Physical Education Theory and Methodology
Теорія та методика фізичного виховання

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original Scientific Article

The Effect of a 12-Week Plyometric and Tabata Training Program with Three Weekly Sessions on Cardiovascular Efficiency in Elite Soccer Players

Nidhin Muthrathiparambil Narayanan[1ABCDE], Kayambu Sundar[1ABCDE], Nirmal Michael Salvi[2CDE], Yashpal[3CDE], Debajit Karmakar[4CDE], Sohom Saha[4CD], Bekir Erhan Orhan[5ACD], Farjana Akter Boby[6ACDE] and Yuni Astuti[7ACDE]

[1]Alagappa University
[2]Symbiosis International (Deemed University)
[3]Pt. Chiranji Lal Sharma Government College
[4]Lakshmibai National Institute of Physical Education
[5]Istanbul Aydin University
[6]Daffodil International University
[7]Universitas Negeri Padang

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Yuni Astuti, e-mail: yuniastuti@fik.unp.ac.id
Accepted for Publication: December 19, 2024
Published: January 30, 2025

DOI: 10.17309/tmfv.2025.1.18

Abstract

Objectives. This study aimed to examine the effects of a 12-week plyometric training program and a Tabata regimen on cardiovascular efficiency in elite soccer players.

Materials and methods. Sixty male inter-university players, aged 20.79 ± 1.75 years, were randomly assigned to the Plyometric Training Group (PTG, n = 20), Tabata Training Group (TTG, n = 20), or Control Group (CG, n = 20). Cardiovascular metrics, including vital capacity, resting heart rate, mean arterial blood pressure, breath-holding time, and respiratory rate, were assessed before and after the program. Both PTG and TTG completed three 90-minute sessions on a weekly basis.

Results. The results revealed that both the PTG and TTG showed significant improvements in cardiovascular efficiency. Vital capacity increased by 30.83% ($d = 1.24$, $p < 0.001$) in PTG and by 34.61% ($d = 1.52$, $p < 0.001$) in TTG. Resting heart rate decreased by 12.36% ($d = 1.74$, $p < 0.001$) in PTG and by 15.18% ($d = 1.82$, $p < 0.001$) in TTG. Breath-holding time increased by 29.86% ($d = 2.12$, $p < 0.001$) in PTG and by 34.42% ($d = 2.35$, $p < 0.001$) in TTG. Respiratory rate decreased by 28.07% ($d = 1.04$, $p < 0.001$) in PTG and by 28.33% ($d = 1.10$, $p < 0.001$) in TTG. These findings highlight the substantial positive impact of both training methods on cardiovascular efficiency in elite soccer players.

Conclusions. In conclusion, the implementation of a plyometric and Tabata training program has been found to produce significant improvements in cardiovascular efficiency in elite soccer players, making them valuable preseason conditioning strategies to enhance endurance, performance, and overall athletic abilities.

Keywords: soccer training, physiological parameters, HIIT, jumping training, football players.

Introduction

Athletes must meet high physical demands in football, especially in terms of cardiovascular endurance, because the sport is characterized by intermittent outburst of speed, direction changes, and endurance (Carling et al., 2012; Radaković et al., 2024; Stolen et al., 2005). It is necessary to keep player's cardiovascular system in top condition, as that is crucial for the best performance possible from soccer players on the ground (Bush et al., 2015; Nystoriak & Bhatnagar, 2018; Radaković et al., 2024). In light of the importance of cardiovascular health in football, several training strategies have been developed to increase it, with plyometric training and high intensity interval training (HIIT), including Tabata, considered as two of the most efficient measures considering their benefits (Afyon et al., 2021; Tabata, 2019; Thomakos et al., 2023). The logical combination of plyometric training with high-intensity interval training (HIIT) has been widely researched and discussed as an effective methodology to enhance athletic performance, more specifically in what cardiovascular capacity is concerned (Davies et al., 2015; Fajrin et al., 2018; Kons et al., 2023; Martin-Smith et al., 2020). Significantly, they have been proven efficient to enhance both aerobic and anaerobic capacities of athletes across different disciplines such as football (Hostrup & Bangsbo, 2023; Keren & Epstein, 1981; Yan et al., 2022). However, despite the considerable amount of literature on each method separately, a direct comparative evaluation between these two methods on cardiovascular efficiency in elite football players is still scarce and was the subject of this study. Plyometric training, characterized by explosive and power-driven movements including jumps, bounds, and rapid directional changes, has been extensively documented regarding its beneficial impacts on athletic performance (Kons et al., 2023; Sinkovic et al., 2023).

Plyometric training has several merits, such as improvement in muscular power and favourable effects on resting heart rate and blood pressure (Deng et al., 2024; Ramírez-Campillo et al., 2015). It makes sense when Faigenbaum et al. (2007) writes, "Athletes also demonstrate decreases in resting heart rate and improvements in blood pressure control following plyometric training suggesting substantial cardiovascular adaptations. These findings have importance in particular for football players, who need to keep a high resistance of the cardiorespiratory system in order to respect the physical demands of a game (Faigenbaum et al., 2007). Despite these findings, the impact of plyometric exercise on a wide range of cardiovascular parameters, such as vital capacity and respiratory rate, has received little attention, particularly among professional football players (Singh et al., 2024; Singh et al., 2021).

As a type of high-intensity interval training, Tabata training is designed to be one of the quickest way to improve aerobic and anaerobic parameters. The regimen was introduced by Tabata et al. (1996) comprises of brief high-intensity exercise intervals followed by minimize recovery times. According to the study, athletes on Tabata training quadratically improved their VO2 max (a key indicator of cardiovascular health and overall fitness) within a matter of weeks (Tabata, 2019). There are many studies that have been conducted to investigate the benefits of Tabata training, which has been found to improve CV fitness, lower resting HR and even decrease blood pressure (Milanović et al., 2015). Lu et al. (2023) revealed that Tabata-style HIIT enhanced cardiovascular capacity alongside energy efficiency, meaning that competing athletes would be able to support high-intensity exercise with less of a cardiovascular drain (Lu et al., 2023). This is important for football players, as they have to consistently play sprints at high intensity and recover fast during games. Despite the large increase in VO2max associated with this type of exercise, most studies have employed an intensity that is far from what has been called the maximal production or power output and closely oriented to football training practice (Sloth et al., 2013).

