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COMPARISON OF THE DIFFERENT PLYOMETRIC TRAINING VOLUME ON PHYSICAL FITNESS IN FUTSAL PLAYERS

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Abstract

This study aimed to compare the effect of 8 weeks of different plyometric training volumes on measures of physical fitness in futsal players. The study randomly assigned twenty-six male futsal players into two groups: low-volume plyometric training (LVPT: n=13) and high-volume plyometric training (HVPT: n=13). All subjects participated in an 8-week plyometric training (PT) program, twice a week, with varying training volumes. The LVPT group performed 50–120-foot contact per session, and the HVPT group performed 110–225-foot contact per session for the entire 8-week PT program. Pre- and post-test measurements consist of a countermovement jump to assess power, a 20-meter sprint for speed, and the t-test for agility. The results demonstrated a significant difference in the HVPT group regarding CMJ ($p < 0.05$), 20-m sprint ($p < 0.05$), and t-test ($p < 0.05$) during 8 weeks of plyometric training compared to the LVPT groups. In conclusion, HVPT is suitable for short-term performance enhancement and can be utilized by teams in the pre-season phase to prepare players for high physical demands. In contrast, LVPT is more suitable for gradual strength development and long-term injury risk reduction.

Keywords: plyometric training, volumes, foot contact, neuromuscular

INTRODUCTION

Futsal is a high-intensity intermittent sport necessitating players to engage in repeated sequences of intense movements (e.g., sprinting, changes of direction, acceleration, deceleration, and kicking) during training and matches (Spyrou et al., 2020). Futsal players cover 3000–4500 meters during a match (Barbero-Alvarez et al., 2008), executing approximately 26 high-intensity sprints per match (Caetano et al., 2015). Moreover, proficient speed, agility, muscular strength, and power are crucial for executing particular futsal actions (e.g., shooting, dribbling, passing, and ball recovery) and movements (e.g., accelerations, decelerations, sprints, changes of direction, and jumps) (Junior et al., 2017; Ribeiro et al., 2020).

Plyometric training (PT) is a well-established method widely utilized to enhance the physical performance of athletes in team sports (Ebben et al., 2010; Asadi et al., 2016; Ramirez-Campillo et al., 2022). Prior research has demonstrated that plyometric training can be a safe, effective, and beneficial strategy for improving jump performance, sprinting, and change of direction abilities in soccer (Ramirez-Campillo et al., 2022), basketball (Huang et al., 2023; Aztarain-Cardiel et al., 2024), handball, and futsal (Yanci et al., 2017; Branquinho et al., 2022). Plyometric training (PT) is a fast, explosive form of exercise engaging both the lower and upper limbs, relevant to almost all sports (Haff & Triplett, 2015). PT refers to a specific form of exercise characterised by movements that involve a rapid stretch-shortening cycle (SSC) (Chu, 1998; Fleck & Kreamer, 2004; Aztarain-Cardiel et al., 2024), which consists of an eccentric phase or stretch, an isometric transitional period, and concludes with an explosive concentric action (Turner & Jeffreys, 2010).

The precise mechanisms behind the performance-enhancing effects of PT remain under scrutiny; however, substantial scientific evidence indicates that the coordinated interplay of muscle concentric and eccentric contractions enables muscles and connective tissues to optimally store elastic potential energy. This energy is subsequently released through the stretch reflex principle, facilitating instantaneous and rapid concentric contractions that generate significant explosive strength (Roberts & Marsh, 2003; Slimani et al., 2016). Additionally, it serves as a form of explosive training that enhances force rate, neural response, agility, and speed (Asadi et al., 2016). In this context, enhancing stretch-shortening cycle (SSC) likely enhances physical performance (Komi, 2000). Several studies have indicated that PT is the best strategy to enhance jumping ability, linear sprinting, agility, and changes of direction (COD) (Ramirez-Campillo et al., 2022; Huang et al., 2000).

