

Long-term effects of a structured training program on physical fitness in male football players aged 18-22 years

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ABSTRACT

Background: Football performance relies on multiple physical capacities, including aerobic endurance, anaerobic power, muscle strength, speed, agility, and technical skills. Comprehensive training programs that integrate various conditioning elements may lead to multidimensional improvements in player performance. However, limited evidence exists regarding the long-term effects of such integrated programs, particularly whether physical performance gains can be sustained after training cessation.

Objectives: This study aims to evaluate the long-term effects of a one-year structured training program on physical fitness components in male university football players, including assessment of sustained outcomes after a six-month detraining period.

Materials and methods: A retrospective-prospective cohort study was conducted involving 15 male university-level competitive football players aged 18-22 years. Participants underwent a structured training regimen that incorporated aerobic, anaerobic, strength, speed, and football-specific drills. Physical fitness parameters were measured before the training period, immediately after one year of training, and again at six months post-training. Statistical analysis involved repeated-measures ANOVA and Bonferroni post hoc testing.

Results: The program significantly improved VO₂max, leg strength, sprint speed, and anaerobic power ($p < 0.05$). However, these gains were not sustained at the six-month follow-up. Other measures, such as handgrip strength, flexibility, and vertical jump, did not show significant changes.

Conclusion: Structured multimodal training is effective in improving essential fitness attributes for football performance. However, without continued stimulus, performance gains diminish over time, suggesting the need for long-term maintenance strategies.

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Introduction

Football is a high-demand intermittent sport characterized by intermittent high-intensity bouts interspersed with lower-intensity recovery periods.¹ During a standard 90-minute match, players perform more than 1,000 activity changes, including sprinting, jumping, tackling, and rapid changes in direction.^{2,3} These actions impose substantial physiological and neuromuscular demands, requiring the integration of multiple components of physical fitness. Key components include aerobic endurance, anaerobic

capacity, muscular strength, speed, agility, flexibility, and technical skills, all of which contribute to overall match performance.⁴ Aerobic capacity, commonly represented by maximal oxygen uptake (VO_2max), plays a fundamental role in sustaining performance and enhancing recovery between high-intensity efforts.^{5,6} In contrast, anaerobic capacity supports short-duration, high-intensity actions that are critical for decisive moments during match play.⁶ Muscular strength, particularly in the lower limbs, has also been shown to be closely associated with sprint performance, jump ability, and overall physical performance in football players.^{7,8}

Previous studies have demonstrated that specific training modalities, including aerobic conditioning, resistance training, and small-sided games (SSGs), can effectively improve individual components of physical fitness in football players.^{4,9,10} Aerobic training has been shown to enhance VO_2max and endurance capacity, while resistance and plyometric training improve muscular strength, power, and sprint performance.^{2,7} SSGs have gained popularity as an effective training method that simultaneously develops technical skills and physical conditioning under game-like conditions.^{4,9,10} However, football performance is inherently multifactorial, requiring the interaction of several physiological and neuromuscular systems. Therefore, integrated training programs that combine multiple training modalities may provide more comprehensive benefits compared to isolated training approaches.

Despite the growing body of literature, most existing studies have focused on short-term interventions

or individual training components, with limited investigation into the long-term effects of structured, multimodal training programs. Furthermore, there is limited evidence on the sustainability of training-induced adaptations following detraining, particularly in university-level football players.^{4,10} Understanding whether improvements in physical fitness can be maintained after training cessation is important for designing effective long-term training strategies and preventing performance decline during off-season periods.

Therefore, this study aimed to investigate the long-term effects of a comprehensive structured training program on multiple components of physical fitness in university-level football players and to examine the sustainability of these adaptations following a six-month detraining period.