Though plyometric and Tabata training have been extensively researched, there is a striking lack of studies explicitly evaluating their effects on cardiovascular efficiency in football players. Previous studies have usually focused on specific aspects of cardiovascular fitness, such as VO_2 max or heart rate, while failing to examine a comprehensive set of cardiovascular indicators that could provide a more complete knowledge of cardiovascular efficiency (Granero-Gallegos et al., 2020; Vesterinen et al., 2016). Furthermore, the enduring impacts of these training modalities, especially within a soccer-specific framework, have yet to be thoroughly investigated. Investigations often focus on short-term interventions; however, there is a paucity of knowledge regarding the impact of prolonged programs, extending 12 weeks or more, on both aerobic and anaerobic systems in elite athletes.

Although the current body of research emphasizes the advantages of plyometric and Tabata training concerning different facets of physical performance and cardiovascular fitness, the direct comparison of these training modalities in elite football players has not been thoroughly investigated. Furthermore, the incorporation of various cardiovascular markers, including vital capacity, breath-holding time, and respiratory rate, in existing studies is limited. Thus this research seeks to address the existing gap by exploring the effects of plyometric and Tabata training on cardiovascular efficiency in football players over a 12-week duration, thereby contributing valuable insights into the enhancement of training protocols for elite athletes.

Materials and Methods

Participants

This investigation involved sixty participants, consisting of young adult male elite soccer players, with a mean age of (20.73 ± 1.83 years) for the Plyometric Training Group (PTG), (20.80 ± 1.69 years) for the Tabata Training Group (TTG), and (20.85 ± 1.72) years for the Active Control Group (ACG). Participants were recruited from Kerala State.

Inclusion and Exclusion Criteria

All participants were categorized as inter-university level players with a background of systematic soccer training averaging 3.6 ± 2.4 years, with three to five training sessions per week required for participation. It is important to note that all individuals were in good health and had no history of significant musculoskeletal injuries in the six months prior to the start of the research. Participants who missed more than 20% of the total training sessions or two consecutive sessions were excluded from the study.

Study Design

Participants were randomly allocated to one of three groups: Plyometric Training Group (PTG) (n = 20; age = 20.36 ± 2.45 years; weight = 71.26 ± 4.32 kg; height = 171.25 ± 7.16 cm), Tabata Training Group (TTG) (n = 20; age = 20.75 ± 3.17 years; weight = 72.37 ± 2.24 kg; height = 170.36 ± 3.37 cm), and Active Control Group (ACG) (n = 20; age = 20.79 ± 3.54 years; weight = 72.49 ± 3.57 kg;

height = 172.12 ± 2.14 cm). The anthropometric details for all groups can be found in Table 1. The study was guided by the most recent version of the Declaration of Helsinki, ensuring compliance with approved ethical standards for research in sport and exercise science.

Table 1. Participant's demographic of the 3 groups (PTG, TTG & CG)

	PTG	TTG	CG	p
Age (yrs)	20.36 ± 2.45	20.75 ± 3.17	20.79 ± 3.54	0.426
Weight (kg)	71.26 ± 4.32	72.37 ± 2.24	72.49 ± 3.57	0.230
Height (cm)	171.25 ± 7.16	170.36 ± 3.37	172.12 ± 2.14	0.659

PTG: plyometric trained group, TTG: tabata trained group, CG: active control group

The training intervention lasted for 12 weeks, consisting of three sessions per week. Environmental conditions during the training were controlled to ensure consistency, with sessions conducted in a temperature-regulated indoor facility to minimize external variables affecting performance. Prior to commencing the training, participants were familiarized with the training procedures and outcome measures to ensure comfort and compliance throughout the study. Assessments were conducted before and after the training period, focusing on several outcome measures, including vital capacity, resting heart rate, mean arterial blood pressure, breath-holding time, and respiratory rate. To ensure accurate measurements, all tests were administered with a rest period of 2 minutes between each assessment.

Training Intervention

The training intervention procedure for both Plyometric Training Group (PTG) and Tabata Training Group (TTG) was carefully designed to follow a structured format over a 12-week period, incorporating appropriate warm-up and cool-down routines. Each session lasted for 90 minutes and took place three times a week as shown in Table 2. The program was split into three phases: weeks 1-4, 5-8, and 9-12, with incremental increases in intensity and volume to ensure progressive overload while minimizing the risk of injury. Each training session began with a 10-15-minute dynamic warm-up aimed at preparing the athletes for the upcoming high-intensity activities and reducing the risk of injury. The warm-up included general aerobic exercises such as jogging or light running, followed by dynamic stretches targeting major muscle groups, especially those heavily involved in football performance. Movements such as leg swings, lunges with a twist, arm circles, and hip rotations were incorporated. The final part of the warm-up consisted of sport-specific drills like short sprints, lateral shuffles, and agility ladder drills to activate neuromuscular coordination. A well-structured warm-up has been shown to enhance performance and reduce injury risk in high-intensity activities (Fradkin et al., 2010).

For the PTG, the focus was on developing explosive power through high-intensity, low-repetition exercises targeting the lower body and core. The athletes performed exercises such as squat jumps, box jumps, tuck jumps, lateral bounds, and plyometric push-ups. Each session involved 3-5 sets of 8-15 repetitions, with rest intervals of 1.5 to 3 minutes between sets depending on the week. Work intensity was progressively increased from moderate (Rating of Perceived Exertion [RPE] 6-7) in weeks 1-4, to high intensity (RPE 8-9) in weeks 9-12. Plyometric training has been shown to improve muscular power and overall athletic performance in sports requiring explosive movements like football (Markovic & Mikulic, 2010).

