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Original article

Effect of different weekly frequencies of plyometric-jump and linear-sprint training on youth male futsal athlete's physical fitness

Efeito de diferentes frequências semanais de treinamento pliométrico e sprint linear no desempenho físico de jovens atletas de futsal masculino

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ABSTRACT

Aim: This prospective cross-sectional intervention study aimed to compare the effect of different frequencies (equated for total repetitions) of plyometric-jump and linear-*sprint* training on U-18 (age, 17,0 ± 1,05) male futsal athlete's physical fitness. **Methods:** Athletes (33) were randomly distributed into groups with one (1-TSW, n = 10), two (2-TSW, n = 11), and three (3-TSW, n = 12) training session per week (TSW), during 4 weeks of their regular futsal training routine. Plyometric-jump training involved bipedal and unipedal horizontal maximum-intensity jumps. Linear-sprint training involved maximal-intensity 10-msprints with 30 seconds of rest between sprints. **Results:** The three training groups completed an equal number of total jumps (n = 780) and sprints (n = 260). A two-way ANOVA with repeated measures on time revealed significant main effects of time for all physical fitness outcomes, i.e., squat jump and counter-movement jump height, power, relative power, standing long jump distance, 10-m and 20-m sprint time, and change of direction sprint time in the T-test (all $p < 0.001$; $d = 0.36$-0.69), without significant group × time interaction effects ($p = 0.133$-0.861; $d = 0.01$-0.13). **Conclusion:** Adding plyometric-jump and linear-sprint training to the standard training of youth male futsal athlete's improves their physical fitness, with similar improvements regardless of the training frequency.

Keywords: athletic performance; stretch-shortening cycle; high-intensity interval training; sports; youth.

RESUMO

Objetivo: Este estudo de intervenção prospectivo transversal teve como objetivo comparar o efeito de diferentes frequências (equalizadas para o total de repetições) do treinamento pliométrico e *sprint* linear sobre o desempenho físico de atletas de futsal masculino sub-18 (idade, 17,0 ± 1,05). **Métodos:** Os atletas (33) foram distribuídos aleatoriamente em grupos com uma (1-TSW, n = 10), duas (2-TSW, n = 11) e três (3-TSW, n = 12) sessões de treinamento por semana (TSW), durante 4 semanas de suas rotinas regulares de treinamento de futsal. O treinamento pliométrico envolveu saltos horizontais bipodais e unipodais de intensidade máxima. **Resultados:** O treinamento de *sprint* linear envolveu *sprints* de 10-m em intensidade máxima com 30 segundos de descanso entre os *sprints*. Os três grupos de treinamento completaram um número igual de saltos totais (n = 780) e *sprints* (n = 260). A ANOVA de duas vias com medidas repetidas revelou efeitos significativos do tempo para todos os resultados de desempenho físico, ou seja, altura de salto no *squat jump* e contramovimento, potência, potência relativa, distância do salto horizontal, tempo de *sprint* em 10-m e 20-m, e mudança de direção no teste T (todos $p < 0,001$; $d = 0,36$-$0,69$), sem efeitos significativos de interação grupo x tempo ($p = 0,133$-$0,861$; $d = 0,01$-$0,13$). **Conclusão:** Adicionar treinamento pliométrico e *sprint* linear ao treinamento habitual de jovens atletas de futsal masculino melhora seu desempenho físico, com melhorias semelhantes, independentemente da frequência de treinamento.

Palavras-chave: desempenho atlético; ciclo alongamento-encurtamento; treinamento intervalado de alta intensidade; esportes; jovens.

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Introduction

Futsal athletes are taxed with repeated high-intensity actions across a match (e.g., sprints; change of direction), requiring adequate levels of muscle strength and power [1,2]. For example, high-intensity running (18.1-25.0 km/h) represent ~13% of total distance covered during futsal games, and sprinting (≥ 25.1 km/h) represent ~9% [3,4]. Further, elite futsal athletes had faster 10-m and 20-m sprints compared to their sub-elite peers [5,6]. Moreover, ~695 fast changes of direction are performed in futsal games [7], with elite futsal athletes performing 34.7% more changes of directions than their sub elite peers [8]. Additionally, greater jump performance may discriminate between professional and junior futsal athletes ($p < 0.05$, effect size (ES) = 0.2 to 1.6) [9,10].

