ORIGINAL SCIENTIFIC PAPER

Physical Performance and Muscle Soreness in Tennis Players After Plyometric Training Performed at Different Weekly Frequencies

Athos Trecroci[1], Marco Cadonati[1], Tindaro Bongiovanni[2], Rodrigo Ramirez-Campillo[3,4,5], Stefano Longo[1]

Affiliations: [1]Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan, Italy, [2]Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy, [3]Exercise and Rehabilitation Sciences Institute, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Chile, [4]Sport Sciences and Human Performance Laboratories, Instituto de Alta Investigación, Universidad de Tarapacá, Chile, [5]Department of Physical Activity Sciences, Universidad de Los Lagos, Chile

Correspondence: Trecroci Athos. Department of Biomedical Sciences for Health, Università degli Studi di Milano, Via G. Colombo 71, Milano, 20133. E-mail: athos.trecroci@unimi.it

Abstract

High-frequency plyometric jump training (PT) may benefit tennis players, but little is known about how its weekly distribution affects performance and acute perceived soreness. The aim was to investigate the effects of PT, conducted at different weekly frequencies, on physical performance and muscle soreness in competitive tennis players. Eighteen competitive tennis players were randomly assigned to PT-1 (1 session/week) (n=9; age 17.0±2.0 yrs) or PT-3 (3 sessions/week) (n=9; age 19.0±3.9 yrs), both performing 180 jumps over 8 weeks. Countermovement vertical (CMVJ) and squat jumps (SJ), single-leg horizontal hop (SLHH), 10- and 20-m sprints, and a repeated change-of-direction (COD) test were measured pre- and post-intervention. Muscle soreness was recorded before and immediately after each PT session using a 7-point Likert scale. Both groups improved jump height, hop distance, sprint time, and repeated COD performance ($p<0.05$). No between-groups differences were noted for CMVJ ($p=0.419$), SJ ($p=0.692$), SLHH ($p=0.512$), 10- and 20-m sprints ($p=0.658$ and $p=0.741$), nor repeated COD performance ($p=0.191$). Distributing the same PT volume over three weekly sessions produces performance gains comparable to a single weekly session. However, the increase in muscle soreness was significantly lower in PT-3 than in PT-1 group. Higher-frequency, lower-dose PT may reduce acute muscle soreness perception while maintaining performance improvements.

Keywords: *Plyometric exercise; Athletic performance; Human physical conditioning; Stretch-shortening cycle*

@MJSSMontenegro
WEEKLY PLYOMETRIC FREQUENCY IN TENNIS PLAYERS
http://mjssm.me/?sekcija=article&artid=315

Cite this article: Trecroci, A., Cadonati, M., Bongiovanni, T., Ramirez-Campillo, R. Longo, S. (2026) Physical Performance and Muscle Soreness in Tennis Players After Plyometric Training Performed at Different Weekly Frequencies. *Montenegrin Journal of Sports Science and Medicine, 22 (1)*, 85–91. https://doi.org/10.26773/mjssm.260310

Received: 03 January 2026 | Accepted after revision: 16 February 2026 | Early access publication date: 25 February 2026 | Final publication date: 15 March 2026

Conflict of interest: None declared.

Introduction

The stretch-shortening cycle (SSC) involves a rapid eccentric-concentric muscle action that underpins plyometric training (PT). By leveraging the SSC, PT enhances force and power in multidirectional movements (Moran et al., 2017).

In tennis, players frequently engage in high-intensity SSC movements across the court (Hughes & Meyers, 2005), including accelerations, decelerations, jumps, and lateral movements (Trecroci et al., 2024), often under unpredictable conditions. PT is recognized for its efficacy in enhancing these critical demands by inducing neuromuscular adaptations that improve key performance determinants (Markovic & Mikulic, 2011) such as reactive strength, speed, and change of direction (COD) ability (Sinkovic et al., 2023). Previous research has investigated the effects of PT combined with regular tennis-specific training on upper- and lower-body physical performance in young players (Fernandez-Fernandez et al., 2016) reporting positive effects on vertical and horizontal jump, 20-m sprint, and modified 505 COD test. However, tennis-specific evidence on high-frequency PT (≥ 3 sessions/week) is scarce, especially regarding how distributing an equivalent volume across in-season weeks may impact physical performance and perceptual responses (e.g., muscle soreness).

