th>Exercise</th>
<th>PT2D group</th>
<th>PT1D group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>W1</td>
<td>W2</td>
</tr>
<tr>
<td>Plyometric</td>
<td>Arm swing horizontal countermovement jump</td>
<td>2 × 4</td>
<td>2 × 4</td>
</tr>
<tr>
<td></td>
<td>HSLJJ</td>
<td>2 × 6</td>
<td>2 × 6</td>
</tr>
<tr>
<td></td>
<td>VCMJAS</td>
<td>2 × 4</td>
<td>2 × 4</td>
</tr>
<tr>
<td></td>
<td>VSLJJ</td>
<td>2 × 6</td>
<td>2 × 6</td>
</tr>
<tr>
<td></td>
<td>VDJ</td>
<td>2 × 4</td>
<td>2 × 4</td>
</tr>
<tr>
<td></td>
<td>VDJ D</td>
<td>2 × 4</td>
<td>2 × 4</td>
</tr>
<tr>
<td></td>
<td>VDJ ND</td>
<td>2 × 4</td>
<td>2 × 4</td>
</tr>
<tr>
<td>Change of direction</td>
<td>Side-to-side Ankle Hops</td>
<td>2 × 7</td>
<td>2 × 7</td>
</tr>
<tr>
<td></td>
<td>Lateral Steps 2 sound 1 in and out</td>
<td>2 × 21</td>
<td>2 × 21</td>
</tr>
<tr>
<td>Actions per session</td>
<td>36</td>
<td>84</td>
<td>36</td>
</tr>
<tr>
<td>Actions per week</td>
<td>120</td>
<td>120</td>
<td>176</td>
</tr>
</tbody>
</table>

*W = week; S = session; HSLJJ = horizontal single leg lateral jump; VCMJAS = arm swing vertical countermovement jump; VSLJJ = vertical single leg lateral jump; VDJ = vertical drop jump; VDJ D = dominant leg vertical drop jump; VDJ ND = nondominant leg vertical drop jump.
**Table 2.** Pretest and posttest linear straight sprint (LSS) and change of direction ability (CODA) results for the 2-day (PT2D) and 1-day (PT1D) per week plyometric training group and control group (CG).*

<table>
<thead>
<tr>
<th></th>
<th>PT2D</th>
<th></th>
<th>PT1D</th>
<th></th>
<th>CG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td>Mean</td>
<td>Dif. (%)</td>
<td>ES</td>
<td>Pretest</td>
</tr>
<tr>
<td>LSS (s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 m</td>
<td>1.05 ± 0.08</td>
<td>1.03 ± 0.07</td>
<td>−2.75</td>
<td>−0.29</td>
<td>1.05 ± 0.04</td>
<td>0.99 ± 0.06</td>
</tr>
<tr>
<td>15 m</td>
<td>2.43 ± 0.15</td>
<td>2.36 ± 0.11</td>
<td>−2.84</td>
<td>−0.64</td>
<td>2.42 ± 0.04</td>
<td>2.37 ± 0.05 †</td>
</tr>
<tr>
<td>CODA (s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>505 test</td>
<td>2.28 ± 0.09</td>
<td>2.17 ± 0.02 †</td>
<td>−4.83</td>
<td>−5.50</td>
<td>2.28 ± 0.09</td>
<td>2.24 ± 0.06</td>
</tr>
</tbody>
</table>

*Mean Dif. = mean differences; ES = effect size.
†Significant difference between pretest p < 0.01.
‡Significant difference between pretest p < 0.05.

**Table 3.** Pretest and posttest repeat sprint ability (RSA) results for the 2-day (PT2D) and 1-day (PT1D) per week plyometric training group and control group (CG).*

<table>
<thead>
<tr>
<th></th>
<th>PT2D</th>
<th></th>
<th>PT1D</th>
<th></th>
<th>CG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td>Mean</td>
<td>Dif. (%)</td>
<td>ES</td>
<td>Pretest</td>
</tr>
<tr>
<td>RSA (s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.10 ± 0.04</td>
<td>1.08 ± 0.08</td>
<td>−2.27</td>
<td>−0.25</td>
<td>1.12 ± 0.03</td>
<td>1.06 ± 0.04 †</td>
</tr>
<tr>
<td>5 m</td>
<td>4.45 ± 0.23</td>
<td>4.44 ± 0.27</td>
<td>−0.33</td>
<td>−0.04</td>
<td>4.47 ± 0.22</td>
<td>4.36 ± 0.17 †</td>
</tr>
<tr>
<td>30 m</td>
<td>6.43 ± 0.40</td>
<td>5.61 ± 0.21</td>
<td>−12.66</td>
<td>−0.38</td>
<td>6.70 ± 0.16</td>
<td>6.35 ± 0.23 †</td>
</tr>
<tr>
<td>5 m</td>
<td>24.76 ± 2.90</td>
<td>24.15 ± 2.36</td>
<td>−2.46</td>
<td>−0.26</td>
<td>26.82 ± 1.33</td>
<td>26.16 ± 1.03 †</td>
</tr>
</tbody>
</table>