Plyometric-jump training improved jumping in U-20 male soccer players (ES=1.50) [11] and female university futsal athletes (ES=0.81) [12]. Similarly, linear-sprint training improved linear-sprint performance in youth (age, ~16 years) male soccer players (5-m and 20-m sprints, ES= 0.77 and 0.58, respectively) and semi-professional (age, ~23 years) female handball players (10-m and 30-m, ES=0.51 and 1.56, respectively) [13,14]. A recent study combined both plyometric-jump training and linear-sprint training in U-19 male soccer players, improving squat jump (SJ) (ES=1.53), counter-movement jump (CMJ) (ES=1.6), standing long jump (SLJ; ES=1.27), 5-m and 20-m linear-sprint speed (ES=1.38, both), and change of direction speed (ES=1.46) [15]. Considering the relevance of jumping, sprinting, and change of direction speed in futsal players, a replication of the aforementioned study [15] in futsal players might offer advancement in the field.

Nonetheless, the optimal weekly frequency of application for combined plyometric-jump and linear-sprint training is unclear. Researchers analyzed the effects of 8-week plyometric-jump training with one session versus two sessions per week at the same volume on the physical performance of prepuberal male soccer players (age, ~ 12 years), noticing similar adaptations in both training groups for 10-m and 20-m sprint time, change of direction speed, and jumping performance (ES = 0.3 to 1.1) [16]. Similarly, in youth male soccer athletes (age, ~14 years), compared the effects of one versus two repeated-sprint training sessions with the same weekly volume during 6 weeks, noticing similar adaptations for both training groups in 20-m sprint time (ES=0.32-0.53) [17]. Other studies [3,17] examined the effects of one versus two plyometric training sessions on the physical performance of male futsal players (age, ~22 years), finding significant results for two plyometric training sessions per week on change of direction performance (ES = -5.5), SLJ (ES = 0.62) and 15-m linear-sprint time improvement (ES = -0.64). One plyometric training session per week improved 5-m and 15-m linear-sprint time (ES = -1.00) and change of direction performance (ES = -0.67). However, none of the aforementioned studies analyzed the effects of different plyometric-jump and linear-sprint training frequencies on components of physical fitness in youth male futsal players. The identification of optimal weekly training frequencies may provide relevant logistical information, particularly among those athletes with congested training and competition schedules, being able to base the prescription of an ideal volume to obtain greater and significant results in the physical performance of this population.

Therefore, the aim of this study was to compare the effect of different frequencies (i.e., one, two, and three sessions per week; equated for volume (i.e., number of repetitions) and intensity) of plyometric-jump and linear-sprint training on youth male futsal athlete's physical fitness (i.e., squat jump; countermovement jump; 10-m and 20-m sprinting speed, and change of direction speed). Based on key references [3,15], we hypothesized similar physical fitness improvements on youth male futsal athletes, independent of the training frequency involved during the intervention.

Methods

This is a prospective cross-sectional intervention study approved by the Research Ethics Committee of the Federal University of São Paulo, CEP/UNIFESP n: 0656/2019, CAAE number: 15177719.0.0000.5505 and all procedures were conducted according Helsinki Declaration. All participants were informed about the procedures, and signed an informed consent form, according to resolution 466/12 of the National Health Council.

Subjects

A sample of male futsal athletes from the U-18 age competitive category (mean ± standard deviation age = 17.0 ± 1.0 y) were recruited to participate in the study according to the following inclusion criteria: i) be a federated futsal athlete, ii) without a history of neuromuscular injuries in the >6 months preceding their inclusion in the intervention. The exclusion criteria were: i) completed <75% of programmed intervention training sessions, ii) missed testing session before or after intervention. Thirty-six players (including 7 goalkeepers) were recruited, however thirty-three were included and randomly (by the app-based randomization tool provided by random.org (School of Computer Science and Statistics, Trinity College, Dublin, Ireland Version 1.2.11) distributed into groups with one (1-TSW, n = 10), two (2-TSW, n = 11), and three (3-TSW, n = 12) training session per week (Figure 1), and there was no loss of sample.

