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Research article

Microdosing Plyometric Training Enhances Jumping Performance, Reactive Strength Index, and Acceleration among Youth Soccer Players: A Randomized Controlled Study Design

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Abstract
Microdosing can facilitate better accommodation to the training stimulus while aligning with the scheduling needs of teams. In this study, the effectiveness of microdosing exposure was investigated by comparing the effects of microdosing plyometric jump training (microPJT) with those of regular plyometric jump training (regPJT) and a control group not exposed to plyometric training. The comparison focused on the effects on jumping performance, reactive strength index (RSI), and acceleration over a 10-meter distance. Fifty-two male youth soccer players (16.3 ± 0.6 years old) from under-17 teams participated in a randomized controlled study, with interventions lasting 8 weeks. Assessments were conducted twice, before and after the intervention, measuring squat jump (SJ), countermovement jump (CMJ), RSI during drop jumps, and acceleration in a 10-meter sprint test. The regPJT group completed 34 bilateral jumps and 48 unilateral jumps per week over two weekly sessions, totaling 82 jumps. Conversely, the microPJT group performed 17 bilateral jumps and 24 unilateral jumps weekly over 4 sessions week, totaling 41 jumps. Significant interactions between groups and time were observed concerning SJ ($p < 0.001$; $\eta^2 = 0.282$), CMJ ($p < 0.001$; $\eta^2 = 0.368$), RSI ($p < 0.001$; $\eta^2 = 0.400$) and 10-m sprint time ($p < 0.001$; $\eta^2 = 0.317$). Between-group analysis indicated that both the microPJT ($p < 0.001$) and regPJT ($p < 0.001$) groups exhibited significant better results compared to the control group in post-intervention evaluation of SJ, CMJ, RSI and 10-m sprint time, while no significant differences were found between experimental groups ($p > 0.050$). In conclusion, this study has revealed that both microPJT and regPJT are equally effective in enhancing jumping performance and acceleration time in soccer players. This suggests that a smaller training volume, distributed more frequently across the week, can effectively induce improvements in soccer players.

Key words: Football; resistance training; physical fitness; athletic performance; reactive strength training.

Introduction

The challenges imposed by weekly team sports training programs necessitate the optimization of training stimuli, utilizing the minimal effective dose to minimize physical strain on players, enabling their participation in sessions and matches with minimal fatigue (Issurin, 2016; Afonso et al., 2020). This involves applying the necessary training stimulus to maintain or even enhance athletic performance (Mujika et al., 2018). Achieving this balance between specific training methods and their concurrent effects, among increasingly congested fixtures in team sports like soccer, presents a significant difficulty (Ekstrand et al., 2004).

Efforts to mitigate the impact of training volume on players emphasize intensity and reducing overall volume (McQuilliam et al., 2023). However, certain training methods, such as resistance training, even when conducted at a lower frequency, can still disrupt the flow of in-field sessions due to residual fatigue and scheduling conflicts for players (Cuthbert et al., 2024). To address this challenge, microdosing has emerged as a popular approach in recent years (Afonso et al., 2022; Cuthbert et al., 2024). It advocates for the distribution of a single session's volume across multiple days (distributed practice), while decreasing the volume of a given training method (Afonso et al., 2022). This strategy aims to ensure the minimal dose necessary to achieve training objectives without compromising players' physical readiness for the primary focus of soccer training: tactical and technical in-field sessions (Bonder and Shim, 2023).

One of the common practices employed by strength and conditioning coaches as supplementary training methods to in-field sessions is plyometric jump training (Weldon et al., 2022). This training method focuses on exercises witch taxes rapid muscle lengthening and shortening, primarily involving the stretch-shortening cycle (Markovic and Mikulic, 2010). Plyometric jump training is particularly relevant for soccer players as it enhances muscle power, change-of-direction ability, and speed (Bedoya et al., 2015; van de Hoef et al., 2020), crucial for maneuvers such as sprinting, jumping, and changing direction on the field. These adaptations significantly contribute to overall athletic fitness, thereby improving performance in key aspects of soccer gameplay (Ramirez-Campillo et al., 2020). However, plyometric training can induce acute fatigue due to its high-intensity nature and the demand it places on the neuromuscular system which can prevail (Skurvydas et al., 2010), although shortly, possible negatively affecting the physical readiness for in-field session (Chatzinikolaou et al., 2010).

Several studies have examined the impact of varying plyometric jump training volumes and frequencies on achieving optimal physical fitness adaptations. For instance, Chaabene and Negra (2017), Palma-Muñoz et al (2021), or Otero-Esquina et al (2017) have all reported similar levels of improvement in countermovement jump (CMJ) across different training volumes, suggesting no significant difference between lower and higher training volumes. Furthermore, studies by Bianchi et al. (2019) and

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Chaabene and Negra (2017) investigating the effects of plyometric training on 10-meter sprint times found comparable improvements. Most of these studies compared two training sessions, with the reduction in volume achieved through a decrease in repetitions. However, Ramirez-Campillo et al. (2018b) uniquely compared training once a week to training twice a week in their lower-volume regimen.