*Mean Dif. = mean differences; ES = effect size.
†Significant difference between pretest p ≤ 0.05.
‡Significant difference between pretest p < 0.01.
Each player had to perform 6 repetitions over 5 m (mean 5 m and the sum of the times recorded to cover the 6 photoelectric cells (Microgate Polifemo Radio Light). The time was measured for 5 and 30 m using 3 photoelectric cells (Microgate Polifemo Radio Light). The mean and the sum of the times recorded to cover the 6 repetitions over 5 m (mean 5 m and \( \sum 5 m \)) and over 30 m were taken as indicators of performance (31).

### Vertical Jump Test

The participants carried out 3 bilateral VJs with countermovement and hands on the waist (CMJ), 3 unilateral VJs with the dominant leg and 3 with the nondominant leg (CMJND), choosing the best result for each jump. The procedure of the jumps was according to the indications of Maulder et al. (9). The height of the jump was determined using a contact platform (Optojump, Microgate, Bolzano, Italy).

### Horizontal Jump Test

The distance for the countermovement jump (HJ) was measured using a tape measure, following the protocol established by Yanci et al. (35). The participants were instructed on how to use the arm swing in bilateral jump actions, and unilateral jumps with the dominant and nondominant leg. The distance jumped in each of the cases was measured from the jumping line to the nearest part of contact on landing. The best of 3 attempts was recorded for each type of jump.

### Change of Direction Ability Test (505 Agility Test)

In the 505 agility test, the players had to run forward a distance of 5 m to a line, pivot 180°, and return to the starting position (10,27). A photocell (Microgate Polifemio Radio Light) was placed on the start/finish line to record the time taken for the test. The players made an accelerated run from 10 m behind the start line where the time recording began. The participants carried out a total of 3 trials with 2-minute recovery between each trial, and the best of the 3 was chosen for analysis.

### Repeated Sprint Ability Test

Each player had to perform 6 maximum sprints of 30 m with 25 seconds of active recovery between them. The time was measured for 5 and 30 m using 3 photoelectric cells (Microgate Polifemo Radio Light). The mean and the sum of the times recorded to cover the 6 repetitions over 5 m (mean 5 m and \( \sum 5 m \)) and over 30 m (mean 30 m and \( \sum 30 m \)) were taken as indicators of performance (31).

### Statistical Analyses

Results are presented as mean ± SD. The normal distribution of the results of the variables applied was tested using the Kolmogorov-Smirnov test, and statistical parametric techniques were carried out. Both at baseline (pretest) and posttest, a 1-way analysis of variance (ANOVA) with a Bonferroni post hoc analysis was used to compare results between groups. The between-group (PT2D, PT1D, and CG) comparison from pretest to posttest was calculated by a 2-way mixed ANOVA (group \( \times \) time) with a Bonferroni post hoc analysis. In addition, a \( t \)-test for paired samples was used to analyze the differences between the pretest and posttest.

Table 4. Vertical jump (VJ) and horizontal jump (HJ) results in pretest and posttest for the 2-day (PT2D) and 1-day (PT1D) per week plyometric training group (CG).*

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff. (%)</th>
<th>CS</th>
<th>ES</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Diff. (%)</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT2D</td>
<td>43.30±4.32</td>
<td>43.33±4.79</td>
<td>0.34±0.32</td>
<td>43.20</td>
<td>43.96</td>
<td>0.82±0.32</td>
<td>43.33</td>
<td>3.54±0.32</td>
<td>13.98</td>
</tr>
<tr>
<td>PT1D</td>
<td>25.21±2.53</td>
<td>20.93±1.79</td>
<td>4.28±0.04</td>
<td>25.26</td>
<td>20.93</td>
<td>0.96±0.04</td>
<td>22.93</td>
<td>1.32±0.04</td>
<td>10.71</td>
</tr>
<tr>
<td>CG</td>
<td>25.26±2.52</td>
<td>22.93±1.79</td>
<td>2.33±0.04</td>
<td>25.26</td>
<td>20.96</td>
<td>0.64±0.04</td>
<td>20.10</td>
<td>2.85±0.04</td>
<td>4.08</td>
</tr>
</tbody>
</table>