Design

The study was carried out as part of an ongoing training program for athletes, aiming to compete in a futsal regional (state) championship. Athletes performed physical fitness tests (i.e., squat jump; countermovement jump; 10-m and 20-m sprinting speed, and change of direction speed) before and after the 4 week training period. Tests were always completed on the same training court between 2 and 5 p.m. where players trained. During pre- and post-tests, participants used the same futsal sports clothes that they usually wear during training. The same investigator conducted all measurements. Participants were asked to perform at their maximum effort during evaluations. During pre- and post-tests players were evaluated in 2 days. On the first day, data on age, body mass, stature and experience in the modality. During the intervention period, neither of the participants were involved in the practice of complementary training, resistance training and did not use food supplements. During the first day, participants performed the CMJ and SJ test, SLJ test. On the second day, they performed the 10-m and 20-m linear-sprint test and agility-T test. The highest score from three trials was recorded for all tests. A rest interval of at least 3 minutes was provided between each physical fitness test. While waiting, participants performed low-intensity activities (e.g., walking) to maintain readiness for the next test. Submaximal running was performed for 3 minutes with changes of direction for the tests of speed and agility-t test. For the jumping tests, specific gestures (submaximal vertical and horizontal jumps) were performed before each test session as a warm-up.

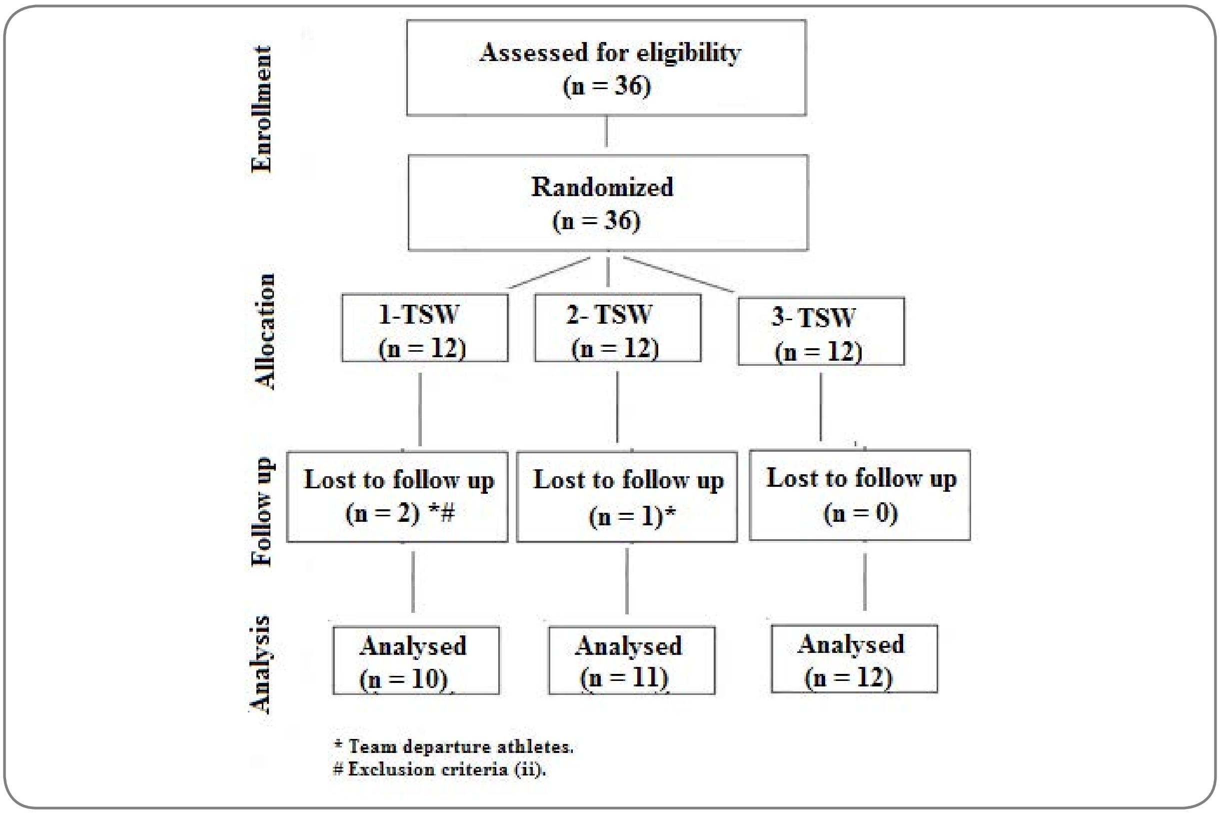

Figure 1 - The CONSORT diagram of the study

Anthropometric measurements

Standing height (SANNY® stadiometer; precision = 0.1 cm), and body mass were measured (BALMAK® digital anthropometric scale, model BK 300 GC, 2120 series; precision = 0.1 kg), according to international standards, obtained in accordance with the procedures outlined [19].