Recent studies have examined how different PT session distributions (i.e., 1 vs. 2 sessions per week) impact physical performance in young athletes of multidirectional sports (Bouguezzi et al., 2020; Moran et al., 2024; Ramirez-Campillo et al., 2018; Yanci et al., 2017), revealing comparable results. Similarly, no significant differences were observed between 1 vs. 2 PT sessions per week in jump performance, sprint and service speed among volleyball players (Hernandez-Martinez et al., 2023). Of note, tennis has distinct biomechanical (e.g., lateral push-offs and unilateral stroke actions) and temporal (i.e., intermittent rally–rest patterns) constraints compared with team sports (Hughes & Meyers, 2005). Therefore, tennis-specific evidence is required to confirm whether the potential frequency-response association applies to tennis.

On one hand, the appropriate frequency of PT for optimal physical performance improvements has not yet been elucidated, even though a high number of weekly sessions (>2 per week) has previously been suggested for court-based sports such as tennis (Booth & Orr, 2016). This approach would help athletes to better tolerate the in-season training load by a lower PT dose per session. On the other hand, evidence comparing low- versus high-frequency PT programs (e.g., 1 vs. ≥ 3 sessions/week) under volume-matched conditions, is still limited.

While PT remains an effective strategy for enhancing athletic performance, it can also impact muscle soreness, especially if introduced without proper caution alongside regular tennis-specific training (Kovacs, 2006). Given the neuromuscular and biomechanical demands of tennis activities, players often experience muscular fatigability due to frequent stop-and-start movements, and prolonged periods of rapid first-step explosiveness (Kovacs, 2006).

In this scenario, without appropriate recovery strategies, the integration of PT sessions during the week could exacerbate muscle soreness by exceeding the capacity to tolerate repetitive, high compressive and shear forces, consequently increasing injury risk (Davies et al., 2015; Kovacs, 2006). Hence, the implementation of PT requires careful attention, not only to training structure and volume but also to session frequency, as previously reported in adolescent soccer players (Trapletti et al., 2025).

Although a high-frequency PT distribution may be desirable, there is still limited evidence on how various training distributions influence physical performance and muscle soreness in tennis players. This remains a key aspect to effectively manage the weekly training load and recovery.

Therefore, the aim of this study was to investigate the effects of PT, conducted at different weekly frequencies, on physical performance and muscle soreness in competitive tennis players. We hypothesized that PT weekly distribution would lead to comparable improvements in physical performance (Liu et al., 2024), regardless of session frequency. We also hypothesized that a high-frequency distribution would elicit a lower acute perceived soreness response potentially due to the reduced PT dose per session.

Methods

Participants

Eighteen competitive tennis players from the same club volunteered to participate and were randomly allocated to two experimental groups. Nine participants (7 males, 2 females) underwent PT once per week (PT-1; age = 17.0 ± 2.0 yrs, height = 175.0 ± 10.8 cm, body mass = 64.0 ± 11.8 kg, ranking 2.8 ± 4.0 arbitrary units) while the other nine participants (7 males and 2 females) received a total volume-matched program distributed over three weekly sessions (PT-3, n = 7 males and 2 females, age = 19.0 ± 3.9 yrs, height = 176.0 ± 8.1 cm, body mass = 67.0 ± 5.7 kg, ranking 2.8 ± 5.0 arbitrary units) for an 8-week training period. The ranking of each participant refers to the Italian Tennis and Padel Federation. To be included, participants had to engage in a minimum of 3 training sessions per week (90 min/session), and one official game per week. Participants were excluded if they had chronic conditions (e.g., asthma), illnesses (e.g., flu-like conditions), musculoskeletal and osteoarticular disorders (i.e., injuries). As only the 18 recruited players who met all eligibility criteria were available during the in-season period, we performed a sensitivity analysis in G*Power 3.1.9.7 (F tests, RM-ANOVA within-between interaction; groups = 2; measurements = 2; r = 0.50; ε = 1). With the available sample of 18 players, α = 0.05 and power = 0.80, our study could detect an interaction effect of at least f = 0.66 on the primary outcome (i.e., single-leg horizontal hop). Prior to the intervention, players and their parents or legal guardians were informed about the protocol used and provided a signed informed consent. The Ethics Committee of the local University approved the study (approval number 29/24), which was conducted in accordance with the principles of the Declaration of Helsinki.