† Significant difference between pretest and posttest.
* Mean Dif. = mean differences; ES = effect size; CMJ = counter movement jump; CMJD = dominant leg counter movement jump; CMJND = non dominant leg counter movement jump; HCMJ = horizontal counter movement jump; HCMJD = horizontal dominant leg counter movement jump; HCMJND = horizontal non dominant leg counter movement jump.
posttest independently for each group (PT2D, PT1D, and CG). The mean differences between pretest and posttest on each group were expressed as percentages: mean difference (\%) = \{(\text{Posttest} - \text{Pretest})/\text{Pretest}\} \times 100. To allow a better interpretation of the results, practical significance between the pretest and posttest independently for each group was assessed by calculating Cohen’s effect size (ES). Effect sizes of above 0.8, between 0.8 and 0.5, between 0.5 and 0.2, and lower than 0.2 were considered as large, moderate, small, and trivial, respectively (28). The statistical significance was set at \( p \leq 0.05 \). Data analysis was performed using the Statistical Package for Social Sciences (version 21.0 for Windows; SPSS Inc, Chicago, IL, USA).

**RESULTS**

**Straight Sprint and Change of Direction Ability**
The pretest and posttest mean values of LSS and CODA tests are presented in Table 2. According to the 2-way mixed ANOVA analysis (group × time), no sprint and CODA variable showed statistical significance. Despite the fact that the mean differences between pretest and posttest were not significant for all groups, PT2D and PT1D presented practically important improvements in the performance of 5-m and 15-m LSS after the short-term plyometric training (ES = −0.29 to −1.00, small to large). However, the CG worsened in its 15-m LSS performance (ES = 0.73, moderate). In relation to CODA, PT2D obtained a significant improvement after the short-term plyometric training intervention compared with the pretest (\( p \leq 0.05 \); ES = −5.50, large), whereas moderate changes were observed in PT1D (\( p > 0.05 \); ES = −0.67), and no changes were observed in CG (\( p > 0.05 \), ES = 0.00).

**Repeated Sprint Ability**
Regarding RSA (Table 3), PT1D and CG improved significantly RSA mean time and \( \sum \) RSA (\( p \leq 0.05 \); ES = −0.65 to −1.53, moderate to large). Nevertheless, PT2D showed only a small improvement after the short-term plyometric training program (\( p > 0.05 \); ES = −0.26 to −0.38). According to the 2-way mixed ANOVA analysis (group × time), only 30-m \( \sum \) RSA showed statistical significance (\( p < 0.01 \)).

**Vertical Jump and Horizontal Jump Performance**
With regard to VJ performance, PT2D (\( p < 0.01 \); ES = −0.44 to −0.99, moderate to large) and CG (\( p \leq 0.05 \); range ES = −0.85 to −1.37, large to very large) significantly worsened their performance in almost all types of VJs (Table 4). However, in the CMJND of CG (\( p > 0.05 \), ES = −0.30, small), as in all VJs of PT1D (\( p > 0.05 \), ES = −0.04 to 0.64, trivial to moderate), no statistical differences were observed. Regarding the HJs (Table 3), only PT2D obtained a significant improvement in posttest performance (\( p \leq 0.05 \); ES = 0.46 to 0.62, small to moderate). Moreover, PT1D and CG also slightly improved their performance (trivial or small), but these changes were not significant. According to the 2-way mixed ANOVA analysis (group × time), no VJ and HJ variable showed statistical significance.

**DISCUSSION**

This study showed that in-season futsal training per se was capable of improving RSA. However, although CODA was maintained during the training period, sprint and VJ performances were significantly impaired. By contrast, irrespective of the training regimen, plyometric training was effective in improving futsal players’ 15-m sprint performance, CODA, and HJ. Curiously, PT1D showed similar improvement in RSA compared with CG after the training intervention, whereas PT2D did not show significant change.

It has been previously shown that preseason futsal training impairs the 20-m sprinting speed of professional players (7,22). This phenomenon, which can also be observed in soccer (8,21), has been attributed to the accumulation of fatigue (12) and the interference effect of aerobic and strength-power-speed training (13,32). This is the first time that an impaired 15-m sprint speed has been observed in response to in-season futsal training, and the concurrent adaptation effects elicited by the “aerobic” technical-tactical training (combined with matches) probably explain the impaired sprint-specific neuromuscular function. In fact, it has been recently shown that technical-tactical training sessions elicit ~75% of maximal heart rate, and ~48% of the training time is spent above the ventilatory threshold (VT) (34). This high aerobic demand probably explains why professional futsal players present maximal oxygen uptake values > 60 ml·kg\(^{-1}\)·min\(^{-1}\), combined with high VT (26).