Jump evaluation

The CMJ and SJ was measured to the nearest 0.1 cm as previously described [20,21]. During the CMJ and SJ, the participant was instructed to rest his hands on his hips and to execute maximal-effort vertical jump on a 50 x 60 cm mobile contact platform (*Jumptest®,Hidrofit Ltda, Brasil*), connected to a software (*Multisprint®, Hidrofit Ltda, Brasil*). The flight and landing phase of the jump were standardized to the same point and players were instructed to perform full knee and ankle extensions during the flight phase. The standing long jump was standardized as previously described [22]. The participants were instructed to perform maximum effort jumps. Three repetitions were executed for each jump test, with 30-40 seconds of rest between trials, and the best performance result was used for statistical analysis.

Speed assessment

The 20-m linear-sprint time (with a split time at 10-m) was measured to 0.01 s using three pairs of wireless infrared laser timing photocells (Brower® Timing System, Utah, USA). Participants started the test when they felt ready, which started timing automatically. Three attempts were made, and the one with the best performance was considered for statistical analysis. Two minutes of rest were allowed between 20-m trials. Times were reported to an accuracy of 0.01 second. The time gates were positioned at the start (0.3 m in front of the athlete), 10 m and 20 m, being fixed ~1.2 m above the ground, according to the method used by [23].

Assessment of change of direction

The T-test was performed to measure change of direction speed. During the test, the athlete runs to the front cone, which will be at a distance of 9.14 meters, moving laterally to the left, covering a distance of 4.57 meters, later returning to the center and moving to the right for another 4.57 meters, returning to the center and running backwards to the finish line, again in the course of 9.14 meters [24]. Three repetitions were executed, with 120 seconds of rest between trials, and the best performance result was used for statistical analysis. Test time was measured using the same equipment previously described for the linear sprint test.

Plyometric-jump and linear-sprint training

There was no learning/adaptation period for the training exercises, as players were used to these throughout the competitive year, and are routinely assessed for physical fitness with the tests used in this investigation. During the pre-season, the athletes performed 4 weeks of maximum-effort horizontal jumps and linear-sprints (Table I). The intervention was based on previous studies [11,15,21,25,26], and through discussion with the technical staff of the team. Each intervention training session started with the plyometric-jump exercises, including bipedal horizontal jumps and alternated unilateral horizontal jumps sets, being the 10-m sprints done immediately in sequence (Figure 2). After completing exercise 1 the athletes rested 30s and the same after exercise 2 and 3. Thereafter, 120s of rest were allowed before the sequence was repeated. There was a minimum interval of 48 hours between sessions. The intervention was carried out in an official futsal training court (epoxy surface), replacing part of the ~90 min regular training sessions. Intervention sessions lasted 18-42 min for G1, 12-21 min for G2, and 9-14 min for G3. An experienced strength and conditioning coach supervised all training sessions.

Tabela I - Jump and sprint volume* distribution during training

	Week 1		Week 2		Week 3		Week 4	
	PT	ST	PT	ST	PT	ST	PT	ST
1-TSW (n=10)	150	500	180	600	210	700	240	800
2-TSW (n=11)	75	250	90	300	105	350	120	400
3-TSW (n=12)	50	167	60	200	70	233	80	266

1-TSW, 2-TSW, and 3-TSW = one, two, and three training sessions per week groups, respectively; ST = sprint training; PT = plyometric training.*: volume values for horizontal jumps (i.e., foot contacts) and linear sprints (i.e., distance) are depicted per training session

According to the overload training principle, the total number of repetitions per session was increased (~20%) from week 1 to week 4. The total number of repetitions per session was distributed in sets that varied between 5-10 repetitions and 10-m for the plyometric-jump training and the linear-sprint training components, respectively. We used the rating of perceived exertion (RPE) method to quantify the internal training load (i.e., psychophysiological stress), through the 0 (no effort) 10 (extreme effort) point Borg scale [27]. The RPE value reported by the athlete was multiplied by the total time of each training session, thus obtaining a dimensionless index of internal load expressed in arbitrary units (AU).