The concept of microdosing differs somewhat from these approaches. The idea is to spread the load throughout the week while maintaining a smaller total volume, which can still be effective for maintaining or even facilitating favorable adaptations (Afonso et al., 2022). For example, a study (Cuadrado-Peñafiel et al., 2023) examining the microdosing concept in sprint distribution applied to field hockey players revealed that microdosing yielded similar effects to traditional sprint training, thereby enhancing sprint performance. However, it is important to note that this study did not actually reduce the overall training volume with microdosing; it simply distributed it across the week (Cuadrado-Peñafiel et al., 2023). Thus, it only represents distributed practice rather than true microdosing, which involves both reducing the training dose and spreading it out over the week (Afonso et al., 2022).

As the microdosing concept continues to evolve, and given that only a limited amount of research has explored the idea of achieving similar effects to traditional training by spreading a smaller volume of exposure across the week (Afonso et al., 2022), further investigation is needed to fully grasp its real effects and practicality for strength and conditioning coaches. Conducting studies in this area could offer concrete evidence for practitioners and potentially shed light on its feasibility within training schedules, facilitating its integration into practice contexts.

This study aimed to compare the effectiveness of microdosing exposure on squat jump (SJ), countermovement jump (CMJ) height, reactive strength index (RSI) during drop jumps, and acceleration in a 10-meter sprint test, by contrasting the effects of microdosing plyometric jump training (microPJT) with regular plyometric jump training (regPJT), alongside a control group not undergoing plyometric training. Our first hypothesis posits that microdosing will yield comparable adaptations to those observed with regular training. This assertion is supported by prior research indicating that utilizing half the usual workload can still produce similar adaptations to full-load plyometric training in soccer players (Chaabene and Negra, 2017).

Methods

Study design

This study employed a randomized controlled design, comparing two experimental groups (microPJT and regPJT) to a control group enrolled solely in regular in-field sessions. The two experimental groups underwent an 8-week training intervention, supplementing their regular in-field sessions (Figure 1). Participants belonged to two soccer teams, selected for convenience. These soccer teams competed at the same competitive level, sharing identical schedules and training frequencies. Furthermore, the content of their sessions followed similar approaches, with neither team incorporating additional training sessions beyond their regular routines, focusing solely on in-field sessions.