In the PT program, the manipulation of training variables including intensity and volume will affect the stimuli and may provoke varying training responses and adaptations (de Villarreal et al., 2009; Davies & Riemann, 2015). PT volume is typically determined by the number of foot contacts with the ground during each session (Davies & Riemann, 2015; Haff & Triplett, 2015). Low-volume plyometric training encompasses foot contacts between 50 and 140 per session (Miller et al., 2006; Ebben et al., 2010; Petushsek et al., 2010), whereas high-volume plyometric training involves more than 200-foot contacts (Chu & Myer, 2013; Davies & Riemann, 2015). A study conducted by Diallo et al. (2001) investigated the effects of high-volume plyometric training (100–360-foot contacts per session) among prepubertal male soccer players, the finding showed a significant improvement of 7% in squat jump height, 12% in countermovement jump height, and a 3% increase in 20-meter sprint speed. Similarly, Söhnlein et al. (2014) examined the effects of high-volume physical training (112–350-foot contacts) on mid-pubertal soccer players and revealed a significant improvement in sprint performance, jumping ability and change of direction (COD) test scores.

In another study by, Chaabene & Negra (2017) investigated the effects of low-volume plyometric training (60-120 jumps) on soccer-specific performance in prepubertal male players, and were observed a significant improvement in sprint time and jumping capability. Simultaneously, Ramirez-Campillo et al. (2013) demonstrated that a 7-week low-volume PT program (60-foot contacts per session) was a significantly improved countermovement jump height and change of direction performance in young male soccer players.

The collective evidence from these studies suggests that both low- and high-volume PT can significantly improve physical performance; however, the training methodologies employed have largely been treated in isolation. Moreover, to date, no research has explicitly compared the impacts of low- and high-volume physical training on futsal players. Thus, the study aims to investigate and compare the effects of 8-week of low- and high-volume PT program on physical fitness (countermovement jump, 20-m sprint and T-test).

MATERIALS AND METHOD

Participants

Twenty-six male futsal players were recruited from the futsal club at Universiti Pendidikan Sultan Idris (UPSI). All the participants were free of injuries three months prior to the study, and none of them were taking any dietary supplements or any pharmaceutical drugs that may affect their performance during the study. None of the participants have any previous regular strength training and/or plyometric training. We obtained written informed consent from the participants prior to the study.

Research Design

The study employed a quasi-experimental design with pre-and post-tests. Participants were randomly assigned to either low-volume plyometric training (LVPT; n = 13) or high-volume plyometric training (HVPT; n = 13). All subjects were ordered according to their performance in the countermovement jump test (CMJ) and sequence distribution following order (ABBA). The LVPT group engaged in low-volume plyometric training for a total of 16 sessions over 8 weeks, while the HVPT group completed in high-volume plyometric training for the same duration. The parameters of this study were assessed before the participants underwent the training program (pre-test) and after they completed the 16 training sessions (post-test). A familiarization session was conducted two weeks before baseline to acquaint participants with the test procedures. One week before and after 72 hours of completing the PT program, the subjects performed a countermovement jump (CMJ), a 20-m sprint in a straight line, and a t-test for assessing power, speed, and agility (Chaabene & Negra, 2017).

Procedures

Before the measurement, the participant engaged in a 15-minute warm-up, which comprised 5 minutes of jogging, dynamic stretching exercises, submaximal jump exercises for 10 vertical jumps, and a specific sprint warm-up lasting 5 minutes. Each testing session allowed all the subjects to rest for 5 minutes. During the all-measurement, subjects were encouraged to give the best performance. The following sections provide a detailed description of each test conducted.

Countermovement jump (CMJ) was measured using a smartphone via the My Jump 2 application (My Jump 2, Apple Inc.). My Jump 2 software was utilized to determine jump height by selecting the take-off and landing frames from the recorded video of the jump. According to Bogataj et al. (2020) stated that the application calculates jump height using the formula $h = t^2 \times 1.22625$, where h denotes jump height (in meters) and t represents flight time (in seconds). All data and video recordings were conducted from the same position and at an equal distance of 1.5 meters from the participant while adhering to the standard calibration as per the manufacturer's instructions (Apple Inc.). The jump heights displayed in the My Jump 2 app were recorded. To perform the CMJ, subjects were instructed to execute it with the correct technique. This technique requires the subjects to keep their hands on their hips throughout the jump to minimize lateral and horizontal displacement and prevent any influence of arm movements on jump performance (Chaouachi et al., 2009).