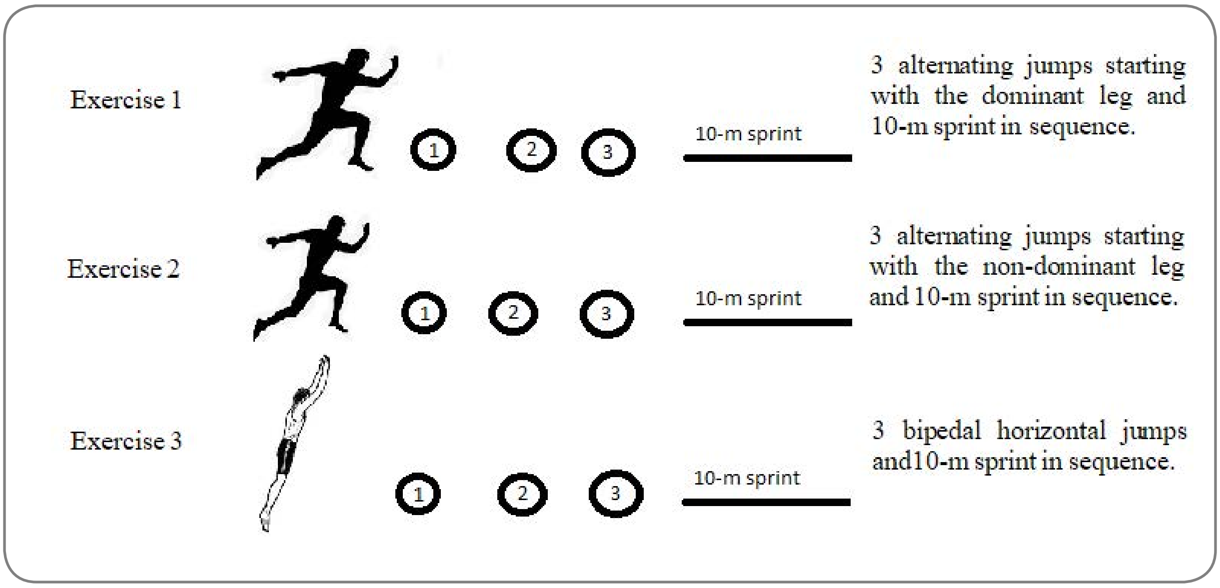

Figure 2 - Training exercise sequences during in plyometric jump and linear repeated sprint training program

Statistical analyses

Data are presented as group mean values and standard deviations. After data normality was verified with the Shapiro-Wilk test, an independent t-test was used to detect baseline between-group differences. A two-way ANOVA with repeated measures on time was used to group-specifically analyze all dependent variables (Groups: one, two, and three training sessions per week: 1-TSW, 2-TSW, 3-TSW) × 2 (Time: pre, post). Post-hoc tests with Bonferroni adjustment were conducted to identify comparisons that were statistically significant. Effect sizes for main effects of 'group' and 'time' as well as Group × Time interactions were taken from the ANOVA output (partial eta squared), classified as small (= 0.0099), medium (= 0.0588), and large (= 0.1379) [28,29]. Statistical analyses were carried out using STATISTICA statistical package (*Version 8.0; StatSoft, Inc., Tulsa, USA*). Significance levels were set at α= 5%. The reliability of all dependent variables was acceptable [30], with intra-class correlation coefficients values amounted to 0.97, 0.95, 0.93, 0.91 and 0.89 for the CMJ, CMJA, DJ20, 30-m sprint, and CODS tests, respectively, and coefficients of variation < 4.2.

To calculate the sample size, statistical software (*G*Power; University of Düsseldorf, Dusseldorf, Germany*) was used. Given the study design (3 groups, 2 repeated measures), the within-group effect size 0.67 and 231 ± 4.23 in SLJ for the experimental group and control group, respectively [18], alpha error<.05, the non-sphericity correction ∊ = 1, the correlation between the repeated measures = .5, and a desired power (1-ßerror) = 0.80, the total sample size resulted in a minimum of 9 participants required in each condition. Due to potential attrition, to increase the probability to obtain an adequate sample size after the intervention, ≥ 9 participants were considered to be included in the experimental groups.