Materials and methods

Study design

This study employed a retrospective-prospective cohort design to evaluate the long-term effects of a structured training program on physical fitness in university-level football players. Baseline assessments were conducted before the training program. The intervention period lasted for one year (August 2023 to July 2024), followed by a six-month follow-up period (January 2025) to examine detraining effects. During the follow-up phase, participants were not provided with a structured training program and were instructed to continue their usual daily activities without supervised training, allowing the follow-up assessment to reflect a natural detraining condition (Figure 1).

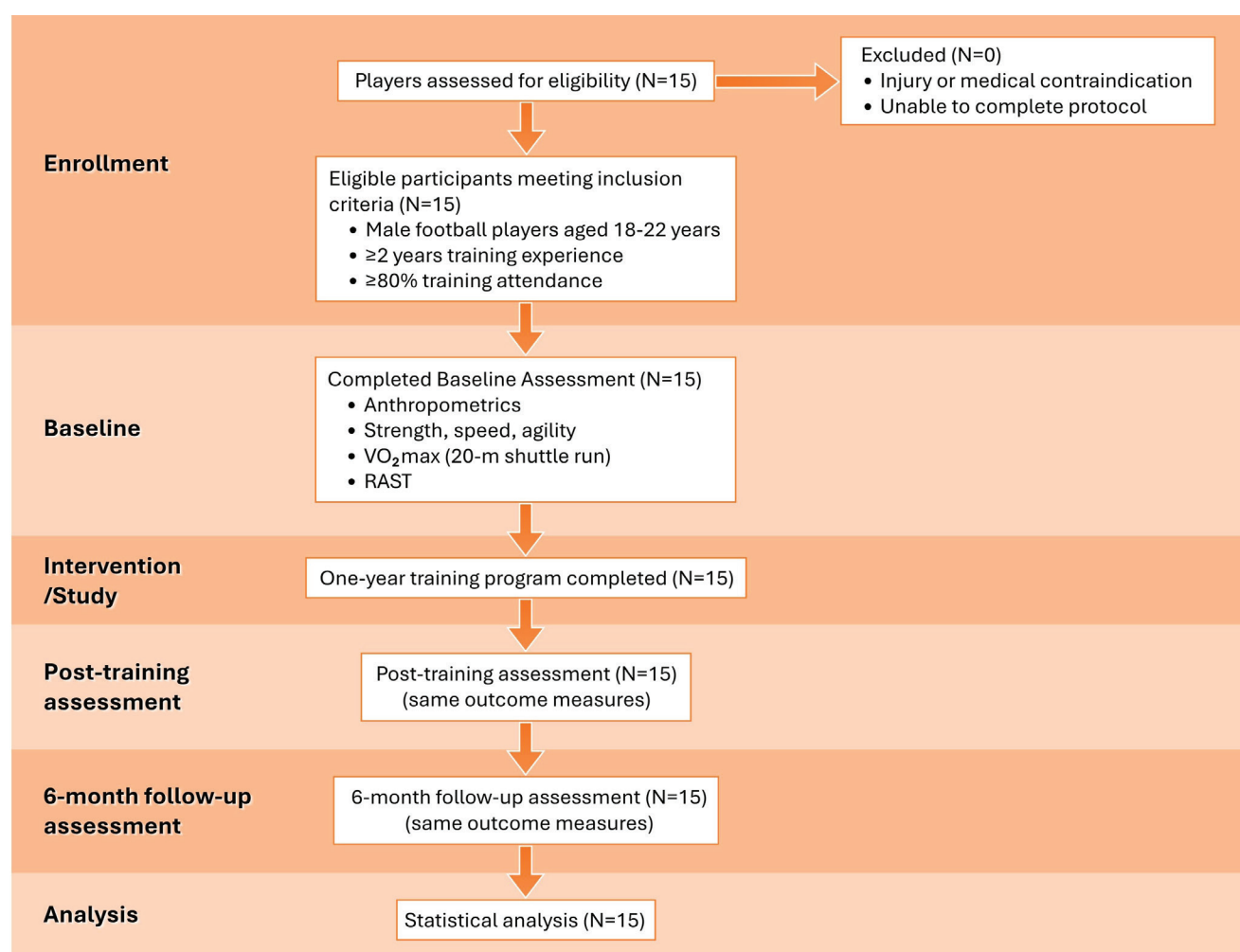


Figure 1. Flow diagram of the study.