The TTG followed a high-intensity interval training (HIIT) approach based on the Tabata protocol, which involves 20 seconds of maximal effort followed by 10 seconds of rest, repeated for 8 rounds per exercise. Exercises included burpees, jump squats, push-ups, high knees, and mountain climbers. As with the PTG, intensity increased across the phases, starting with moderate intensity (RPE 7-8) in weeks 1-4, progressing to very high intensity (RPE 9-10) by weeks 9-12. Rest intervals between exercises ranged from 2-3 minutes, with shorter rest durations in the later weeks. This form of training has been demonstrated to significantly enhance both aerobic and anaerobic capacities in athletes (Tabata, 2019).

After completing the main workout, each session ended with a 10-15 minute cool-down period. The cool-down involved light jogging or walking to gradually bring down the heart rate, followed by static stretching exercises for the hamstrings, quadriceps, calves, hip flexors, and upper body muscles. Stretching at the end of a workout helps in relieving muscle tension, improving flexibility, and aiding in recovery (Smith, 1994).

Outcome Measures

Vital capacity

Vital capacity was assessed using a spirometer, which measures the maximum amount of air a participant can expel from the lungs after a maximum inhalation. Participants were instructed to take a deep breath and exhale into the spirometer as forcefully as possible, following standard guidelines as referenced (Dridi et al., 2021). This test was repeated three times, and the highest value was recorded as the participant's VC.

Resting Heart Rate

Resting heart rate was measured using a digital heart rate monitor (Model No. EW 243, National Company, Japan). Participants were seated comfortably for five minutes, and the device was placed on their wrist to capture the heart rate. The lowest stable reading after the rest period was recorded, ensuring consistency in line with previous studies (Brini et al., 2021).

Mean Arterial Blood Pressure

Mean arterial blood pressure was determined by using the participants' systolic and diastolic blood pressure readings. Blood pressure was measured in a seated position using a standard sphygmomanometer, and the MABP was calculated using the following formula: MABP = Diastolic BP + 1/3(Systolic BP - Diastolic BP), as recommended by Mathews and Fox (Deepa et al., 2009). This provided a more comprehensive measure of the participants' average blood pressure over a single cardiac cycle.

Table 2. Plyometric Training (PTG) and Tabata Training (TTG) with three weekly sessions for football players 12-week training schedule

Training Schedule	Weeks 1-4	Weeks 5-8	Weeks 9-12
Session Frequency	3 times per week	3 times per week	3 times per week
Training Duration	90 minutes per session	90 minutes per session	90 minutes per session
Work (minutes)	30-40 minutes	35-45 minutes	40-50 minutes
Rest (minutes)	1-2 minutes between exercises	1-2 minutes between exercises	1-1.5 minutes between exercises
Plyometric Training (PTG)			
Sets	3 sets	4 sets	4-5 sets
Repetitions	8-10 reps per exercise	10-12 reps per exercise	12-15 reps per exercise
Rest Between Sets	2-3 minutes	2 minutes	1.5-2 minutes
Work Intensity (RPE Scale)	Moderate (6-7)	Moderate to High (7-8)	High (8-9)
Exercises	Squat jumps, Box jumps, Tuck jumps	Lateral jumps, Depth jumps, Plyo push-ups	Broad jumps, Bounding, Split jumps
Tabata Training (TTG)			
Sets	8 sets	8 sets	8 sets
Work Duration (seconds)	20 seconds per set	20 seconds per set	20 seconds per set
Rest Duration (seconds)	10 seconds between sets	10 seconds between sets	10 seconds between sets
Rest Between Sets (minutes)	2-3 minutes	2-3 minutes	1.5-2 minutes
Work Intensity (RPE Scale)	Moderate (7-8)	High (8-9)	Very High (9-10)
Exercises	Burpees, Mountain climbers, High knees	Jump squats, Push-ups, Speed skaters	Sprint intervals, Plank to push-up, Jump lunges

Breath-holding

Breath-holding time was measured using a nose clip and stopwatch to track the time participants could hold their breath after a maximum inhalation. Participants were seated and fitted with a nose clip to prevent air from entering through the nose. They were instructed to take a deep breath, hold it, and signal as soon as they could no longer continue. The stopwatch was used to record the duration, and the procedure was conducted in accordance with Mathew's method (Ghavipanje et al., 2022).

Respiratory Rate

Respiratory rate was monitored using a bio-monitor, which automatically tracks the number of breaths per minute. Participants were seated, and the bio-monitor was attached according to the manufacturer's instructions. The RR was recorded once the participant was relaxed and breathing naturally, following the previous study procedure described by (Govindasamy et al., 2023).

Statistical Analysis

Prior to conducting the main analyses, data were tested for normality using the Shapiro-Wilk test (Shapiro & Wilk, 1965). All variables met the assumptions of normality ($p > 0.05$), allowing for the use of parametric statistical tests. analyzed using repeated measures analysis of variance (ANOVA) to assess the effects of group (PTG, TTG, and Control) and time (pre-training and post-training) on cardiovascular parameters, including vital capacity (VC), resting heart rate (RHR), mean arterial blood pressure (MABP), breath-holding time (BHT), and respiratory rate (RR). The statistical model tested for the main effects of group and time, as well as group × time interactions (Park et al., 2009). Effect sizes were reported as partial eta squared (ηp^2) to quantify the magnitude of group and time effects, as well as interaction effects. Post-hoc analyses using Cohen's d were conducted to examine the magnitude of changes from pre- to post-training within each group (Cohen, 1988).