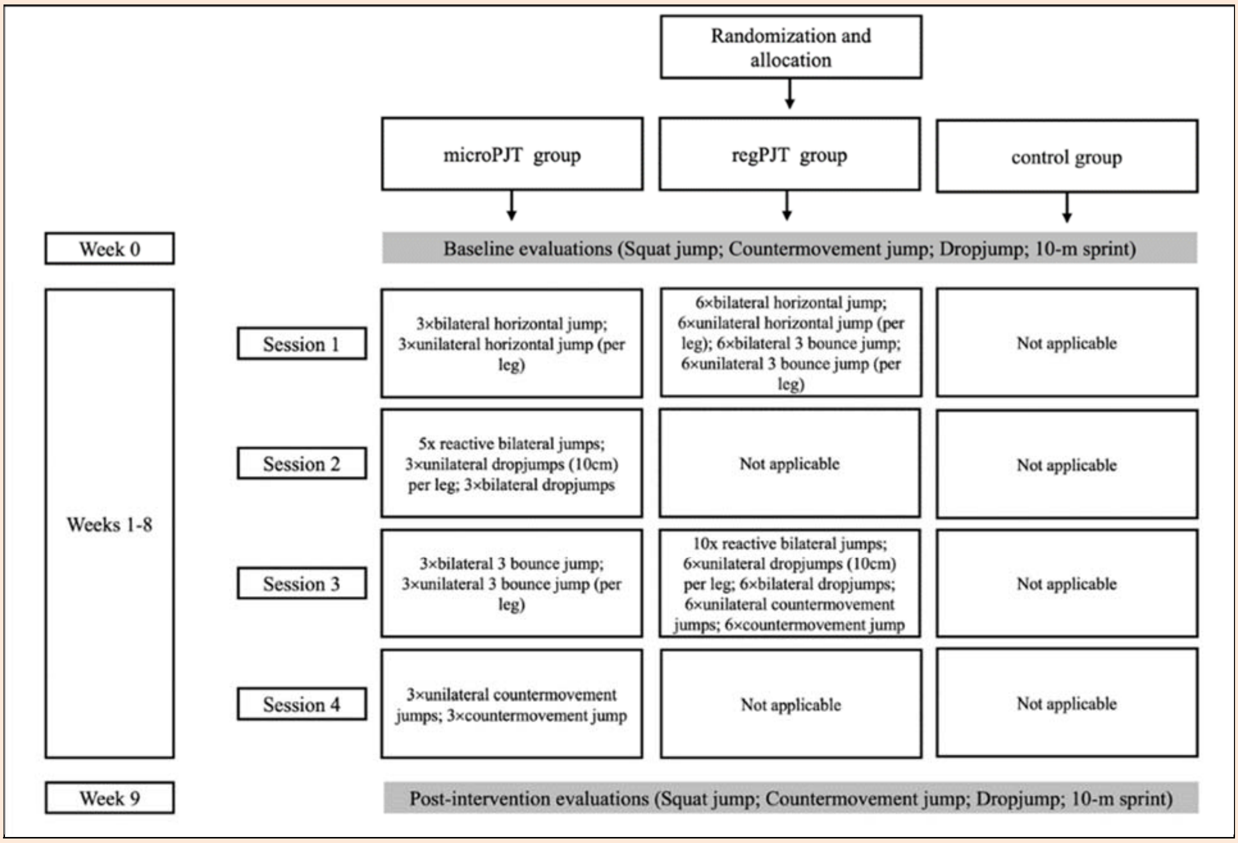

Figure 1. **Illustration describing the study's design.**

Randomization was conducted before the initial evaluation to ensure allocation concealment. However, an equal number of players from each team were randomly assigned to each group, with the aim of achieving balanced representation of both teams within each group. The randomization utilized a simple strategy, using opaque envelopes randomly assigned to players. Both teams had a similar number of players across the three groups, maintaining balance. Players were evaluated one week before the start of the intervention and again immediately after the 8th week. Evaluations were performed by researchers blinded to group assignment. However, blinding the intervention and participants was not possible due to the nature of sports interventions.

Ethical aspects

Participants and their legal guardians were informed about the study design, risks, and benefits. Upon agreement, legal guardians provided free and informed consent, explicitly stating the option to withdraw from the study at any time without consequence. The study complied with human research standards in accordance with the Declaration of Helsinki. Approval for the study was secured from the Institutional Ethical Review Board of Chengdu Institute of Physical Education (2023#125).

Participants

The sample size for this study was determined based on previous studies comparing smaller versus higher training frequencies of plyometric training in soccer players with respect to adaptations in jumping performance parameters (Yanci et al., 2016; Ramirez-Campillo et al., 2018b). Specifically, it was calculated for an effect size of 0.5, considering three groups and 2 measurements, aiming for a power of 0.95 and a significance level of 0.05. Utilizing G*power software (version 3.1.9), it was recommended that the study involve 51 participants.

To be eligible for participation, individuals had to meet certain criteria: (i) they needed to be outfield players, (ii) they must not have engaged in any other resistance training aside from what was assigned by the experiment, (iii) they should not have sustained any injuries within the past month or during the intervention period, (iv) they were required to adhere to at least 85% of the training intervention, and (v) they must not have missed the two physical fitness assessments. The exclusion criteria included: (i) being a goalkeeper; (ii) having sustained an injury within the month preceding the commencement of the study, or experiencing an injury during the experiment that led to missing training sessions; (iii) missing more than 15% of the available intervention sessions; (iv) failing to attend any of the evaluation tests or periods.

Following the recruitment phase, 57 potential participants were identified (see Figure 2). Subsequently, after applying the eligibility criteria, 52 participants were deemed suitable for inclusion in the final analysis (Figure 2). These participants had an average age of 16.3 ± 0.6 years, a body mass of 62.3 ± 2.1 kilograms, a height of 173.5 ± 2.9 centimeters, and an average of 4.9 ± 2.9 years of experience. It is noteworthy that all participants were affiliated with regional-level under-17 teams, with an average of four training sessions per week. The training volume was similar across teams, typically ranging from 80 to 100 minutes per session (depending on the day of the week). Moreover, teams exhibited comparable levels of exposure to technical training as well as the main training objectives.

Plyometric jump training

While the control group continued with their regular in-field training sessions without any additional strength and