Participants

Fifteen male university-level football players aged 18-22 years were recruited from the Chiang Mai university football team. All players who met the inclusion criteria were included; therefore, the sample represented the entire available team roster rather than being determined through an a priori sample size calculation. Participants had at least two years of continuous training experience and regularly participated in structured team training sessions approximately 3-5 days per week.

Participants were eligible for inclusion if they were male football players aged 18-22 years, actively registered with the university team, had at least two years of continuous training experience, and attended at least 80% of scheduled training sessions. Participants were excluded if they had any current musculoskeletal injury, cardiovascular or other medical conditions contraindicating high intensity exercise, or were unable to complete the full training protocol. Withdrawal criteria included absence from more than 20% of training sessions or injury during the study period.

All eligible participants completed the full training program and met the adherence criteria. This study was approved by the institutional ethics committee

(AMSEC-67EX-040), and all participants provided written informed consent prior to participation.

Training protocol

Participants engaged in a structured training program lasting one year, developed under the supervision of a qualified sports scientist. The program was designed to enhance multiple components of physical fitness relevant to football performance, including aerobic capacity, sprint performance, muscular strength, flexibility, and sport-specific skills.

Aerobic training consisted of continuous running performed at moderate-to-high intensity (approximately 75-85% of maximum heart rate), conducted three times per week. Sprint training involved repeated 100-meter sprints alternated with jogging recovery, with progressive increases in training volume from 10 to 15 sets per session. Additional speed development was targeted using short-distance sprint repetitions (30 meters), performed in 5 to 8 sets per session, three times weekly.

Resistance training focused on lower-limb strength, using functional exercises such as squats and front lunges with a 4 kg medicine ball. Training was performed three times per week with 3-5 sets per

session. Flexibility training was incorporated three times per week and included dynamic stretching during the warm-up and static stretching during the cool-down. Dynamic stretching targeted major lower limb muscle groups using controlled movements, while static stretching was performed in standardized positions and held for 15-30 seconds, repeated 2-3 times per muscle group. In addition, participants performed football-specific drills, including ball possession, passing, attacking, and defending exercises, as well as SSGs (e.g., 3v3 and 5v5), for approximately 30-45 minutes per session.

Training progression was implemented according to the principle of progressive overload, with gradual increases in training volume, repetition number, and exercise complexity throughout the intervention period. Aerobic duration and sprint repetitions were progressively increased, while resistance training volume was adjusted across the season. Football-specific drills evolved from basic technical drills to more complex tactical scenarios. All training sessions were supervised by a qualified sports scientist and coaching staff. Training attendance was systematically recorded to monitor adherence, and participants were required to attend at least 80% of sessions to be included in the analysis (Table 1).^{4,10,11}

Table 1. Structured one-year training program.

Component	Frequency	Intensity	Duration	Description	Progression
Flexibility training	3 sessions/week	Low intensity	10-15 minutes	Dynamic (pre-training) and static (post-training) stretching	Maintained throughout season
Aerobic training	3 sessions/week	75–85% HRmax	30- 45 minutes	Continuous running	Gradual increase in duration and intensity over season
Interval sprint training	3–4 sessions/week	High intensity	10-15 sets	100-m repeated sprints alternated with jogging	Sets progressed from 10 to 15 per session
Resistance training	3 sessions/week	Moderate load	3-5 sets/session	Squats and front lunges using 4-kg medicine ball	Gradual increase in training volume
Speed training	3 sessions/week	High intensity	5-8 sets	30-m sprint repetitions	Increased repetitions over time
Football-specific skill training	Daily	Sport-specific	30-45 minutes	Ball possession, passing, attacking, defending (1v1, 2v2), small-sided games (3v3, 5v5)	Increased tactical complexity and game intensity

Outcome measures

Physical fitness assessments were conducted at three time points: baseline (prior to training), post-training (immediately after completion of the one-year training program), and follow-up (six months after the training period). To ensure consistency and minimize fatigue effects, all assessments were conducted in a standardized sequence for all participants and at all time points.