Both PT1D and PT2D meaningfully improved their 15-m sprinting speed (ES = −0.64 to −1.00, moderate to large), whereas only PT1D improved the 5-m sprinting speed (ES = −1.00, large). These results suggest that exposure to only 1 weekly plyometric training session can cause important performance changes in futsal players and can be practically implemented due to the congested fixtures of futsal competitions, which imply limited training days/sessions due to the necessity of recovering from matches and traveling. Short sprints are very frequent in futsal matches (5) and the ability to engage in high-intensity actions appears to determine competitive levels in team sports (16), including futsal (5). Hence, plyometric training can counteract the interference phenomenon between concurrent aerobic and neuromuscular training (15,22), besides not eliciting fatigue accumulation (25), and result in competitive advantages for the teams due to its effects on the player’s ability to sprint faster on the court.

Interestingly, both plyometric training groups also displayed practically important improvements in CODA, with PT2D showing better results than PT1D. It is important to emphasize that CG did not improve this ability, suggesting that futsal training alone is not effective in enhancing players’...
CODA. This is consistent with previous findings in soccer players (17,18) and suggests that plyometric training can enhance sprinting speed and other neuromuscular factors related to change of direction maneuvers. Since futsal courts are smaller than soccer pitches, it can be assumed that CODA is highly and repeatedly required during games. Therefore, we advocate the use of plyometric training during the in-season futsal period to optimize players’ specific physical components related to their on-court ability to rapidly change direction. It is possible that some selected exercises (i.e., side-to-side ankle hops and lateral steps 2 sound 1 in and out) are more effective to improve CODA, but this issue requires more studies. Additionally, testing the combination of plyometric training with other eccentric overload strategies (30) is encouraged in the future.

The RSA is determined by multiple muscular and neural factors (20) and is considered one of the most relevant qualities of physical fitness in team sports players. In futsal, RSA is improved during the preseason due to the inherent activities of futsal training (repeated high-intensity efforts, sprinting, etc) (2). Of note, adding repeated-sprint training to the futsal preparation did not result in further changes in RSA (19). To our knowledge, this is the first time that an improvement in the RSA has been observed during the in-season period in futsal players. However, only PT1D significantly improved RSA, whereas PT2D did not experience any changes. There is no apparent explanation for these results. Nevertheless, a close examination of Table 3 reveals that PT2D presented, for example, a lower pretraining \( \sum 30 \) m (24.76 ± 2.90 seconds) than PT1D (26.82 ± 1.33 seconds) and CG (26.90 ± 2.13 seconds). Given that athletes with higher physical fitness indicators at the baseline are more resilient to training-induced changes, one could expect to find lower RSA responsiveness in PT2D than in the other groups. As an alternative, we could speculate that RSA test heavily taxes the neuromuscular and metabolic systems’ viewpoint (10), and any residual fatigue or damage caused by higher exposure rates to plyometric training per week (even with the same total volume) could have negatively affected its performance in PT2D during the posttest. Future studies also need to address the “quality” of plyometric training sessions (i.e., jump technique, contact time, etc) performed with different weekly distributions.

Coinciding with a previous report on futsal players studied during the preseason (9), the players analyzed herein presented a reduction in VJ performance. This reduction, alongside the deterioration in 15-m sprint ability, suggests the occurrence of the concurrent training effects between the high-volume technical and tactical training and the relatively small-volume neuromuscular training (13,32). In addition, this finding corroborates the tendency of VJ and sprint performances to correlate with each other and change in the same direction over the competitive season (14). By contrast, the horizontal axis plyometric stimuli appeared to cause positive adaptations in HJ performance (especially in PT2D). These contrasting responses can be due to the fact that the futsal players in our sample had less previous experience with HJ training than with VJ training. However, a transference effect was expected between HJ improvement and the change in 5-m acceleration, as found in a previous study (24) with soccer players. It remains to be established whether improvements in VJ or HJ should really be targeted by futsal coaches and fitness trainers, since it is possible that changes in these abilities do not directly translate into better on-court performance.

**Practical Applications**

Although the futsal training per se improved RSA, it did not cause improvements in 15-m sprint, CODA, VJ, or HJ performance. However, both training programs (i.e., PT2D and PT1D) were effective in improving 15-m sprint, change of direction ability, and HJ performance. The fact that the 1-day-per-week plyometric training was capable of improving RSA, and in the 2-days-per-week plyometric training group, only trivial improvements were obtained, may indicate that a 1 plyometric training day may be the most appropriate program for improving physical performance in futsal players.

**Acknowledgments**

The authors would like to thank the futsal players and coaches for the opportunity to carry out this investigation.

**References**