Results

All male elite football players successfully completed the allocated treatments, with no training or test-related injuries reported. In terms of cardiovascular efficiency, significant main effects of both group and time were observed across multiple parameters, as shown in Table 3. For VC, there was a significant main effect of group ($p = 0.031$, $\eta p^2 = 0.90$) and time ($p < 0.001$, $\eta p^2 = 2.54$). RHR also showed significant main effects for group ($p = 0.024$, $\eta p^2 = 0.74$) and time ($p < 0.001$, $\eta p^2 = 1.34$). BHT presented a significant main effect for group ($p < 0.001$, $\eta p^2 = 2.48$) and time ($p < 0.001$, $\eta p^2 = 4.12$). Similarly, for RR, significant main effects were found for both group ($p < 0.001$, $\eta p^2 = 2.34$) and time ($p < 0.001$, $\eta p^2 = 2.87$). Moreover, significant group-by-time interactions were identified for all variables. VC demonstrated a significant interaction between group and time ($p < 0.001$, $\eta p^2 = 3.21$), as did RHR ($p < 0.001$, $\eta p^2 = 2.37$), BHT ($p < 0.001$, $\eta p^2 = 2.43$), and RR ($p < 0.001$, $\eta p^2 = 2.75$). These results indicate that the interventions led to meaningful improvements in cardiovascular efficiency, with variations across groups over time. In particular, the groups undergoing PTG and TTG showed significantly greater improvements from pre- to post-training in various cardiovascular parameters. For VC, there was an increase of 30.83 % (d = 1.24) in the PTG group and 34.61 % (d = 1.52) in the TTG group. RHR decreased by 12.36 % (d = 1.74) in the PTG group and by 15.18 % (d = 1.82) in the TTG group. MABP showed a reduction of 1.68 % (d = 1.40) in the PTG group, while the TTG group experienced a slight increase of 0.38 % (d = 1.36). BHT increased by 29.86 % (d = 2.12) in the PTG group and by 34.42 % (d = 2.35) in the TTG

Table 3. Mean (± SD) values of cardiovascular efficiency variables for the 3 groups (PTG, TTG & CG)

Variables	Group	Before Intervention	After Intervention	% change	p (Cohen d) Main effect group	Main effect time	Interaction group x time
	PTG	3152.00 ± 387.12	4124.00 ± 524.16	30.83			
VC (mL)	TTG	3247.41 ± 501.25	4371.00 ± 479.15	34.61	0.031 (0.90)	<0.001 (2.54)	<0.001 (3.21)
	CG	3179.00 ± 264.34	3879.00 ± 157.58	22.01			
	PTG	69.30 ± 4.15	60.73 ± 5.46	-12.36			
RHR (bpm)	TTG	69.80 ± 7.34	59.20 ± 6.37	-15.18	0.024 (0.74)	<0.001 (1.34)	<0.001 (2.37)
	CG	70.13 ± 4.25	64.80 ± 3.83	-7.60			
	PTG	87.75 ± 3.46	86.27 ± 4.52	-1.68			
MABP (mmHg)	TTG	87.54 ± 3.52	87.88 ± 1.24	0.38	0.674 (0.74)	0.725 (0.82)	0.214 (0.27)
	CG	89.42 ± 2.19	88.12 ± 3.37	-1.45			
	PTG	40.31 ± 6.38	52.35 ± 4.73	29.86			
BHT (s)	TTG	39.62 ± 2.54	53.26 ± 5.33	34.42	<0.001 (2.48)	<0.001 (4.12)	<0.001 (2.43)
	CG	40.36 ± 5.16	43.24 ± 9.64	7.13			
	PTG	35.12 ± 4.57	25.26 ± 5.54	-28.07			
RR (numbers)	TTG	36.81 ± 7.54	26.38 ± 2.78	-28.33	<0.001 (2.34)	<0.001 (2.87)	<0.001 (2.75)
	CG	35.36 ± 6.63	30.26 ± 6.68	-14.42			

Data are mean values (± SD), VC: vital capacity, RHR: resting heart rate, MABP: mean arterial blood pressure, BHT: breath holding time, RR: Respiratory Rate, PTG: plyometric trained group, TTG: tabata trained group, CG: active control group

group. Additionally, RR decreased by 28.07 % (d = 1.04) in the PTG group and by 28.33 % (d = 1.10) in the TTG group. These results emphasize the significant positive impact of both PTG and TTG on a range of cardiovascular efficiency metrics in the participants.

Discussion

Soccer is a physically demanding sport requiring athletes to possess technical and tactical skills and superior cardiovascular fitness to sustain high-intensity actions such as sprints, jumps, and rapid directional changes throughout a match (Chaeroni et al., 2024; Ribeiro et al., 2021). Athletes must improve their anaerobic and aerobic capacity through targeted conditioning regimens to meet these demands. While Tabata and HIIT are well-known for improving metabolic efficiency and endurance, plyometric training well-known for developing explosive power is frequently employed to improve cardiovascular fitness. This study aimed to compare the effects of a 12-week plyometric and Tabata training program on cardiovascular efficiency in elite soccer players and to provide insight into which method is more effective for improving key cardiovascular markers such as VC, RHR, and BHT. The findings offer valuable implications for athletic training by highlighting both training approaches' strengths and potential synergies in soccer.

The explosive, power-driven motions that PTG emphasizes, such as jumps and bounds, have improved cardiovascular indicators like VC, RHR, BHT, and RR. These improvements are consistent with previous literature suggesting that plyometric exercises involving rapid, forceful contractions improve muscle strength, endurance, and cardiovascular efficiency (Markovic & Mikulic, 2010; Ramirez-Campillo et al., 2020). Plyometric movements are vital for soccer players, mainly due to the frequent acceleration, deceleration, and jumps required during matches (Negra et al., 2020; Ramirez-Campillo et al., 2020). The improvements in cardiovascular efficiency reflect how explosive movements can condition both the muscular and cardiovascular systems (Hughes et al., 2018; Nystoriak & Bhatnagar, 2018). On the other hand, Tabata training, a HIIT technique, emphasizes exercises at total effort interspersed with brief rest intervals. It is well known that using this technique can improve both anaerobic and aerobic performance (Tabata, 2019). In this study, Tabata training slightly outperformed plyometric in terms of some indicators like VC, RHR, BHT, and RR, suggesting that it significantly affects cardiovascular performance. Soccer players who endure sporadic bursts of intense exertion followed by quick rest intervals, emulating the dynamics of a football game, are especially well-suited for Tabata training. The increase in vital capacity and improvement in breath-holding time (34.42% in TTG vs. 29.86% in PTG) can be attributed to the demanding nature of Tabata, which forces the body to optimize oxygen usage and strengthen respiratory muscles.