Procedures

A randomized parallel group design was conducted at a single tennis academy during the 2023/2024 season. Participants were familiarized with all procedures prior to the experiment. Testing occurred at the same time of day, one week before and after the intervention over a three-day period. First, stature and body mass were measured using a stadiometer (SECA 213, Germany) and portable scale (SECA 813, Germany) with an accuracy of 0.1 cm and 0.1 kg, respectively. To minimize fatigue, performance assessments were split: vertical and horizontal jumps on day two, and sprints on day three. A standardized 10-min warm-up consisting of slow running, dynamic mobility exercises, progressive acceleration and deceleration drills, bilateral and unilateral jumping activities

DOI 10.26773/mjssm.260310

preceded physical tests (Trecroci, Bongiovanni, et al., 2020; Trecroci, Rossi, et al., 2020). All tests were conducted indoors with players wearing habitual tennis shoes.

Field-based physical performance assessment

Jump performance. Participants performed countermovement vertical jump (CMVJ), squat jump (SJ) and a single-leg horizontal hop (SLHH) tests. In the CMVJ, the participants performed three maximal vertical jumps interspersed by 2 min of rest. During each jump, the participants were asked to keep their hands on the hips without bending the legs from the take-off and landing phases (Bongiovanni et al., 2021). In the SJ, players also performed three maximal attempts starting from a static semi-squat position with no countermovement. For both CMVJ and SJ, the Ergojump® system (Ergojump apparatus, Globus Italia, Codogne, Italy) recorded contact and flight times while returning jump height. The highest jump performance in both tests was used for the analysis. The SLHH consisted of a horizontal single-leg jump with the toe at the starting line and free use of the arms. Each participant was instructed to sink to a self-selected depth as quickly as possible and then jump as far forward as possible. They were instructed to land on the same leg by holding the final position for at least 2 s. The distance was measured by a measuring tape (accuracy of 0.1 cm) from the starting line to the heel of the foot, at the point of impact on the landing surface. Participants performed three jumps with the right and left leg, and the longest jump with each leg was used for analysis.

Sprint performance. Each subject performed three maximal 10 m and 20 m sprints with a free departure, interspersed by 2 min of passive recovery. The starting position was in a two-staggered stance. The best performance time was considered in the analysis. An electronic timing system based on photocells (Witty, Microgate, Bolzano, Italy) was employed to measure sprinting time. The photocells were placed at a height of 0.7 m near the start and finish lines. The athletes were positioned 0.3 m away from the start timing gates to prevent an early trigger of the electrical instrumentation due to the leaning trunk.

Shuttle run test 6×8 m. This test consisted of six maximal sprints over 8 m, requiring a 180° COD at each 8-m interval course. It is traditionally used by the Italian Tennis and Padel Federation as part of the athletes' assessment protocol of their repeated COD ability. Indeed, the 8-m distance closely replicates the standard width of a single tennis court. Completion time was recorded using the same timing gate system employed for linear sprint assessment.

Perceptual assessments. Players' muscle soreness was recorded by a 7-point Likert scale (Impellizzeri & Maffiuletti, 2007) that includes seven descriptive values, from 0 to 6, where 0 corresponds to complete absence of muscle soreness and 6 to soreness that limits the participant's ability to move. In an upright position, participants reported thigh and leg muscle soreness from the nondominant limb, operationally defined as the leg not preferred for push-off when jumping. The 7-point Likert scale was administered before and immediately after each PT session. The delta values (post–pre) were computed for each PT session and averaged within each week for analysis.

Training intervention

The PT intervention in both PT-1 and PT-3 lasted 8 weeks, with 1 or 3 training sessions per week, respectively. During the intervention, players continued their sport-specific and habitual strength and conditioning activities, which were comparable between groups and unchanged throughout the study. The PT was integrated after the regular tennis-specific session. The PT combined double- and single-leg jumps in different directions, with a particular focus on horizontal jumps. The work-to-rest ratio was 1 to ≥7 to ensure recovery periods of at least ≥60 s between sets.