A 20-m straight line was used to assesses sprint performance using a timing gate (Fusion, Ltd., Australia). The subjects were instructed to start 0.5 m behind the first timing gate and ran at maximal speed until reached the second timing gate, which was located 20 m from the first. The subjects were permitted two attempts with rest for three minutes. The best attempt was recorded for subsequent analysis.

The T-test was involved with four cones arranged in a "T" shape, with the distance from cone A to cone B was set at 10 yards (9.14 m) and the distance from cones C and D to cone B was measured at 5 yards (4.57 m) by using a timing gate (Fusion, Ltd, Australia). Cone A serves as both the start and final point for this test. The T-test was used to evaluated agility during with directional changes such as forward sprinting, left and right-side shuffling, and backward movements. Subjects completed two attempts with 3 minutes of rest, and the best time was recorded for further analysis.

Training Programme

The intervention of two experimental groups (LVPT and HVPT) was carried out for 8 weeks with two sessions per week conducted before the technical futsal training routine. After a 15-minute warm-up (jogging, dynamic stretching, submaximal jump exercise, and specific sprint), the LVPT group performed 10-15 repetitions x 5-8 sets for the entire 8 weeks of PT training, with total foot contact being 50–120. However, the HVPT requires performing twice the training volume (12–15 repetitions x 9–15, and total foot contact is 108–225) to complete 8 weeks of PT training (Table 1). A 3-minute rest was implemented for every set. All the subjects were instructed to perform at maximal effort for every PT exercise. All the training protocols were supervised by two qualified fitness instructors with certificated level 1 in sports sciences.

Table 1: Characteristics of the 8-weeks low volume plyometric training (LVPT) and high-volume plyometric training (HVPT)

		Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
LVPT	Volume (sets x reps)	5 x 10	6 x 10	6 x 12	6 x 15	7 x 15	7 x 15	8 x 15	8 x 15
	Foot contact per session	50	60	72	90	90	105	120	120
HVPT	Volume (sets x reps)	9 x 12	10 x 12	9 x 15	12 x 15	13 x 15	13 x 15	14 x 15	15 x 15
	Foot contact per session	108	120	135	180	195	195	210	225

LVPT: Low volume plyometric training; HVPT: High volume plyometric training

Statistical Analysis

All the data were analysed by using the Statistical Package for the Social Sciences (SPSS, 23, for Windows, Chicago, Illinois, USA). Data are presented as means and standard deviation (M ± SD). In addition, Levene's test was performed to confirm the normality of distribution and homogeneity of variance in each of the variables. The independent sample t-test was employed in this study to examine the study's hypothesis and measure any significant variable outcomes of low and high volumes of plyometric training programs on power, speed, and agility after 8 weeks. The alpha level of significance was set at $p \leq 0.05$.

RESULTS

Descriptive Statistic

The demographic characteristics of participants consist of age, height, weight, and body mass index (BMI) are detailed in Table 2, presented in mean and standard deviation (M±SD) for both groups (LVPT and HVPT). The high-volume group (HVPT) demonstrated a mean and standard deviation for age, height, weight, and BMI of 23.0 ± 0.7 years, 171.5 ± 6.5 centimetres, 71.0 ± 2.7 kilogrammes, and 23.9 ± 3.8 kg/m², respectively. In contrast, the low-volume group (LVPT) demonstrated a mean and standard deviation for age, height, weight, and BMI of 23.1 ± 0.2 years, 165.4 ± 6.9 centimetres, 68.2 ± 2.1 kilogrammes, and 24.9 ± 3.1 kg/m², respectively