Results

Ten, eleven and twelve futsal players completed the intervention programs involving one, two and three weekly training session, respectively. During the whole intervention period (4 weeks), no injuries were reported. The three groups had similar age, height, adherence, participation and internal load (Table II) and with no differences between-groups in any dependent variable before the intervention (p = 0.160-0.785).

The main effects of group, time, and group-time interactions are displayed in Table III. Results revealed significant main effects of time for all physical fitness outcomes (all p < 0.001; d = 0.36-0.69), without significant group × time interaction effects (p = 0.133-0.861; d = 0.01-0.13).

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Table II - Characteristics of the different groups

	Age	Height	Adherence intervention (%)	Participation total (%)	Internal load (A.U)
1-TSW (n=10)	16.6 ± 0.9	170.4 ± 4.3	100	94.1	588.7 ± 68.9
2-TSW (n=11)	16.9 ± 1.0	172.1 ± 5.53	96.4	97.7	606.9 ± 63.8
3-TSW (n=12)	17.3 ± 1.1	174.7 ± 5.6	94.5	95.1	558.1 ± 82.2

1-TSW, 2-TSW, and 3-TSW= one, two, and three training sessions per week groups, respectively; A.U= Arbitary units

According to the PEDro [31] and TESTEX scales, we comply with items eligibility criteria (e.g., federated futsal athlete from a national futsal league), random allocation (e.g., randomly introduced to 1-TSW, 2-TSW and 3-TSW), allocation concealment (e.g., athletes were unaware of which group they would be allocated to, at the time they give their consent), inter-group homogeneity (e.g., no baseline inter-group differences in main outcomes), participation ≥94% (e.g., all athletes completed the study),intention to treat analysis (e.g., all athletes received training as allocated), between group comparison (e.g., a two-way ANOVA and post-hoc tests with Bonferroni were applied), measure of variability (e.g., standard deviation reported), adverse effects reported (e.g., no injuries were reported), attendance reported (e.g., the compliance with training was >94%), exercise intensity controlled (e.g., participants in the experimental groups were requested to perform with maximum effort in the jumps and sprints),and exercise volume/energy expended controlled (e.g., the 1-TSW 2-TSW and 3-TSW groups performed ~780 jumps and ~1,200-m sprint throughout the intervention). However, we were unable to comply with blinding of subjects, blinding of assessors, and the activity monitoring of groups outside the intervention and regular futsal training sessions (other than the total number of sessions and minutes of training). Nonetheless, all groups reported no changes in their training habits during the intervention, as compared to their training routine prior to recruitment.

Table III - Means and (±) standard deviation of outcome measures for each group before and after the intervention period

			ANOVA outcomes		
	Before	After	Group F(2, 30), p-value (η_p^2)	Time F(1, 30), p-value (η_p^2)	Group x Time F(2, 30), p-value (η_p^2)
Body mass (kg)			F=0.5, p=0.562 (0.04)	F=3.2, p=0.08 (0.10)	F=0.1, p=0.849 (0.01)
1-TSW (n=10)	67.1±7.3	67.5±7.1			
2-TSW (n=11)	66.5±8.1	67.0±9.4			
3-TSW (n=12)	70.1±10.6	71.0±10.3			
Squat jump (cm)			**F=0.5, p=0.611 (0.03)**	**F=29.6, p<0.001 (0.50)**	**F=0.7, p=0.503 (0.05)**
1-TSW (n=10)	35.7±4.4	37.6±4.3			
2-TSW (n=11)	33.9±5.6	36.0±5.2			
3-TSW (n=12)	33.2±5.2	36.3±4.6			

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Table III - Continuation.