Participants were familiar with the drills included in the PT intervention, although they did not apply the drills systematically (nor with the same volume, intensity) into their regular tennis training sessions. The PT interventions followed a non-periodized structure, maintaining a consistent total training volume and session duration throughout the intervention. This approach was adopted to reflect the in-season practice and to minimize additional load fluctuations during the competitive period. Players were instructed to perform each jump with maximal effort, with minimal contact time and maximal propulsion phase. Additionally, each session was carefully monitored, maintaining a 1:4 coach-to-player ratio to ensure proper execution through demonstrations and continuous feedback.

The PT-1 involved 180 jumps per session (per week), distributed in three drills: Drill #1: 5 [sets] × 6 [repetitions] double-leg forward jumps and single-leg forward hops (both over hurdles of 30 cm); Drill #2: 6 × 6 double-leg forward jumps combined with double-leg lateral jumps and 6 × 4 single-leg forward hops combined with single-leg lateral jump; Drill #3: 4 × 7 double-leg forward jump followed by a vertical jump upon landing and 4 × 8 single-leg forward bounds with alternating foot contacts.

The PT-3 completed the same 180 jumps per week as the PT-1 group, although distributed in 60 jumps per session, with the same drill structure and content applied respectively to session #1, #2, and #3. The distribution considered that ≥50 foot contacts per session are suggested for court sport athletes (Booth & Orr, 2016).

Statistical Analyses

Normality was checked using the Shapiro−Wilk's test. Relative reliability was assessed with the intraclass correlation coefficient (ICC, model 3,k) and 95% confidence intervals (CI), interpreted as poor (< 0.50), moderate (0.5-0.74), good (0.75-0.90) and excellent (> 0.90) (Koo & Li, 2016). Absolute reliability utilized the coefficient of variation (CV = (SD/mean) × 100) categorized as poor (>10%), moderate (5–10%), or good (<5%) (Banyard et al., 2017). Sensitivity was determined by the Bland-Altman limits of agreement (LoA) calculated as the mean difference ± 1.96 times the standard deviation of the differences, providing the range within which most measurement differences are expected to fall (De Vet et al., 2006). A two-way repeated-measures ANOVA (group × time) was employed, followed by Bonferroni's post-hoc test for multiple comparisons. The Hedges' g (g) effect size (Wasserman et al., 1988) was calculated and reported as a point estimate, with thresholds: $g < 0.2$ (trivial), $0.2 < g \le 0.5$ (small), $0.5 < g \le 0.8$ (moderate), and $g > 0.8$ (large). The small worthwhile change (SWC) was computed as 0.2 × between-subject SD from baseline measures (Batterham & Hopkins, 2006), assessing practical significance. Data are reported as mean ± SD, and relative changes as mean ± 95% CI. All analyses were performed using JASP software (version 0.18.1, JASP team, Amsterdam, Netherlands).

Results

Table 1 presents reproducibility values of each physical performance variable. Absolute and relative data reported excellent reliability, with overall ICC > 0.9 and CV% < 2.5%. Sensitivity values expressed by LoA were narrow across all tests, upper and lower bounds close to zero. From pre- to post-intervention, all physical performance outcomes, percentage changes, and their effect sizes for PT-1 and PT-3 are shown in Table 2.

Table 1. Physical performance measure's reliability.

	ICC (95% CI)	CV (%)	Upper LoA	Lower LoA
Squat jump height (cm)	0.99 (0.98-0.99)	1.9	0.09	-0.45
Countermovement vertical jump height (cm)	0.98 (0.96-0.99)	2.5	0.01	-0.07
Single-leg (R) horizontal hop distance (cm)	0.96 (0.91-0.98)	2.3	0.00	-0.05
Single-leg (L) horizontal hop distance (cm)	0.97 (0.93-0.98)	1.9	0.01	-0.05
10-m sprint time (s)	0.91 (0.83-0.96)	1.7	0.02	-0.02
20-m sprint time (s)	0.94 (0.88-0.97)	1.7	0.04	0.00
6 x 8 m shuttle-test total time (s)	0.95 (0.87-0.98)	1.5	0.27	-0.03

Note: LoA = limits of agreement, ICC = intraclass correlation coefficient, CI = 95% confidence interval, CV = coefficient of variation, R = right, L = left.

Table 2. Changes in physical performance following PT interventions (PT-1 and PT-3).