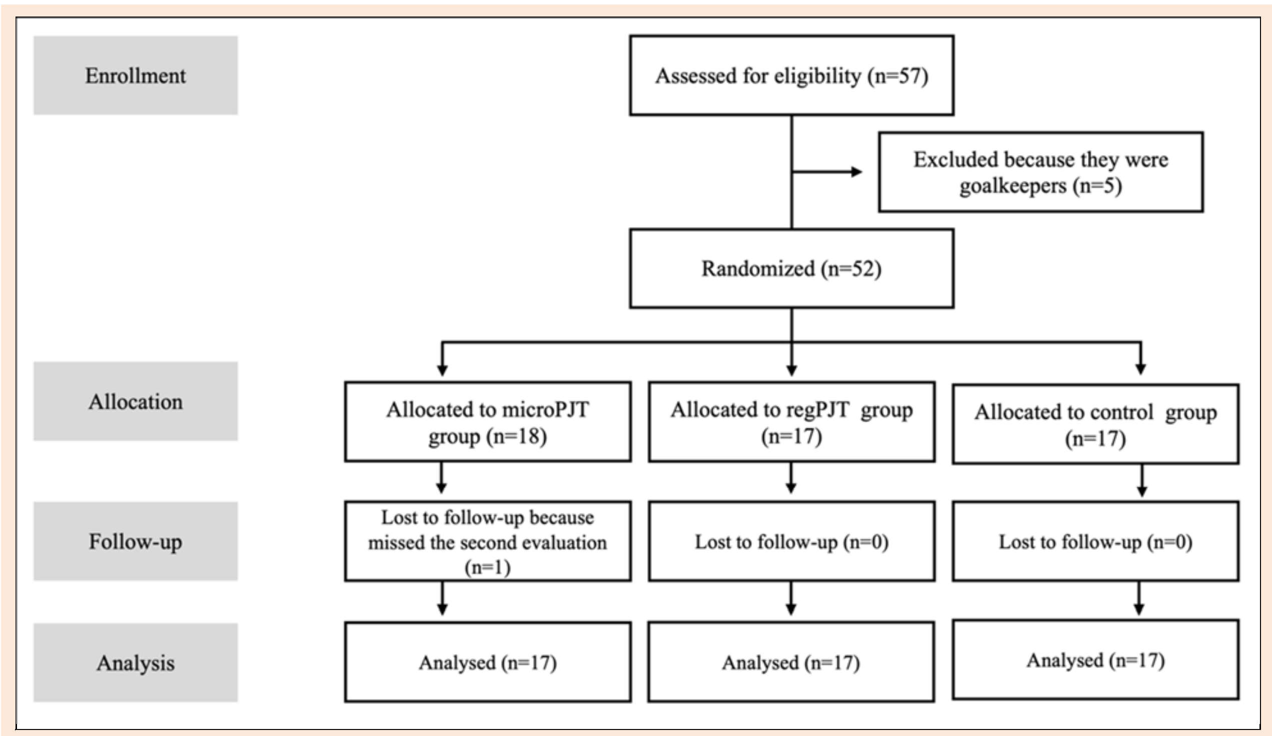

Figure 2. Flowchart illustrating participant recruitment and allocation.

conditioning training, the experimental groups (microPJT and regPJT) participated in supplementary plyometric jump training in addition to their usual in-field sessions.

The regPJT group participated in two weekly training sessions of plyometric jump training. In the first session, they engaged in horizontal-based jump exercises, while in the second session, they focused on vertical-based jump exercises. The specific exercises conducted are outlined in Figure 1. During the first session, players performed 6 repetitions of bilateral horizontal jumps, 6 repetitions of unilateral horizontal jumps per leg, 6 repetitions of bilateral 3-bounce jumps, and 6 repetitions of unilateral 3-bounce jumps per leg. In the second session, players completed 10 repetitions of reactive bilateral jumps, 6 sets of unilateral drop jumps (10cm) per leg, 6 repetitions of bilateral drop jumps, 6 repetitions of unilateral countermovement jumps, and 6 repetitions of countermovement jumps. The repetitions were performed continuously without rest, while a rest period of 3 minutes was provided between exercises. Participants completed only one set per exercise. On average, the sessions of regPJT had a training duration of 14 minutes.

On the other hand, the microPJT group underwent four training sessions (Figure 1). During the first session, they performed 3 repetitions of bilateral horizontal jumps and 3 repetitions of unilateral horizontal jumps per leg. In the second session, they engaged in 5 repetitions of reactive bilateral jumps, 3 repetitions of unilateral drop jumps (10cm) per leg, and 3 repetitions of bilateral drop jumps. The third session included 3 repetitions of bilateral 3-bounce jumps and 3 repetitions of unilateral 3-bounce jumps per leg. Finally, the fourth session consisted of 3 repetitions of unilateral countermovement jumps and 3 repetitions of countermovement jumps. The repetitions were performed continuously without rest, while a rest period of 3 minutes was provided between exercises. Participants completed only one set per exercise. On average, the sessions of microPJT had a training duration of 11 minutes.

In total, the regPJT group completed 34 bilateral jumps and 48 unilateral jumps per week, totaling 82 jumps. Conversely, the microPJT group performed 17 bilateral jumps and 24 unilateral jumps weekly, totaling 41 jumps. All jumps were executed at maximal intensity, adhering to instructions provided to the players. The plyometric training sessions took place on a concrete floor and were preceded by a standardized warm-up protocol, consisting of 5 minutes of jogging and 5 minutes of lower-limb dynamic stretching, which was consistent across both groups.