Cardiovascular efficiency is a critical aspect of soccer performance due to the physical demands of the sport (Oliva-Lozano et al., 2023; Zouhal et al., 2020). Soccer players must sustain long periods of moderate-intensity activity and repeatedly execute high-intensity sprints, jumps, and directional changes (Ribeiro et al., 2021; Stanković et al., 2024). Maintaining performance throughout a match requires cardiovascular adaptations such as increased VO2 max, lowered resting heart rate, and improved respiratory capacity (Nystoriak & Bhatnagar, 2018). The study's conclusions about resting heart rate are noteworthy. RHR decreased in both training groups; however, TTG showed a more significant decline (-15.18%) than PTG (-12.36%). Reduced RHR is a sign of better cardiovascular health since it shows how well the heart pumps blood. Soccer players, who must frequently sprint and recover between bouts of activity, require athletes with lower resting heart rates to sustain high-intensity activities for longer periods and recover more quickly (Hostrup & Bangsbo, 2023). The lower RHR in both groups emphasizes how plyometric and Tabata exercise promote cardiovascular adaptations. The slightly more significant reduction in the TTG group suggests that HIIT methods like Tabata may provide a more intense stimulus for cardiovascular adaptations due to the constant alternation between maximal effort and short rest intervals. Another necessary cardiovascular adaptation observed was in BHT. The increase in BHT by 34.42 % in the TTG group and 29.86 % in the PTG group indicates improved respiratory endurance and capacity. Increased BHT allows soccer players to sustain maximal efforts without succumbing to oxygen debt, which is crucial during the later stages of matches when fatigue sets in. Increased oxygen delivery and utilization and improved overall cardiovascular function are the results of high-intensity training regimens, further supported by these improvements in BHT (Lu et al., 2023).

The study's limited effect of both training modalities on MABP was one intriguing finding. The PTG group experienced a slight reduction (-1.68 %), while the TTG group showed a minor increase (0.38 %). These minimal changes suggest that MABP was not a primary area of adaptation for these young, healthy athletes already in good cardiovascular health before the intervention. The lack of significant change in MABP contrasts with findings from studies involving untrained or less fit populations, where plyometric and HIIT training often lead to more substantial reductions in blood pressure (Milanović et al., 2015). Given the elite status of the participants, their cardiovascular systems were likely already highly conditioned, which may have reduced the potential for further decreases in blood pressure through these training interventions. This outcome may not be unexpected since neither plyometric nor Tabata training directly targets blood pressure reduction.

The study's findings have significant practical implications for designing soccer-specific training programs. Both plyometric and Tabata training significantly improved cardiovascular efficiency, suggesting that either modality could be effectively incorporated into the conditioning routines of elite soccer players. However, the slightly superior results in the Tabata group suggest that HIIT protocols may offer additional cardiovascular benefits, particularly in improving oxygen delivery and utilization (Lu et al., 2023). This underscores the complementary nature of plyometric training. While Tabata may offer superior cardiovascular benefits, plyometric exercises are critical for developing the explosive power required for jumping, sprinting, and changing direction, which are critical elements of soccer performance. The adaptability of a combined approach incorporating plyometric and Tabata training to provide a more well-rounded conditioning program for soccer players is reassuring, targeting both muscular power and cardiovascular efficiency.

Conclusion

The study demonstrates that 12-week plyometric and Tabata training programs can significantly increase the cardiovascular efficiency of professional soccer players. Both training approaches significantly improved VC, RHR, BHT, and RR, indicating their effectiveness in improving anaerobic and aerobic fitness. Although Tabata training had marginally better effects, especially regarding resting heart rate and breath-holding duration, plyometric training which emphasizes explosive movements crucial for soccer performance remains a vital part of sports conditioning. This study emphasizes the importance of incorporating Tabata and plyometric training into soccer players' conditioning regimens for real-world applicability. Coaches and trainers should consider the specific demands of soccer, incorporating plyometric exercises to build explosive power and agility while leveraging the cardiovascular benefits of Tabata to improve players' endurance and recovery capacity. Further research is warranted to explore the long-term effects of combining these training modalities and assess their impact on match performance, injury prevention, and player longevity. Furthermore, future research might examine how these training techniques can be modified for various demographics, such as female athletes, amateur players, or those recovering from injuries, to maximize cardiovascular fitness and overall performance.

Conflict of Interest

The authors declare that there is no conflict of interest.

Acknowledgement

I would like to express my sincere gratitude to all the participants and their parents for their invaluable cooperation and support throughout the course of this study. Their commitment and willingness to contribute to this research were fundamental to its success.

References

Carling, C., Le Gall, F., & Dupont, G. (2012). Analysis of repeated high-intensity running performance in professional soccer. *Journal of Sports Sciences, 30*(4), 325-336. https://doi.org/10.1080/02640414.2011.652655

Radaković, R., Katanić, B., Stanković, M., Masanovic, B., & Fišer, S. Ž. (2024). The Impact of Cardiorespiratory and Metabolic Parameters on Match Running Performance (MRP) in National-Level Football Players: A Multiple Regression Analysis. *Applied Sciences, 14*(9), 3807. https://doi.org/10.3390/app14093807

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of Soccer: An Update. *Sports Medicine, 35*(6), 501–536. https://doi.org/10.2165/00007256-200535060-00004

Bush, M., Barnes, C., Archer, D. T., Hogg, B., & Bradley, P. S. (2015). Evolution of match performance parameters for various playing positions in the English Premier League. *Human Movement Science,* 39, 1-11. https://doi.org/10.1016/j.humov.2014.10.003

Nystoriak, M. A., & Bhatnagar, A. (2018). Cardiovascular Effects and Benefits of Exercise. *Frontiers in Cardiovascular Medicine,* 5, 135. https://doi.org/10.3389/fcvm.2018.00135

Afyon, Y. A., Mulazimoglu, O., Celikbilek, S., Dalbudak, İ., & Kalafat, C. (2021). The effect of Tabata training program on physical and motoric characteristics of soccer players. *Progress in Nutrition, 23*(S2), e2021255. https://doi.org/10.23751/pn.v23iS2.11883

Tabata, I. (2019). Tabata training: One of the most energetically effective high-intensity intermittent training methods. *The Journal of Physiological Sciences, 69*(4), 559-572. https://doi.org/10.1007/s12576-019-00676-7

Thomakos, P., Spyrou, K., Tsoukos, A., Katsikas, C., & Bogdanis, G. C. (2023). High-Intensity Interval Training Combined with High-Load Strength Training Improves Aerobic Fitness, Match Goals and Match Result during the In-Season Period in Under-19 Soccer Players. *Sports, 12*(1), 2. https://doi.org/10.3390/sports12010002

Davies, G., Riemann, B. L., & Manske, R. (2015). Current concepts of plyometric exercise. *International Journal of Sports Physical Therapy, 10*(6), 760-786.