Anthropometric measurements were obtained using a bioelectrical impedance analyzer (InBody, Biospace Co., Ltd., Seoul, Korea) and included body weight, body fat percentage, and body mass index (BMI). Flexibility was assessed using the sit-and-reach test, with the best of two trials recorded.¹² Explosive power was evaluated using a countermovement vertical jump test, and the highest value from two trials was used for analysis.¹³ Muscle strength was assessed using a handgrip dynamometer (JAMAR, USA) and lower-body strength using a leg press test normalized to body

weight.¹⁴ Speed and agility were assessed using a 40-m sprint test and a shuttle run test, respectively, with the fastest performance from two trials recorded.^{15,16}

Aerobic capacity was estimated using the 20-m multistage fitness test,¹⁷ from which maximal oxygen uptake (VO_2max) was calculated based on the final stage achieved using standardized reference equations: $\text{VO}_2\text{max} = (\text{age factor} \times \text{max oxygen uptake} \times 1,000) / \text{body weight (kg)}$

Anaerobic performance was assessed using the Running-Based Anaerobic Sprint Test (RAST). Participants performed six maximal 35-m sprints separated by 10-s recovery intervals, and sprint time for each repetition was recorded.¹⁸ Power output for each sprint was calculated as:

$$\text{Power} = (\text{body mass} \times (\text{distance})^2) / (\text{time})^3$$

From the six sprint trials, peak power, minimum power, mean power, and fatigue index (FI) were

calculated. The fatigue index was determined using the following equation:

$$FI = (\text{peak power} - \text{minimum power}) / \text{total sprint time}$$

All measurements were conducted by trained evaluators under the supervision of a qualified sports scientist, and the same assessor performed all measurements across all time points to minimize inter-rater variability. Participants were familiarized with all testing procedures prior to data collection, and standardized instructions and rest intervals were applied across testing sessions.

Training attendance was recorded by the coaching staff for each session to monitor exercise adherence. Participants were required to attend at least 80% of the scheduled training sessions to be included in the analysis. All participants met this criterion and completed the full training program.

Statistical analysis

All statistical analyses were performed using SPSS software (version 21.0, IBM Corporation, Chicago, IL).

Descriptive statistics, including means and standard deviations, were calculated for all continuous variables. The normality of data distribution was assessed using the Shapiro–Wilk test due to the relatively small sample size. Since the data were approximately normally distributed, repeated-measures analysis of variance was conducted to examine changes in physical fitness outcomes over time. Where significant main effects were identified, Bonferroni-adjusted pairwise comparisons were performed to determine differences between time points (baseline, post-training, and follow-up). The assumption of sphericity was assessed using Mauchly's test, and the Greenhouse–Geisser correction was applied when necessary. Statistical significance was set at $p < 0.05$.

Results

Participants' demographic and physical characteristics, including age, body composition, and baseline physical fitness measures, were collected before the training intervention to establish a reference point for evaluating program effects. These baseline data are summarized in Table 2.

Table 2. Baseline characteristics of male university football players.

Variables	Mean±SD
Age (year)	19.73±0.96
Weight (kg)	73.52±11.84
Height (cm)	174.41±6.27
Position (N)	15
Goalkeeper	1
Center back	3
Right back	2
Left back	2
Defensive midfielder	2
Attacking midfielder	3
Left winger	1
Right winger	1

Note: cm: centimeter, kg: kilogram.