Table 2: Demographic characteristics of participants

Demographic	**HVPT (M±SD) (n=13)**	**LVPT (M±SD) (n=13)**
Age (year)	23.0 ± 0.7	23.1 ± 0.2
Height (cm)	171.5 ± 6.5	165.4 ± 6.9
Weight (kg)	71.0 ± 2.7	68.2 ± 2.1
BMI (kg/m^2)	23.9 ± 3.8	24.9 ± 3.1

Table 3, showed that after 8 weeks of PT program on futsal players, it was found that there was a significant difference ($p < 0.05$) in countermovement jump (CMJ) in HVPT compared to the LVPT groups. The result showed that the HVPT group had a significantly higher jump in countermovement jump (CMJ) (M = 35.1 cm ± SD = 2.5) than the LVPT group (M = 33.6 cm ± SD = 2.1). The HVPT group demonstrated an improvement of Δ= (7%) higher jumping performance, while the LVPT group showed Δ= (4%) improvement in jumping ability after 8-week PT programs. The results for 20-m sprint straight line ($p < 0.05$) and agility t-test ($p > 0.05$) were found a significantly faster time for the HVPT group (M = 3.35 s ± 0.8,), (M = 9.81 s ± 0.7, P > 0.05) compared to LVPT groups (M = 3.41 s± 0.2), (M = 9.97 s ± 0.5,), respectively. The HVPT group demonstrated improvement after an 8-week PT program on 20-m sprint (Δ= 4.3%), and Agility t-test (Δ= 4.9%); LVPT = 20-m sprint (Δ= 3.8%), and agility t-test (Δ= 3.9%), respectively.

Table 3: Pre- and post-test analysis after 8-weeks of plyometric training between LVPT and HVPT for CMJ, 20-m sprint and agility t-test.

	LVPT			**HVPT**			
	Pretest	Posttest	Δ (%)	Pretest	Posttest	Δ (%)	*p*
CMJ (cm)	32.3	33.6±2.1	4.02	32.8	35.1±2.5*	7.01	.001*
20-m sprint (s)	3.54	3.41±0.2	3.67	3.50	3.35±0.8*	4.29	.003*
T-test (s)	10.37	9.97±0.5	3.86	10.31	9.81±0.7*	4.85	.001*

LVPT: Low-volume plyometric training, HVPT: High-volume plyometric training, Δ: pre-training – post training change, CMJ: Countermovement jump,

DISCUSSION

The purpose of this study was to assess and compare the effect of 8-week HVPT and LVPT on countermovement jumps, 20-m sprints, and agility t-tests in futsal players. The main findings indicated that 8 weeks of plyometric training with high volume induced significant and small improvements in CMJ, 20-m sprints, and agility t-tests. Despite the study's results, the entire PT training volume varied significantly between the two groups (LVPT: 50-140 vs. HVPT: 108–225-foot contacts per session). Our data revealed that low-volume PT elicited a similar improvement in CMJ, 20-m sprint, and agility t-test compared to high-volume PT, but statistically, there was no significant difference. This argument asserts that there exists a specific volume threshold beyond which increased volume does not enhance further improvement in performance (de Vellarreal et al., 2009).

Regarding CMJ performance, HVPT (~108-225-foot contact per session) showed significant improvement (M = 35.1 ± 2.5 cm, Δ = 7%) compared to LVPT (M = 33.6 ± 2.1 cm, Δ = 4%) in jump height. In agreement with our findings, Aztarain-Cardiel et al. (2024) conducted a study on the effects of PT volume (LV: 40-64, HV: 80-128 contacts per session) on youth basketball players, demonstrating a significant increase in CMJ and SJ height in both groups after a 6-week PT program. Likewise, Chaabene & Negra (2017) study the effects of PT volume in pubertal male soccer players by implementing high-volume plyometric (~110-220-foot contact per session) that reveal a significant improvement for CMJ [Δ = 14.26% (-5.33 to 37.91 cm)] over the 8-week PT program. PT most positively affected the vertical jump and CMJ through the transfer of muscle power from lower limbs.