	Before	After	ANOVA outcomes		
			Group F(2, 30), p-value (η_p^2)	Time F(1, 30), p-value (η_p^2)	Group x Time F(2, 30), p-value (η_p^2)
Squat jump (W)			F=0.5, p=0.640 (0.03)	**F=36.6, p<0.001 (0.55)**	F=1.0, p=0.382 (0.06)
1-TSW (n=10)	3149.0±386.7	3286.2±433.6			
2-TSW (n=11)	3014.2±403.3	3165.0±340.6			
3-TSW (n=12)	3139.2±494.1	3365.6±507.2			
SJ (W.kg-1)			F=0.5, p=0.630 (0.03)	**F=24.7, p<0.001 (0.45)**	F=0.5, p=0.617 (0.03)
1-TSW (n=10)	47.06±4.15	48.69±3.98			
2-TSW (n=11)	45.64±5.28	47.65±4.98			
3-TSW (n=12)	44.85±4.23	47.48±3.44			
CMJ (cm)			F=0.6, p=0.557 (0.04)	**F=19.4, p<0.001 (0.39)**	F=0.2, p=0.787 (0.02)
1-TSW (n=10)	37.8±5.5	39.2±5.1			
2-TSW (n=11)	36.5±5.0	38.6±6.0			
3-TSW (n=12)	35.3±5.5	37.0±4.5			
CMJ (W)			F=0.1, p=0.879 (0.01)	**F=29.2, p<0.001 (0.49)**	F=0.4, p=0.701 (0.02)
1-TSW (n=10)	3276.5±461.5	3378.5±443.3			
2-TSW (n=11)	3172.0±395.4	3320.8±391.1			
3-TSW (n=12)	3262.7±538.1	3407.8±500.5			
CMJ (W.kg-1)			F=0.6, p=0.564 (0.04)	**F=16.6, p<0.001 (0.36)**	F=0.2, p=0.850 (0.01)
1-TSW (n=10)	48.64±5.79	50.12±4.99			
2-TSW (n=11)	48.00±4.76	50.00±5.90			
3-TSW (n=12)	46.57±4.60	48.10±3.40			
SLJ (cm)			F=0.2, p=0.853 (0.01)	**F=34.6, p<0.001 (0.54)**	F=0.2, p=0.861 (0.01)
1-TSW (n=10)	210.1±14.2	223.3±15.1			
2-TSW (n=11)	213.4±18.1	226.8±19.7			
3-TSW (n=12)	215.3±24.1	226.2±18.5			
10-m sprint (s)			F=0.5, p=0.614 (0.03)	**F=30.0, p<0.001 (0.50)**	F=2.2, p=0.133 (0.13)
1-TSW (n=10)	1.79±0.06	1.75±0.07			
2-TSW (n=11)	1.83±0.07	1.75±0.07			
3-TSW (n=12)	1.83±0.08	1.78±0.08			
20-m sprint (s)			F=0.3, p=0.760 (0.02)	**F=67.3, p<0.001 (0.69)**	F=0.7, p=0.524 (0.04)
1-TSW (n=10)	3.11±0.11	3.01±0.12			
2-TSW (n=11)	3.14±0.14	3.03±0.14			
3-TSW (n=12)	3.14±0.13	3.06±0.11			
CODS T-test (s)			F=0.1, p=0.916 (0.01)	**F=56.5, p<0.001 (0.65)**	F=0.3, p=0.758 (0.02)
1-TSW (n=10)	10.57±0.43	10.12±0.44			
2-TSW (n=11)	10.68±0.53	10.13±0.48			
3-TSW (n=12)	10.61±0.71	10.04±0.35			

1-TSW, 2-TSW, and 3-TSW = one, two, and three training sessions per week groups, respectively; CMJ = countermovement jump; CODS = change of direction sprint; ηp2 = partial eta squared; bold values = significant time effect

Discussion

The main finding of this study is that different weekly frequencies (equated for total repetitions) of plyometric jumping and linear-sprint training improved similarly male´s under-18 futsal athletes physical fitness (jumping ability measured by SJ, CMJ and SLJ, change of direction and linear running speed).

Our novel findings indicates a large improvement for vertical and horizontal jump performance. Current findings expand those reported by Aloui *et al*. [15], noting improved SJ, CMJ and horizontal jump performance in U19 male soccer players after 8 weeks of combined plyometric-jump and linear-sprint training. Furthermore, it was observed significant increases in CMJ performance following combined plyometric and short sprints training, in male U15 soccer players [32]. Improvements in vertical and horizontal jump performance may be mediated through enhanced intermuscular and intramuscular coordination, optimized stretch-shortening cycle function and increased maximal strength [33]. The horizontal jump drills (i.e., bipedal horizontal jumps and alternating jumps), which constituted all of the training program used in this study, may have contributed to sprint and jump performance improvements, thus indicating a specific training stimulus.