	PT-1				PT-3			
	Mean	SD	%Δ	g	Mean	SD	%Δ	g
Squat jump height (cm)								
Pre	37.84	7.77	2.6	0.12	36.17	8.71	3.1	0.12
Post	38.82	8.22			37.28	8.60		
Countermovement vertical jump height (cm)								
Pre	38.74	7.67	2.5	0.12	36.57	8.00	2.1	0.09
Post	39.72	7.61			37.33	7.99		
Single-leg horizontal hop distance (cm)								
Pre	1.82	0.22	3.3	0.26	1.79	0.22	2.8	0.18
Post	1.88	0.22			1.84	0.20		
10 m sprint time (s)								
Pre	2.00	0.15	2.0	0.27	1.97	0.14	2.0	0.28
Post	1.96	0.13			1.93	0.13		
20 m sprint time (s)								
Pre	3.36	0.24	3.6	0.49	3.31	0.31	3.9	0.43
Post	3.24	0.23			3.18	0.27		
6 × 8 m shuttle-test total time (s)								
Pre	12.41	0.83	2.0	0.37	12.15	0.89	1.0	0.13
Post	12.17	0.83			12.03	0.89		

Note: PT-1 = plyometric training intervention with one session per week, PT-3 = plyometric training intervention with three sessions per week, SD = standard deviation, %Δ = post–pre percentage change, g = Hedges' g effect size.

The SWC values were as follows: SJ = 1.61 cm, CMVJ = 1.54 cm, SLHH = 0.04 cm, 10-m sprint = 0.028 s, 20-m sprint = 0.05 s, and 6 × 8-m = 0.17 s. For muscle soreness, a main effect of group ($F(1,16) = 45.44$, $p < 0.001$) was observed, although no interaction ($F(7, 112) = 0.13$, $p = 0.996$) nor main effect of time ($F(7, 112) = 0.60$, $p = 0.749$) were found between PT-3 and PT-1 (Figure 1).

For SJ height, no interaction ($F(1,16) = 0.16$, $p = 0.692$) nor group effect ($F(1,16) = 0.16$, $p = 0.687$) were found. However, a main effect of time ($F(1,16) = 42.70$, $p < 0.001$) was revealed. Similarly, CMVJ height and SLHH distance showed a main effect of time ($F(1,16) = 43.63$, $p < 0.001$ and $F(1,16) = 64.78$, $p < 0.001$, respectively), but no interaction ($F(1,16) = 0.68$, $p = 0.419$ and $F(1,16) = 0.45$, $p = 0.512$, respectively) nor group effect ($F(1,16) = 0.38$, $p = 0.546$ and $F(1,16) = 0.15$, $p = 0.697$, respectively) were found. In the 10 m and 20 m sprint, no interaction ($F(1,16) = 0.20$, $p = 0.658$; $F(1,16) = 0.11$, $p = 0.741$, respectively) nor group effect ($F(1,16) = 0.25$, $p = 0.620$; $F(1,16) = 0.17$, $p = 0.678$, respectively) were found. However, a main effect of time ($F(1,16) = 43.23$, $p < 0.001$; $F(1,16) = 70.75$, $p < 0.001$, respectively) was revealed. For 6 × 8 m sprint, no interaction ($F(1,16) = 1.86$, $p = 0.191$) nor group effect ($F(1,16) = 0.25$, $p = 0.623$) were found. However, a main effect of time ($F(1,16) = 19.87$, $p < 0.001$) was revealed.