The physical fitness profiles of participants, including body composition, flexibility, muscular strength, explosive power, agility, sprint speed, aerobic capacity, and anaerobic performance, were assessed at three time points. Mean and standard deviation

values at baseline, after one year of training, and at the six-month follow-up are summarized to provide a clear overview of participants' physical status throughout the study (Table 3).

Table 3. Mean and standard deviation of physical fitness test scores among male university football players.

Variables	Baseline (N=15)	Post-training (N=15)	Follow-up (N=15)
Body mass index (BMI) (kg/m ²)	22.48±2.06	23.02±2.28	23.56±2.98
Body fat (%)	17.09±4.69	17.86±4.26	17.31±4.06
Sit and reach (cm)	18.67±6.96	17.00±6.20	17.27±6.22
Grip strength (kg/body weight)	0.61±0.10	0.60±0.10	0.61±0.10
Leg strength (kg/body weight)	2.21±0.60	2.50±0.46	2.26±0.39
Vertical jump (cm)	50.27±5.89	50.00±5.68	51.07±6.70
Shuttle run test (second)	10.12±0.50	9.97±0.56	10.50±0.86
Sprint 40-m test (second)	6.05±0.32	5.77±0.49	6.49±0.62
Multistage fitness test (VO ₂ max) (mL/min/kg)	43.68±5.82	46.39±5.70	41.62±9.16
RAST test (watt/kg)	38.25±6.51	28.52±7.72	42.91±7.97

Note: BMI: body mass index, cm: centimeter, m²: square meter, VO₂max: maximal oxygen consumption.

Improvements in leg strength, sprint performance, VO₂max, and anaerobic power were observed following the training program, with statistically significant differences between baseline and post-training assessments. At the six-month follow-up, most outcomes that improved post-training were no longer significantly different from baseline, indicating partial

loss of training- induced adaptations. However, 40-m sprint performance remained significantly improved compared with baseline at follow-up, despite a significant decline from post-training. No significant changes over time were observed in flexibility, handgrip strength, vertical jump, body fat percentage, or BMI (Table 4).

Table 4. Comparison of physical fitness measures at baseline (a), post-training (b), and follow-up (c) in male university football players (N=15).

Variables	b-a	p value	c-a	p value	c-b	p value	F	df	^p (ANOVA)
Body mass index (BMI) (kg/m ²)	0.535	0.080	1.079	0.072	0.545	0.360	5.191	(2, 28)	0.012*
Body fat (%)	0.773	0.901	0.220	0.892	-0.553	1.000	0.497	(2,28)	0.613
Sit and reach (cm)	-1.667	0.101	-1.400	0.572	0.267	1.000	2.551	(1.39, 19.43)	0.118
Grip strength (kg/body weight)	-0.005	1.000	-0.003	1.000	0.002	1.000	0.031	(1.17, 16.37)	0.895
Leg strength (kg/body weight)	0.290	0.005*	0.050	1.000	-0.240	0.096	2.926	(1.38, 19.37)	0.093
Vertical jump (cm)	-0.267	1.000	0.800	0.937	1.067	0.203	2.692	(2, 28)	0.085
Shuttle run test (second)	-0.155	0.663	0.381	0.140	0.536	0.097	3.994	(2, 28)	0.030*
Sprint 40-m test (second)	-0.279	0.023*	0.443	0.018*	0.723	0.005*	10.412	(2, 28)	<0.001*
Multistage fitness test (VO ₂ max) (mL/kg/min)	2.713	0.013*	-2.060	0.658	-4.773	0.005*	2.769	(2, 28)	0.080
RAST test (watt/kg)	-9.733	0.005*	4.660	0.163	14.393	0.002*	6.647	(2, 28)	0.004

Note: BMI: body mass index, cm: centimeter, m²: square meter, VO₂max: maximal oxygen consumption. Values are presented as mean differences between time points; a: baseline, b: post-training, c: follow-up. Statistical analysis was performed using repeated-measures ANOVA with Bonferroni-adjusted pairwise comparisons. Sphericity was assessed using Mauchly's test, and Greenhouse-Geisser correction was applied when assumptions were violated. *,*statistical significance was set at $p < 0.05$.