A large improvement in speed was noted on 10-m and 20-m linear sprint distances. Our results are in line with the 20-m linear sprint improvement noted after plyometric combined with short sprints training interventions [15,21,32]. Improvements in linear sprint performance may be related to improved intermuscular coordination [33], increased muscle fascicle length [13] and other neural factors (i.e. improved neural drive to agonist muscles and changes in musculotendinous stiffness), enhancing the ability of athletes to achieve shorter ground contact times at running speed [34,35]. Another relevant point to be mentioned is the magnitude and orientation of muscle force application which are the largest determinants speed performance improvement, so, an athlete’s greater ability to generate force in the horizontal vector translates into better performance in short sprints, which may result in greater mechanical efficiency [11,36-38].

The present results as well showed a large effect on change of direction (COD) ability performance. The ability to change direction involves a lot of technique, good straight-line running speed condition [39], neural adaptations [35] and portrays a planned movement, not involving reaction to an external stimulus [21]. Our results are in agreement with researchers who analyzed the effect of combined plyometric--jump and sprint repeated training during 8 weeks in the preseason period, finding a significant change of direction speed improvement ($p = 0,001$ on T-test) [40] . Possible underlying mechanism gains include improvements in muscle strength, energy output and on the ability to use the stretch shortening cycle efficiently during ballistic movements [21]. Despite the reported improvements in the different variables in the previous paragraphs, these results should be interpreted with caution due to the limitation of not having included a control group for comparisons.

Previous studies with horizontal plyometric training frequencies [3] and different volumes [25] showed contrasting results in athlete´s performance on sprints, change of direction, vertical and horizontal jumps. In addition, sprint training with different frequencies and the same volume per week in young soccer players did not demonstrate significant improvements in sprint performance (up to 10 m) [17]. However, the combination of plyometric training with sprints proved to be an efficient method in the aforementioned actions with young handball players [21] and young soccer players [32] when compared to the control group. Thus, the magnitude and the ground reaction force vectors seems to be determinant for the velocity [36], and, our study shows that it can happen regardless of the frequency (1-TSW, 2-TSW or 3-TSW) of the proposed intervention, resulting in similar ability and efficiency to apply horizontal force on the ground, at speeds that progressively increase. In this context, it is worth mentioning that the positive adaptations obtained by the athletes and the non-difference between the frequencies studied here may be due to the adequacy and design of the training program (i.e. specificity) and training volume and density adjustment [32], with moderate volume of jumps (150-240 jumps per week) and distance of sprints (500-800-m per week), which is reasonable since it is already known that high volume of training can even harm the performance of athletes[10]. Considering that, some authors report that such occurrences are due to molecular, biochemical and physiological adaptations such as greater neural activation of the muscles, greater efficiency of the stretching-shortening cycle of the muscle-tendon unit, greater potential for intra and intermuscular coordination [21,33], corroborating to induce a better neuromuscular and metabolic performance of the athletes [32] even with different frequencies of training but with the same weekly volume.

Thus, regardless of the weekly frequency, once, twice or three times, it proves to be a reasonable form of incorporation into the technical-tactical training aiming to increase the athletes' physical performance. Such performance gains can be beneficial for periods of the competitive season, with transfer to game performance. Coaches and sports scientists should consider the season calendar, availability of workouts per week, and equalize training loads. It is a methodology that does not require large financial resources and is easy to organize and implement by the staff of the team.

Conclusion

This study demonstrates that different weekly frequencies (1, 2, or 3) equated for total repetitions of plyometric jumping and linear-sprint training, improved similarly male's under-18 futsal athletes physical fitness.

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Potential conflict of interest
The authors have no conflicts of interest, financial or otherwise, to declare.

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Authors' contributions
Research conception and design: Neves TA, Campillo RR, Guerra RLF; **Data collection:** Neves TA, Guerra RLF; **Data analysis and interpretation:** Neves TA, Campillo RR, Guerra RLF; **Statistical analysis:** Neves TA, Campillo RR, Guerra RLF; **Manuscript writing:** Neves TA, Campillo RR, Guerra RLF; **Critical review of the manuscript for important intellectual content:** Neves TA, Campillo RR, Guerra RL; Final revision: Neves TA, Campillo RR, Guerra RLF

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