Physical fitness assessments

The evaluation of jumping and acceleration performances occurred twice during the study, both before and after the intervention, all within the same day of the week. These assessments were conducted indoors in the afternoon, adhering to a structured sequence: starting with a warm-up, comprising 5 minutes of jogging followed by 5 minutes of dynamic stretching focusing on the lower limbs. Subsequently, the sequence included the tests: squat jump, CMJ, drop jump, and a 10-meter linear sprint. Each test was interspersed with a 5-minute break to allow players to recuperate. To ensure consistency, the assessments were preceded by a 24-hour period of rest and maintained identical procedures during both evaluations.

Squat jump test

The squat jump assessment commenced with a preparatory phase, where participants positioned themselves comfortably in a squat stance with hands resting on their hips. Subsequently, they executed an explosive concentric movement, exerting force to propel themselves off the ground while extending their hips and knees. Following this phase, participants transitioned into a landing phase, wherein they absorbed the impact by flexing their knees to cushion the landing and maintain stability. Measurement of the squat jump height was facilitated using the validated MyJump 2 mobile application (1080p Video Recording: 30 frames per second, version 1.0.8, Xiaomi 11i, China), recognized for its reliability in previous research compared to the Optojump photoelectric cell system (Bogataj et al., 2020). Noteworthy correlations were established between the MyJump 2 app and OptoJump, with significant values for both squat jumps ($r = 0.97$, $p = 0.001$) and countermovement jumps ($r = 0.97$, $p = 0.001$) within the total sample (Bogataj et al., 2020). The height of the jump, recorded in centimeters, served as the primary outcome measure. Participants underwent one familiarization attempt followed by two trials, separated by a 3-minute rest interval. The highest jump height achieved was selected for data analysis, with an average within-player coefficient of variation between trials calculated at 2.1%.

Countermovement jump test

The classical countermovement jump protocol was employed, wherein the athlete initiated from a standing position, then swiftly descended into a rapid downward movement by flexing the hips, knees, and ankles. Following this phase, they promptly transitioned into a vertical jump, maintaining extended knees and hands on their hips throughout, before landing back onto the floor. Jump height expressed in centimeters was measured using the MyJump 2 mobile application (1080p Video Recording: 30 frames per second, version 1.0.8, Xiaomi 11i, China). Participants were granted one familiarization attempt, followed by two trials, with a 3-minute rest period in between. The highest jump height recorded was selected for data analysis, revealing an average within-player coefficient of variation between trials of 2.6%.

Dropjump test

The drop jump test served as the means to evaluate the player's RSI, wherein individuals descended from a platform elevated by 20 centimeters and immediately upon landing, executed a maximal upward jump. Jump height was assessed using the MyJump 2 mobile application, utilizing flight time and ground contact time as variables to compute the RSI. The formula utilized to calculate the RSI involved dividing the flight time by the ground contact time. Jump performance was quantified using the same MyJump 2 application. Each participant received one opportunity for familiarization, succeeded by two trials, with a 3-minute interlude separating them. The superior recorded RSI was chosen for subsequent data analysis, with an average within-player coefficient of variation between trials noted at 3.4%.

10-m linear sprint test

The 10-meter linear sprint test was carried out on synthetic turf to evaluate acceleration performance. Participants initiated the sprint from a split stance, maintaining their preferred leg forward. Positioned 40 cm before the initial set of photocells, they were instructed to uphold a consistent starting posture with the same leading leg throughout.

Upon commencement signaled by a countdown, participants were directed to decelerate only after passing the final set of photocells. The height of the photocells was adjusted to match the hip height of each participant accurately. Sprint times were recorded using two pairs of photocells (SmartSpeed, Fusion Sport, Queensland, Australia). Each participant completed two trials of the 10-meter sprint, with a 3-minute break between each trial. The within-participant variability between trials, expressed as a coefficient of variation, averaged at 1.6%. The faster of the two sprint times (measured in seconds) was utilized for subsequent data analysis.

Statistical procedures

The Kolmogorov-Smirnov test ($p > 0.05$) was utilized to assess normality, while Levene's test ($p > 0.05$) was employed to evaluate homogeneity. Upon confirming both normality and homogeneity assumptions, a mixed ANOVA test (2 time* 3 groups) was executed to compare pre- and post-intervention outcomes across different groups. The effect size was determined using partial eta squared (η_p^2). Thresholds were established as follows: values greater than 0.01 were considered indicative of a small effect, those surpassing 0.06 were categorized as moderate, and those exceeding 0.14 were classified as large (Richardson, 2011). Pairwise comparisons were conducted using the Bonferroni test, with Cohen's standardized effect size utilized to analyze the magnitude of differences between groups. Effect size interpretations followed Cohen's criteria (Cohen, 1988), categorizing magnitudes as small ($0.2 \geq d < 0.5$), medium ($0.5 \geq d < 0.8$), and large ($d \geq 0.8$). The SPSS (version 28.0, IBM, USA) was used to execute the statistical tests with significance set at $p < 0.05$.