DOI 10.26773/mjssm.260310

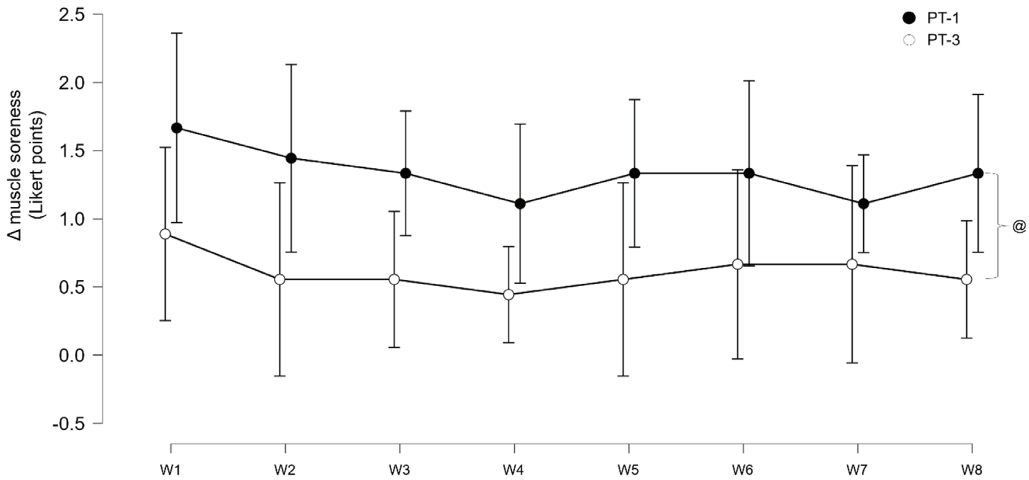

Figure 1. Weekly delta (Δ) muscle soreness (post–pre) in tennis players that performed one (PT-1) or three (PT-3) plyometric sessions per week (W) across the 8-week intervention.
Note: @ = denotes significant ($p < 0.05$) difference between groups.

Discussion

The PT-1 and PT-3 groups achieved similar improvements in performance (SJ, CMVJ, SLHH, COD). However, muscle soreness was significantly lower in PT-3, suggesting that a higher weekly frequency (3 sessions) may optimize PT stimuli while better managing perceived soreness. This strategy is particularly relevant given the high work-to-rest ratios (1:3 to 1:5) typical of competitive tennis (Kovacs, 2006), which demands high tolerance for repetitive, high-impact actions. However, no physiological responses on recovery can be drawn from the present data.

From a practical perspective, vertical jump improvements (SJ and CMVJ) were trivial (below SWC), suggesting limited relevance for tennis. According to this, the detected significant improvements should be inferred with caution. Conversely, changes in SLHH and sprint performance exceeded the SWC, indicating a practically meaningful enhancement. This disparity is likely due to the training program, which predominantly included horizontal and unilateral specificity (Watkins et al., 2021) that mirror the neuromechanical demands of tennis-specific actions like lateral movements, rapid push-offs, and stop-and-start actions (Trecroci et al., 2024; Watkins et al., 2021). These changes may contribute to faster court coverage during rallies, although such an interpretation is indirect, as no in-match tracking metrics were collected. Taken together, these findings, consistent with previous work on sprinting (Gonzalo-Skok et al., 2019), support prioritizing unilateral and horizontal jump exercises within PT programs for tennis players.

Our results align with existing evidence in team sports (Trapletti et al., 2025), which shows that PT enhances lower-limb power regardless of weekly frequency (7–10). For instance, both one and two weekly PT sessions provided equally effective improvements in jump performance, sprint, and service speed in young volleyball players. Similarly, comparable gains in sprint performance, COD ability, and horizontal jump were seen in futsal (Yanci et al., 2017), and in soccer when comparing two versus four weekly sessions (Liu et al., 2024). These results support the hypothesis that the weekly distribution of PT may not critically affect performance gains in explosive and multidirectional tasks, especially when volume is equated. It is worth noticing that evidence on ≥ 3 weekly PT sessions in tennis is scarce, thereby the present study provides novel insights into in-season performance and perceived soreness data. However, in light of the sample size, the non-significant group × time interaction between PT frequency distributions might not be interpreted as evidence of equivalence. Additional large-sample studies are desirable to corroborate the current results while reducing the chance of type II error in court-based sports.

An interesting side finding was the significant improvement in the 6 × 8 m shuttle test, albeit its practical relevance was limited. The higher per-session load in PT-1 (180 jumps) than in PT-3 (60 jumps) might have provided a greater neuromuscular stimulus. Nevertheless, this remains speculative and should be investigated employing a clear assessment of biochemical markers (i.e., creatine kinase) and neuromuscular function (i.e., vertical and horizontal jump kinetics) from pre to post PT.

The present study presents some limitations that should be acknowledged. First, the small and heterogeneous sample size limits the statistical power (i.e., type II error) and generalizability, even though comparable sizes have been previously employed (Ramirez-Campillo et al., 2018; Yanci et al., 2017). Additionally, the reliance on a subjective 7-point Likert scale for muscle soreness is also limited without objective confirmation on delayed soreness (>24 h), and pre-post-session data on physiological and neuromuscular status.