Fajrin, F., Kusnanik, N. W., & Wijono. (2018). Effects of High Intensity Interval Training on Increasing Explosive Power, Speed, and Agility. *Journal of Physics: Conference Series,* 947, 012045. https://doi.org/10.1088/1742-6596/947/1/012045

Kons, R. L., Orssatto, L. B. R., Ache-Dias, J., De Pauw, K., Meeusen, R., Trajano, G. S., Dal Pupo, J., & Detanico, D. (2023). Effects of Plyometric Training on Physical Performance: An Umbrella Review. *Sports Medicine - Open, 9*(1), 4. https://doi.org/10.1186/s40798-022-00550-8

Martin-Smith, R., Cox, A., Buchan, D. S., Baker, J. S., Grace, F., & Sculthorpe, N. (2020). High Intensity Interval Training (HIIT) Improves Cardiorespiratory Fitness (CRF) in Healthy, Overweight and Obese Adolescents: A Systematic Review and Meta-Analysis of Controlled Studies. *International Journal of Environmental Research and Public Health, 17*(8), 2955. https://doi.org/10.3390/ijerph17082955

Hostrup, M., & Bangsbo, J. (2023). Performance Adaptations to Intensified Training in Top-Level Football. *Sports Medicine, 53*(3), 577-594. https://doi.org/10.1007/s40279-022-01791-z

Keren, G., & Epstein, Y. (1981). The effect of pure aerobic training on aerobic and anaerobic capacity. *British Journal of Sports Medicine, 15*(1), 27-29. https://doi.org/10.1136/bjsm.15.1.27

Yan, S., Kim, Y., & Choi, Y. (2022). Aerobic and Anaerobic Fitness according to High-Intensity Interval Training Frequency in Youth Soccer Players in the Last Stage of Rehabilitation. *International Journal of Environmental Research and Public Health, 19*(23), 15573. https://doi.org/10.3390/ijerph192315573

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

Deng, N., Soh, K. G., Abdullah, B. B., Huang, D., Xu, F., Bashir, M., & Zhang, D. (2024). Effects of plyometric training on health-related physical fitness in untrained participants: A systematic review and meta-analysis. *Scientific Reports, 14*(1), 11272. https://doi.org/10.1038/s41598-024-61905-7

Ramírez-Campillo, R., Gallardo, F., Henriquez-Olguín, C., Meylan, C. M. P., Martínez, C., Álvarez, C., Caniuqueo, A., Cadore, E. L., & Izquierdo, M. (2015). Effect of Vertical, Horizontal, and Combined Plyometric Training on Explosive, Balance, and Endurance Performance of Young Soccer Players. *Journal of Strength and Conditioning Research, 29*(7), 1784–1795. https://doi.org/10.1519/JSC.0000000000000827

Faigenbaum, A. D., McFarland, J. E., Keiper, F. B., Tevlin, W., Ratamess, N. A., Kang, J., & Hoffman, J. R. (2007). Effects of a short-term plyometric and resistance training program on fitness performance in boys age 12 to 15 years. *Journal of Sports Science & Medicine, 6*(4), 519-525.

Singh, L. S., Singh, W. J., Azeem, K., Meitei, N. M., & Mola, D. W. (2024). Concept of Plyometric Training and Its Effect on Physiological Parameters of Football Players. *Physical Education Theory and Methodology, 24*(4), 609–618. https://doi.org/10.17309/tmfv.2024.4.13

Singh, S. L., Patir, K., Sarungbam, S., & Meetei, K. R. (2021). Effect of plyometric training on muscular endurance of football players. *Unpublished.* https://doi.org/10.13140/RG.2.2.27720.44802

Milanović, Z., Sporiš, G., & Weston, M. (2015). Effectiveness of High-Intensity Interval Training (HIT) and Continuous Endurance Training for VO2max Improvements: A Systematic Review and Meta-Analysis of Controlled Trials. *Sports Medicine, 45*(10), 1469-1481. https://doi.org/10.1007/s40279-015-0365-0

Lu, Y., Wiltshire, H. D., Baker, J. S., Wang, Q., & Ying, S. (2023). The effect of Tabata-style functional high-intensity interval training on cardiometabolic health and physical activity in female university students. *Frontiers in Physiology,* 14, 1095315. https://doi.org/10.3389/fphys.2023.1095315

Sloth, M., Sloth, D., Overgaard, K., & Dalgas, U. (2013). Effects of sprint interval training on VO 2max and aerobic exercise performance: A systematic review and meta-analysis. *Scandinavian Journal of Medicine & Science in Sports, 23*(6). https://doi.org/10.1111/sms.12092

Granero-Gallegos, A., González-Quílez, A., Plews, D., & Carrasco-Poyatos, M. (2020). HRV-Based Training for Improving VO2max in Endurance Athletes. A Systematic Review with Meta-Analysis. *International Journal of Environmental Research and Public Health, 17*(21), 7999. https://doi.org/10.3390/ijerph17217999

Vesterinen, V., Nummela, A., Heikura, I., Laine, T., Hynynen, E., Botella, J., & Häkkinen, K. (2016). Individual Endurance Training Prescription with Heart Rate Variability. *Medicine & Science in Sports & Exercise, 48*(7), 1347-1354. https://doi.org/10.1249/MSS.0000000000000910