Results

Baseline comparisons revealed no significant differences between groups on SJ ($F_{2,48} = 0.698$; $p = 0.503$; $\eta^2 = 0.028$), CMJ ($F_{2,48} = 1.828$; $p = 0.172$; $\eta^2 = 0.071$), RSI ($F_{2,48} = 0.287$; $p = 0.752$; $\eta^2 = 0.012$), and 10-m sprint time ($F_{2,48} = 2.450$; $p = 0.097$; $\eta^2 = 0.093$). Descriptive statistics of jumping and acceleration performances pre and post-intervention can be observed in Table 1.

Significant interactions between groups and time were observed concerning SJ height ($F_{2,48} = 9.426$; $p < 0.001$; $\eta^2 = 0.282$). Subsequent between-group analysis indicated that both the microPJT (+2.118cm; $p < 0.001$) and regPJT (+2.235cm; $p < 0.001$) groups exhibited significant better results compared to the control group in post-intervention evaluation. However, no significant differences were detected between the experimental groups (0.118cm; $p = 0.999$). Further within-group (post–pre) analysis revealed significant improvements for both the microPJT (+1.588cm; $p < 0.001$) and regPJT (+2.188cm; $p < 0.001$) groups following the intervention period. Conversely, the control group showed no significant differences in pre-evaluation versus post-evaluation (+0.412cm; $p = 0.154$). Figure 3 illustrates the intra-individual differences (post-pre) across various outcomes.

Significant interactions between groups and time were observed concerning CMJ ($F_{2,48} = 13.960$; $p < 0.001$; $\eta^2 = 0.368$). Subsequent between-group analysis indicated that both the microPJT (+2.412cm; $p < 0.001$) and regPJT (+3.000cm; $p < 0.001$) groups exhibited significant better results compared to the control group in post-intervention evaluation. However, no significant differences were detected between the experimental groups (0.588cm; $p = 0.966$). Further within-group (post–pre) analysis revealed significant improvements for both the microPJT (+1.412cm; $p < 0.001$) and regPJT (+2.059cm; $p < 0.001$) groups following the intervention period. Conversely, the control group showed no significant differences in pre-evaluation versus post-evaluation (+0.294cm; $p = 0.224$).
Significant interactions between groups and time were observed concerning RSI ($F_{2,48} = 16.009$; $p < 0.001$; $\eta^2 = 0.400$). Subsequent between-group analysis indicated that both the microPJT (+0.096ms/ms; $p = 0.008$) and regPJT (+0.128ms/ms; $p < 0.001$) groups exhibited significant better results compared to the control group in post-

Table 1. Mean and standard-deviation of outcome measures for each group before (pre) and after (post) the intervention period.

		microPJT (n=17)	regPJT (n=17)	Control (n=17)
SJ (cm)	Pre	31.4 ± 2.5	31.0 ± 2.8	30.5 ± 1.5
	Post	33.0 ± 1.8#	33.1 ± 1.6#	30.9 ± 1.1
	Post–Pre (%)	5.1	6.8	1.3
CMJ (cm)	Pre	32.9 ± 2.4	32.8 ± 2.6	31.6 ± 1.5
	Post	34.3 ± 2.0#	34.9 ± 1.8#	31.9 ± 1.4
	Post–Pre (%)	4.3	6.4	0.9
RSI (ms/ms)	Pre	1.08 ± 0.16	1.11 ± 0.08	1.08 ± 0.11
	Post	1.21 ± 0.11#	1.24 ± 0.08#	1.11 ± 0.07#
	Post–Pre (%)	12.0	11.7	2.8
10-m sprint (s)	Pre	1.75 ± 0.04	1.74 ± 0.03	1.76 ± 0.04
	Post	1.72 ± 0.03#	1.71 ± 0.02#	1.76 ± 0.03
	Post–Pre (%)	-1.7	-1.7	0.0

CMJ: countermovement jump; micro: microdosing; PJT: plyometric jump training; reg: regular; RSI: reactive strength index; SJ: squat jump; # within-group (post-pre) significantly different ($p < 0.05$).