Conclusions

A volume-matched PT with different weekly frequencies led to similar performance gains, but only SLHH and sprint performance were practically meaningful for competitive tennis players. Crucially, distributing PT volume over three weekly sessions (~60 jumps each) may represent a viable alternative to compress volume within a single session, potentially reducing perceived soreness while eliciting comparable performance improvements.

Disclosure of interest

There are no relevant financial or non-financial competing interests to report.

Funding

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Banyard, H. G., Nosaka, K., & Haff, G. G. (2017). Reliability and validity of the load–velocity relationship to predict the 1RM back squat. *Journal of Strength and Conditioning Research*, *31*(7), 1897–1904. https://doi.org/10.1519/JSC.0000000000001657

Batterham, A. M., & Hopkins, W. G. (2006). Making meaningful inferences about magnitudes. *International Journal of Sports Physiology and Performance*, *1*(1), 50–57. https://doi.org/10.1123/ijspp.1.1.50

Bongiovanni, T., Trecroci, A., Rossi, A., Iaia, F. M., Pasta, G., & Campa, F. (2021). Association between change in regional phase angle and jump performance: A pilot study in serie A soccer players. *European Journal of Investigation in Health, Psychology and Education*, *11*(3), 860–865.

Booth, M. A., & Orr, R. (2016). Effects of plyometric training on sports performance. *Strength & Conditioning Journal*, *38*(1), 30–37. https://doi.org/10.1519/SSC.0000000000000183

Bouguezzi, R., Chaabene, H., Negra, Y., Ramirez-Campillo, R., Jlalia, Z., Mkaouer, B., & Hachana, Y. (2020). Effects of different plyometric training frequencies on measures of athletic performance in prepuberal male soccer players. *Journal of Strength and Conditioning Research*, *34*(6), 1609–1617. https://doi.org/10.1519/JSC.0000000000002486

Davies, G., Riemann, B. L., & Manske, R. (2015). Current concepts of plyometric exercise. *Int J Sports Phys Ther*, *10*(6), 760–786.

De Vet, H. C. W., Terwee, C. B., Knol, D. L., & Bouter, L. M. (2006). When to use agreement versus reliability measures. *Journal of Clinical Epidemiology*, *59*(10), 1033–1039. https://doi.org/10.1016/j.jclinepi.2005.10.015

Fernandez-Fernandez, J., De Villarreal, E. S., Sanz-Rivas, D., & Moya, M. (2016). The effects of 8-week plyometric training on physical performance in young tennis players. *Pediatric Exercise Science*, *28*(1), 77–86. https://doi.org/10.1123/pes.2015-0019

Gonzalo-Skok, O., Moreno-Azze, A., Arjol-Serrano, J. L., Tous-Fajardo, J., & Bishop, C. (2019). A Comparison of 3 Different Unilateral Strength Training Strategies to Enhance Jumping Performance and Decrease Interlimb Asymmetries in Soccer Players. *International Journal of Sports Physiology and Performance*, *14*(9), 1256–1264. https://doi.org/10.1123/ijspp.2018-0920

Hernandez-Martinez, J., Guzman-Muñoz, E., Ramirez-Campillo, R., Herrera-Valenzuela, T., Magnani Branco, B. H., Avila-Valencia, S., Luis Carter-Beltran, J., Aravena-Sagardia, P., Méndez-Cornejo, J., & Valdés-Badilla, P. (2023). Effects of different plyometric training frequencies on physical performance in youth male volleyball players: A randomized trial. *Frontiers in Physiology*, *14*, 1270512. https://doi.org/10.3389/fphys.2023.1270512

Hughes, M., & Meyers, R. (2005). Movement patterns in elite men's singles tennis. *International Journal of Performance Analysis in Sport*, *5*(2), 110–134. https://doi.org/10.1080/24748668.2005.11868331

Impellizzeri, F. M., & Maffiuletti, N. A. (2007). Convergent Evidence for Construct Validity of a 7-Point Likert Scale of Lower Limb Muscle Soreness. *Clinical Journal of Sport Medicine*, *17*(6), 494–496. https://doi.org/10.1097/JSM.0b013e31815aed57

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Kovacs, M. S. (2006). Applied physiology of tennis performance. *British Journal of Sports Medicine*, *40*(5), 381–386. https://doi.org/10.1136/bjsm.2005.023309

Liu, G., Wang, X., & Xu, Q. (2024). Microdosing Plyometric Training Enhances Jumping Performance, Reactive Strength Index, and Acceleration among Youth Soccer Players: A Randomized Controlled Study Design. *Journal of Sports Science and Medicine*, *23*(2), 342–350. https://doi.org/10.52082/jssm.2024.342

Markovic, G., & Mikulic, P. (2011). Discriminative ability of the yo-yo intermittent recovery test (level 1) in prospective young soccer players. *The Journal of Strength & Conditioning Research*, *25*(10).