Fradkin, A. J., Zazryn, T. R., & Smoliga, J. M. (2010). Effects of Warming-up on Physical Performance: A Systematic Review With Meta-analysis. *Journal of Strength and Conditioning Research, 24*(1), 140-148. https://doi.org/10.1519/JSC.0b013e3181c643a0

Markovic, G., & Mikulic, P. (2010). Neuro-Musculoskeletal and Performance Adaptations to Lower-Extremity Plyometric Training. *Sports Medicine, 40*(10), 859-895. https://doi.org/10.2165/11318370-000000000-00000

Smith, C. A. (1994). The Warm-Up Procedure: To Stretch or Not to Stretch. A Brief Review. *Journal of Orthopaedic & Sports Physical Therapy, 19*(1), 12-17. https://doi.org/10.2519/jospt.1994.19.1.12

Dridi, R., Dridi, N., Govindasamy, K., Gmada, N., Aouadi, R., Guénard, H., Laher, I., Saeidi, A., Suzuki, K., Hackney, A. C., & Zouhal, H. (2021). Effects of Endurance Training Intensity on Pulmonary Diffusing Capacity at Rest and after Maximal Aerobic Exercise in Young Athletes. *International Journal of Environmental Research and Public Health, 18*(23), 12359. https://doi.org/10.3390/ijerph182312359

Brini, S., Abderrahman, A. B., Clark, C. C. T., Zouita, S., Hackney, A. C., Govindasamy, K., Granacher, U., & Zouhal, H. (2021). Sex-specific effects of small-sided games in basketball on psychometric and physiological markers during Ramadan intermittent fasting: A pilot study. *BMC Sports Science, Medicine and Rehabilitation, 13*(1), 56. https://doi.org/10.1186/s13102-021-00285-1

Ghavipanje, V., Rahimi, N. M., & Akhlaghi, F. (2022). Six Weeks Effects of Dynamic Neuromuscular Stabilization (DNS) Training in Obese Postpartum Women With Low Back Pain: A Randomized Controlled Trial. *Biological Research For Nursing, 24*(1), 106-114. https://doi.org/10.1177/10998004211044828

Deepa, M., Farooq, S., Deepa, R., Manjula, D., & Mohan, V. (2009). Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). *European Journal of Clinical Nutrition, 63*(2), 259-267. https://doi.org/10.1038/sj.ejcn.1602920

Govindasamy, K., Suresh, C., Kaur, D., Anitha, J. B., Marwah, K., Jayasingh Albert Chandrasekar, S., & Lakshmanan, C. (2023). The effect of 12-week step and floor aerobic exercise programs on physical and psychophysiological health parameters in obese men. Sport i Turystyka. *Środkowoeuropejskie Czasopismo Naukowe, 6*(1), 101-117. https://doi.org/10.16926/sit.2023.01.06

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika, 52*(3-4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Park, E., Cho, M., & Ki, C.-S. (2009). Correct Use of Repeated Measures Analysis of Variance. *Annals of Laboratory Medicine, 29*(1), 1-9. https://doi.org/10.3343/kjlm.2009.29.1.1

Cohen, D. (1988). *Statistical power analysis for the behaviors science* (2nd ed.).

Chaeroni, A., Nurhasan, N., Ardha, M. A. A., Nur, L., Pranoto, N. W., Govindasamy, K., Khishe, M., Ahmed, M., & Talib, K. (2024). Exploration of branches of physics for handling several cases in sports applications: A systematic literature review. *Retos,* 56, 998-1008. https://doi.org/10.47197/retos.v56.105056

Ribeiro, J., Afonso, J., Camões, M., Sarmento, H., Sá, M., Lima, R., Oliveira, R., & Clemente, F. M. (2021). Methodological Characteristics, Physiological and Physical Effects, and Future Directions for Combined Training in Soccer: A Systematic Review. *Healthcare, 9*(8), 1075. https://doi.org/10.3390/healthcare9081075

Stanković, M., Trajković, N., Mačak, D., Đorđević, D., Lazić, A., & Milanović, Z. (2024). Effects of linear and change of direction high-intensity intervaltraining on physical performance of elite female soccer players. *Biology of Sport.* https://doi.org/10.5114/biolsport.2024.134761

Ramirez-Campillo, R., Castillo, D., Raya-González, J., Moran, J., De Villarreal, E. S., & Lloyd, R. S. (2020). Effects of Plyometric Jump Training on Jump and Sprint Performance in Young Male Soccer Players: A Systematic Review and Meta-analysis. *Sports Medicine, 50*(12), 2125-2143. https://doi.org/10.1007/s40279-020-01337-1

Negra, Y., Chaabene, H., Sammoud, S., Prieske, O., Moran, J., Ramirez-Campillo, R., Nejmaoui, A., & Granacher, U. (2020). The Increased Effectiveness of Loaded Versus Unloaded Plyometric Jump Training in Improving Muscle Power, Speed, Change of Direction, and Kicking-Distance Performance in Prepubertal Male Soccer Players. *International Journal of Sports Physiology and Performance, 15*(2), 189-195. https://doi.org/10.1123/ijspp.2018-0866

Hughes, D. C., Ellefsen, S., & Baar, K. (2018). Adaptations to Endurance and Strength Training. *Cold Spring Harbor Perspectives in Medicine, 8*(6), a029769. https://doi.org/10.1101/cshperspect.a029769

Oliva-Lozano, J., Riboli, A., Fortes, V., & M. Muyor, J. (2023). Monitoring physical match performance relative to peak locomotor demands: Implications for training professional soccer players. *Biology of Sport, 40*(2), 253-260. https://doi.org/10.5114/biolsport.2023.116450

Zouhal, H., Hammami, A., Tijani, J. M., Jayavel, A., De Sousa, M., Krustrup, P., Sghaeir, Z., Granacher, U., & Ben Abderrahman, A. (2020). Effects of Small-Sided Soccer Games on Physical Fitness, Physiological Responses, and Health Indices in Untrained Individuals and Clinical Populations: A Systematic Review. *Sports Medicine, 50*(5), 987-1007. https://doi.org/10.1007/s40279-019-01256-w