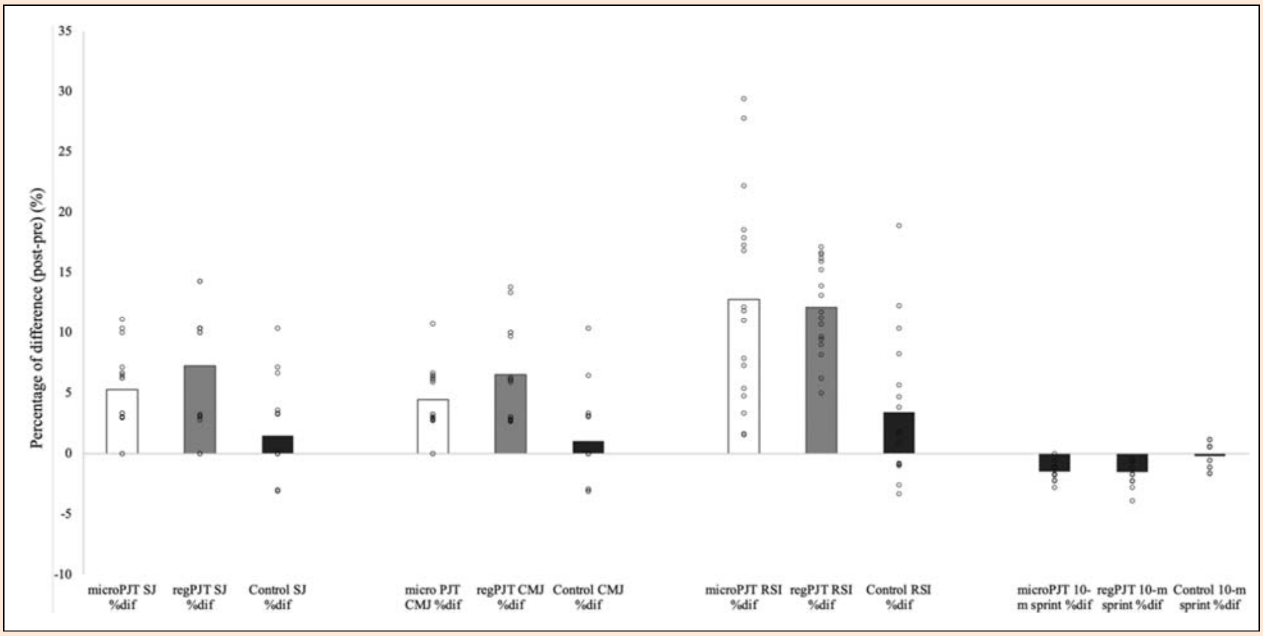

Figure 3. Mean and intra-individual percentages of difference (post-pre) for the different outcomes observed. CMJ: countermovement jump; micro: microdosing; PJT: plyometric jump training; reg: regular; RSI: reactive strength index; SJ: squat jump; %dif: percentage of difference.

intervention evaluation. However, no significant differences were detected between the experimental groups (0.032ms/ms; p = 0.898). Further within-group (post–pre) analysis revealed significant improvements for both the microPJT (+0.128ms/ms; p < 0.001) and regPJT (+0.133ms/ms; p < 0.001) groups following the intervention period. Interestingly, the control group also showed significant improvements after the intervention period (+0.032ms/ms; p = 0.030).

Significant interactions between groups and time were observed concerning 10-meter sprint time ($F_{2,48}$ = 11.119; p < 0.001; η^2 = 0.317). Subsequent between-group analysis indicated that both the microPJT (-0.039s; p < 0.001) and regPJT (-0.049s; p < 0.001) groups exhibited significant better results compared to the control group in post-intervention evaluation. However, no significant differences were detected between the experimental groups (0.010s; p = 0.866). Further within-group (post–pre) analysis revealed significant improvements for both the microPJT (-0.026s; p < 0.001) and regPJT (-0.027s; p < 0.001) groups following the intervention period. Conversely, the control group showed no significant differences in pre-evaluation versus post-evaluation (-0.004s; p = 0.299).

Discussion

This study stands out as one of the few experiments to investigate the effects of microdosing in soccer players, utilizing the concept of reducing training volume and distributing it across the week. By employing plyometric jump training as the chosen method, it was observed that microPJT was as effective as regPJT in significantly enhancing the jumping performance, reactive strength index, and acceleration performance of soccer players. Both approaches were significantly superior to the control group, which exclusively participated in in-field training sessions.

Plyometric jump training has been recognized as an effective method for improving SJ, CMJ, or RSI in soccer players (van de Hoef et al., 2020; Ramirez-Campillo et al., 2020). Our study further revealed that an 8-week training intervention was sufficient to positively impact these variables in players. What distinguishes our experiment is the effectiveness of microdosing, which comprised half the number of repetitions performed compared to the other experimental group (regPJT), yet yielded equally favorable outcomes in jumping performance for soccer players. Previous studies have demonstrated that smaller volumes of plyometric training can produce similar effects as higher volumes (Ramírez-Campillo et al., 2015), even when the volume is halved (Yanci et al., 2016). However, most of these studies maintained the same frequency of training sessions for both lower and higher volume training, typically two sessions per week. One study (Ramirez-Campillo et al., 2018b), in particular, compared two sessions versus a single session, also demonstrating similar positive effects. In our study, we found that splitting the training volume in half over four days was equally effective as doubling the volume over two dedicated sessions.