Moran, J., Sandercock, G. R. H., Ramírez-Campillo, R., Meylan, C. M. P., Collison, J. A., & Parry, D. A. (2017). Age-related variation in male youth athletes' countermovement jump after plyometric training: a meta-analysis of controlled trials. *Journal of Strength and Conditioning Research*, *31*(2), 552–565. https://doi.org/10.1519/JSC.0000000000001444

Moran, J., Vali, N., Tallent, J., Howe, L., Clemente, F. M., Chaabene, H., & Ramirez-Campillo, R. (2024). Evaluating the effects of consecutive phases of plyometric jump training on athletic performance in male soccer players: the effect of training frequency and volume manipulations. *The Journal of Strength & Conditioning Research*, *38*(6), 1082. https://doi.org/10.1519/JSC.0000000000004756

Ramirez-Campillo, R., García-Pinillos, F., García-Ramos, A., Yanci, J., Gentil, P., Chaabene, H., & Granacher, U. (2018). Effects of different plyometric training frequencies on components of physical fitness in amateur female soccer players. *Frontiers in Physiology*, *9*, 934. https://doi.org/10.3389/fphys.2018.00934

Sinkovic, F., Novak, D., Foretic, N., Kim, J., & Subramanian, S. V. (2023). The plyometric treatment effects on change of direction speed and reactive agility in young tennis players: a randomized controlled trial. *Frontiers in Physiology*, *14*, 1226831. https://doi.org/10.3389/fphys.2023.1226831

Trapletti, M., Formenti, D., Moran, J., Merati, G., Esposito, F., & Trecroci, A. (2025). Essential role of weekly high-frequency plyometric training to enhance physical performance and manage muscle soreness in male adolescent soccer players. *International Journal of Sports Physiology and Performance*, *20*(11), 1580–1589. https://doi.org/10.1123/ijspp.2025-0006

Trecroci, A., Bongiovanni, T., Cavaggioni, L., Pasta, G., Formenti, D., & Alberti, G. (2020). Agreement between dribble and change of direction deficits to assess directional asymmetry in young elite football players. *Symmetry*, *12*(5), 787. https://doi.org/10.3390/sym12050787

Trecroci, A., Mantegazza, S., & Formenti, D. (2024). Exploring the relationship and agreement of asymmetry between lateral jump and change of direction in young tennis players. *International Journal of Performance Analysis in Sport*, *25*(4), 675–686. https://doi.org/10.1080/24748668.2024.2437598

Trecroci, A., Rossi, A., Dos'Santos, T., Formenti, D.,

 DOI 10.26773/mjssm.260310

Cavaggioni, L., Longo, S., Iaia, F. M., & Alberti, G. (2020). Change of direction asymmetry across different age categories in youth soccer. *PeerJ*, *8*, e9486. https://doi.org/10.7717/peerj.9486

Wasserman, S., Hedges, L. V., & Olkin, I. (1988). Statistical methods for meta-analysis. *Journal of Educational Statistics*, *13*(1), 75. https://doi.org/10.2307/1164953

Watkins, C. M., Gill, N. D., Maunder, E., Downes, P., Young, J. D., McGuigan, M. R., & Storey, A. G. (2021). The effect of low-volume preseason plyometric training on force-velocity profiles in semiprofessional rugby union players. *Journal of Strength and Conditioning Research*, *35*(3), 604–615. https://doi.org/10.1519/JSC.0000000000003917

Yanci, J., Castillo, D., Iturricastillo, A., Ayarra, R., & Nakamura, F. Y. (2017). Effects of Two Different Volume-Equated Weekly Distributed Short-Term Plyometric Training Programs on Futsal Players' Physical Performance. *Journal of Strength and Conditioning Research*, *31*(7), 1787–1794. https://doi.org/10.1519/JSC.0000000000001644