The improvement in jumping performance after PT could have been induced by various neuromuscular adaptations to demonstrate a transfer from PT to other physical tasks involving lower limbs, generating explosive and speculated, probably due to increased neural drive to the agonist muscle, improved intermuscular coordination, change in muscle size, and changes in single-fiber mechanics (Markovic & Mikulic, 2010; Ramirez-Campillo et al., 2013). In this regard, high-velocity PT training enhances neuromuscular performance by manipulating variables such as volume, frequency, and intensity that influence physical performance (Karavelioglu et al., 2016; Ramirez-Campillo et al., 2021).

Although LVPT is shown not to be significant in this study, nevertheless, low-volume plyometric training would be sufficient to induce changes in pre-post training (Δ = 4% increase in height of jump) to positive adaptation. In support of this contention, a study by, Chaabene & Negra (2017) showed significant improvements in sprint time and jumping ability by using low-volume PT (60–120 contact foot jumps) on the soccer-specific performance of prepubertal male soccer players. Conversely, a significant improvement in CMJ performance was reported in both groups (low- and high-volume groups) in studies by Aztarain-Cardiel et al. (2024) and Chaabene & Negra, (2017).

Post-intervention assessments of the 20-m sprint revealed that the HVPT group exhibited a significantly faster time (M = 3.35 ± 0.8 s) than the LVPT group (M = 3.41 ± 0.2 s). These findings correspond with a prior study by Negra et al. (2016), which demonstrated a notable enhancement in the 20-meter sprint in a straight line (Δ=4%) with high-volume PT (~112–280-foot contacts per session) for prepubertal male soccer players. Diallo et al. (2001) investigated the impact of high-volume PT (100–360-foot contact per session) on prepubertal male soccer players and demonstrated a significant 3% improvement in 20-meter sprint times.

Similarly, the study conducted by Ramirez-Campillo et al. (2013) indicated that following 7 weeks of plyometric training, the HV group (~240 jumps per week) exhibited a significantly improved sprint time in a 20-meter sprint (Δ=0.8%). A study by Chaabene & Negra (2017) demonstrated markedly enhanced sprint times in both the LV and HV groups. Futsal generally executes average sprints of 10 meters every 79 seconds, with an estimated duration of under 40 seconds (Spyrou et al., 2020). Conversely, a substantial amount of plyometric training may be essential for improving sprint performance. A substantial amount of plyometric training yields an adequate adaptive response to improved neural input and eccentric energy storage (Watkins et al., 2021).

The current findings indicated that HVPT significantly decreased the time in the t-test, achieving a faster time (M = 9.81 ± 0.7 s) compared to LVPT (M = 9.97 ± 0.5 s) after 8 weeks. Söhnlein et al. (2014) investigated the impact of high-volume PT (112–350-foot contact) on mid-pubertal football players and demonstrated a significant enhancement in the agility change of direction test. In contrast, research conducted by Ramirez-Campillo et al. (2018) and Chaabene & Negra (2017) demonstrated comparable improvements in both the low-volume (LV) and high-volume (HV) training groups in the Illinois test and t-test, respectively.

In this study, we acknowledge the absence of a control group (CG). However, due to the limited number of players and underpowered sample size effect, the control group appears to be less demanding. Moreover, the study's duration of 8 weeks (16 sessions) restricted its scope to short-term adaptation to PT volume. Therefore, it seems warranted to conduct further studies that consider the long-term effect of PT volume, such as 16 to 24 weeks, to support the current findings.

CONCLUSION

The current study has confirmed that futsal players exhibited improved physical measures of physical fitness following 8 weeks of HVPT (108-225-foot contact per session). Conversely, the study also showed that short-term LVPT could have similar improvements (pre-test to post-test values) in the CMJ (“ -4%), the 20-m sprint (“ -3.8%), and the t-test (” -3.9%), but these differences were not statistically significant. On the other hand, the HVPT program seems suitable to enhance physical performance in the short term but might not be in the long term. Therefore, futsal training programs should incorporate PT as a supplementary measure to enhance physical demands and achieve optimal performance.

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