The current microPJT, characterized by small volumes distributed over four weekly sessions, offered a nuanced approach to enhancing SJ and CMJ in soccer players. This approach is made possible through underlying neuromuscular adaptations (Markovic and Mikulic, 2010). Plyometric training often stimulates the central nervous system, leading to increased motor unit recruitment and synchronization (Wallace and Janz, 2009), which are crucial for optimizing force production. Additionally, it enhances the efficiency of the stretch-shortening cycle, improving the storage and release of elastic energy during the rapid muscle lengthening and contraction phases typical of jumps (Turner and Jeffreys, 2010). Even in a microdosing fashion, the stimuli still optimize tendon stiffness and muscle architecture (Ramírez-delaCruz et al., 2022), promoting better transmission of forces and reducing energy loss during explosive movements.

It was also intriguing to observe the beneficial adaptations taking place in RSI. Possibly, even in microdosing plyometric training facilitates improvements in neuromuscular coordination and efficiency, enhancing the athlete's ability to rapidly transition from eccentric to concentric muscle actions during plyometric movements (Ramirez-Campillo et al., 2018a). This neuromuscular adaptation is crucial for optimizing the amortization phase, where the muscle quickly switches from absorbing force to generating force, thereby increasing the efficiency of energy transfer and enhancing RSI (Barker et al., 2018). Furthermore, microdosing plyometric training may stimulates adaptations in muscle-tendon unit stiffness (Moran et al., 2023), enabling the athlete to store and release elastic energy more effectively during rapid stretch-shortening cycle movements. This increased stiffness contributes to a higher RSI (Kalkhoven and Watsford, 2018) by allowing the athlete to produce greater force in a shorter amount of time, essential for explosive actions such as acceleration or jumping, on the soccer field.

In this regard, this could be one of the possible reasons why soccer players exposed to either microPJT or regPJT have shown a significant and positive improvement in their 10-meter sprint time, becoming faster. The plyometric training possibly improved neuromuscular coordination and motor unit recruitment (Markovic and Mikulic, 2010), enhancing the athlete's ability to generate maximal force quickly during the sprinting motion (Sáez de Villarreal et al., 2012). Additionally, microdosing plyometric training possibly enhanced the stretch-shortening cycle efficiency, optimizing the storage and release of elastic energy during each stride (Kurt et al., 2023), thereby increasing the power output and speed of movement.

While our study employed a randomized controlled design, it is important to acknowledge its limitations. One such limitation is the absence of evaluation regarding other physical fitness variables affected by plyometric training, such as maximal force output, long sprints, or running economy. Examining these factors could provide further insights into the potential impacts of various training methodologies utilizing plyometrics. Additionally, our experiment focused on under-17 players, which raises questions about the transferability of results to higher competitive levels with varying levels of trainability. Furthermore, since our participants were new to plyometric training, it remains uncertain whether microdosing would be effective for individuals already well-trained in this method. Exploring progressive or periodized training, involving gradual volume increments over time, could offer valuable insights into the efficacy of different training approaches in future research as well.

Finally, the control group, despite not undergoing a specific training regimen like the experimental groups, showed enhancements in both RSI and 10-meter sprint performance. While these enhancements were significantly smaller in comparison to the experimental groups, they indicate that even conventional in-field training methods could yield positive effects. Hence, it is crucial for future research to explore further the dosage and characteristics of in-field training, by monitoring them. This exploration will facilitate a better comprehension of the impacts of experimental interventions versus standard training. It will be essential to isolate potential confounding variables to accurately evaluate the overall effectiveness of novel intervention strategies.

Despite these limitations, our study stands out as one of the few dedicated to investigating microdosing in soccer through a randomized study design. Our findings suggest that microdosing may prove as effective as regular plyometric training. Strength and conditioning practitioners could find this approach particularly relevant in certain contexts, allowing for better integration into training schedules while ensuring that players can adapt to the stimulus without compromising their physical readiness for in-field activities.

Conclusion

The current experimental study has revealed that employing microdosing in plyometric jump training is equally effective as using regular approaches. Both methods demonstrated significant improvements in jumping performance, reactive strength index, and acceleration performance among soccer players. Given the challenges associated with integrating resistance training into soccer teams, adopting microdosing - which involves reduced volumes spread across training sessions - can be a viable strategy to mitigate potential fatigue from extensive plyometric training, while still promoting similar positive adaptations in players. Strength and conditioning coaches may find this approach beneficial in situations where it can optimize training organization.

Acknowledgements

The authors declare that there are no conflicts of interest. The experiments comply with the current laws of the country where they were performed. The data that support the findings of this study are available on request from the corresponding author.

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Key points

- Utilizing microdosing in plyometric training yielded results comparable to those of traditional plyometric training, which involved greater volume condensed into two sessions, in terms of enhancing jumping performance and acceleration.
- Coaches have the opportunity to enhance the physical fitness of young male football players by implementing microdosing. This method involved spreading small volumes of plyometric training sessions throughout the week, thus minimizing the accumulation of fatigue and preserving physical readiness.

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