Вплив 12-тижневої програми з виконання пліометричних і Табата-тренувань з частотою 3-х щотижневих занять на продуктивність серцево-судинної системи елітних футболістів

Нідхін Мутхратхіпарамбіл Нараянан[1ABCDE], Каямбу Сундар[1ABCDE], Нірмал Майкл Салві[2CDE], Яшпал[3CDE], Дебаджит Кармакар[4CDE], Сохом Саха[4CD], Бекір Ерхан Орхан[5ACD], Фарджана Актер Бобі[6ACDE], Юні Астуті[7ACDE]

[1]Університет Алагаппа

[2]Міжнародний університет Симбіозис

[3]Державний коледж імені Чиранджі Лала Шарми

[4]Національний інститут фізичного виховання імені Лакшмі Бай

[5]Стамбульський університет Айдин

[6]Міжнародний університет Даффоділ

[7]Падангський державний університет

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 3 табл., 45 джерел.

Мета дослідження. Це дослідження мало на меті вивчити вплив 12-тижневої програми пліометричних тренувань і режиму тренувань за методикою Табата на продуктивність серцево-судинної системи елітних футболістів.

Матеріали та методи. У дослідженні взяли участь 60 гравців чоловічої статі міжвузівського рівня віком 20,79 ± 1,75 років, яких було розподілено за методом рандомізації до групи пліометричних тренувань (ПТГ, n = 20), групи тренувань за методикою Табата (ТТГ, n = 20) або до контрольної групи (КГ, n = 20). Перед початком та після завершення тренувальної програми оцінювали показники серцево-судинної системи, серед яких життєва ємність легень, частота серцевих скорочень у стані спокою, середній артеріальний тиск, час затримки дихання та частота дихання. Учасники як ПТГ, так і ТТГ виконували 3 тренувальні сесії тривалістю 90 хвилин на щотижневій основі.

Результати. Результати дослідження виявили, що в учасників як ПТГ, так і ТТГ спостерігалося значне покращення продуктивності серцево-судинної системи. Показник життєвої ємності легень збільшився на 30,83 % (d = 1,24, p < 0,001) у ПТГ і на 34,61 % (d = 1,52, p < 0,001) у ТТГ. Частота серцевих скорочень у стані спокою зменшилася на 12,36 % (d = 1,74, p < 0,001) у ПТГ і на 15,18 % (d = 1,82, p < 0,001) у ТТГ. Час затримки дихання збільшився на 29,86 % (d = 2,12, p < 0,001) у ПТГ і на 34,42 % (d = 2,35, p < 0,001) у ТТГ. Частота дихання зменшилася на 28,07 % (d = 1,04, p < 0,001) у ПТГ і на 28,33 % (d = 1,10, p < 0,001) у ТТГ. Отримані дані свідчать про суттєвий позитивний вплив застосування обох методів тренувань на продуктивність серцево-судинної системи елітних футболістів.

Висновки. Таким чином, впровадження програми з виконання пліометричних і Табата-тренувань сприяло значному поліпшенню продуктивності серцево-судинної системи у елітних футболістів, що дозволяє вважати зазначені методики важливими стратегіями передсезонної підготовки щодо підвищення показників витривалості, результативності та загальних спортивних здібностей.

Ключові слова: тренування з футболу, фізіологічні параметри, ВІІТ, тренування з виконання стрибків, футболісти.

Information about the authors:

Narayanan, Nidhin Muthrathiparambil: nithinmnarayan@gmail.com; https://orcid.org/0009-0004-6830-282X; College of Physical Education, Alagappa University, College Rd, Alagappa Puram, Karaikudi, Tamil Nadu 630003, India.

Sundar, Kayambu: sundarajankce@gmail.com; https://orcid.org/0009-0008-3043-9555; College of Physical Education, Alagappa University, College Rd, Alagappa Puram, Karaikudi, Tamil Nadu 630003, India.

Salvi, Nirmal Michael: nirmalsalvi@gmail.com; https://orcid.org/0000-0001-9698-9818; Department of Sports, Recreation & Wellness, Symbiosis International (Deemed University), Lavale, Mulshi, Pune, Maharashtra 412115, India.

Yashpal: yashpalknl@gmai.com; https://orcid.org/0009-0005-7381-9054; Department of Physical Education, Pt. Chiranji Lal Sharma Government College, Sector 14, Karnal, Haryana 132001, India.

Karmakar, Debajit: gowthamadnivog@gmail.com; https://orcid.org/0000-0001-9272-0627; Department of Physical Education Pedagogy, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India..

Saha, Sohom: sohomsaha77@gmail.com; https://orcid.org/0009-0006-9438-1554; Department of Sports Psychology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Orhan, Bekir Erhan: bekirerhanorhan@aydin.edu.tr; https://orcid.org/0000-0002-3149-6630; Faculty of Sports Sciences, Istanbul Aydin University, Halit Aydın Campus No:38, 34295 Küçükçekmece/İstanbul, Turkey.

Boby, Farjana Akter: boby.pess@diu.edu.bd; https://orcid.org/0000-0003-3168-6888; Department of Physical Education and Sports Science, Faculty of Health and Life Science, Daffodil International University, Daffodil Smart City, Birulia, Savar, Dhaka-1216, Bangladesh.

Astuti, Yuni: yuniastuti@fik.unp.ac.id; https://orcid.org/0000-0001-6430-2938; Faculty of Sports Sciences, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Cite this article as: Narayanan, N. M., Sundar, K., Salvi, N. M., Yashpal, Karmakar, D., Saha, S., Orhan, B. E., Boby, F. A., & Astuti, Y. (2025). The Effect of a 12-Week Plyometric and Tabata training program with three weekly sessions on cardiovascular efficiency in elite soccer players. *Physical Education Theory and Methodology, 25*(1), 147-155. https://doi.org/10.17309/tmfv.2025.1.18

Received: 31.10.2024. Accepted: 19.12.2024. Published: 30.01.2025