Discussion

The present study investigated the long-term effects of a structured training program on multiple components of physical fitness and examined the sustainability of these adaptations following a detraining period. The findings demonstrated that the one-year training program significantly improved aerobic capacity, lower-body strength, sprint performance, and anaerobic power. However, these improvements were not maintained after six months of detraining, indicating that continued training stimulus is required to sustain performance adaptations in university-level football players. These findings highlight the importance of continuous training and structured maintenance strategies to preserve physical performance in football players.

The significant increase in VO_2max observed post-training aligns with previous research emphasizing the importance of aerobic endurance for football performance. Aerobic capacity supports prolonged activity and facilitates recovery during intermittent high-intensity efforts typical of match play. The training protocol in this study included moderate-to-high-intensity continuous running and interval sprints, which likely contributed to the observed improvement. This finding is supported by Helgerud et al.,¹¹ who found that high-intensity aerobic training significantly enhances VO_2max and overall match-related endurance. Recent studies have also reported improvements in aerobic capacity and repeated sprint performance following structured training programs in football players.¹⁹ Sprint performance and anaerobic power also improved significantly. These elements are essential for explosive actions such as accelerations, tackles, and transitions during matches. The inclusion of short-distance sprint drills, plyometric movements, and anaerobic running intervals likely contributed to these improvements.^{20,21} RAST scores and 40-meter sprint times both reflected enhanced anaerobic output, supporting the view that repeated high-intensity bouts can lead to neuromuscular adaptations that benefit speed and power.¹⁸ Lower body strength, as measured by leg press normalized to body weight, showed significant improvement after training. Resistance exercises such as squats and lunges were integrated into the weekly routine and performed consistently throughout the intervention period. Enhanced strength may also have contributed to better sprint performance and anaerobic output, indicating interdependence among physical fitness domains in football-specific activities.²⁰ The progressive overload applied throughout the one-year training program may also have contributed to these improvements. Gradual increases in training volume, sprint repetitions, and resistance training workload likely promoted physiological and neuromuscular adaptations that enhanced aerobic capacity, sprint performance, anaerobic power, and lower-body strength.

Despite these improvements, the six-month follow-up assessments indicated regression in all

variables that had initially shown significant gains. Although values did not fall below baseline, they no longer differed significantly from pre-training levels. This suggests that the observed benefits were not sustained without continued training. The reversal of gains can be attributed to detraining, a phenomenon characterized by the partial or complete loss of training-induced adaptations when the training stimulus is reduced or withdrawn.²²⁻²⁴ Mujika et al.²³ have reported that aerobic and strength performance can decline rapidly during periods of training cessation.

No significant changes were observed in flexibility, handgrip strength, vertical jump height, body fat percentage, or BMI across the study period. These results suggest that either the training program did not sufficiently target these components or that these variables are less sensitive to the type and volume of stimulus provided. For example, static flexibility and grip strength may require more specific or isolated interventions to elicit meaningful improvements.^{25,26} Flexibility improvements may be achieved through structured stretching programs performed regularly throughout the training week. Dynamic stretching during warm-up and static stretching during cool-down sessions, performed for 10-15 minutes per session at least three times per week, may help improve joint mobility and muscle flexibility. In addition, grip strength and upper-body strength may benefit from specific resistance exercises such as pull-ups, farmer's carries, medicine ball throws, and handgrip training performed two to three times per week with progressive overload. These targeted interventions may complement football-specific training and help improve physical components that were not significantly affected in the present study.

The findings underscore the importance of consistent and ongoing conditioning for sustaining physical performance in football. For university athletes, training frequency often declines during off-season periods or during academic exam schedules, increasing the risk of detraining. Therefore, implementing maintenance programs, such as one to two sessions per week focusing on aerobic intervals and strength maintenance, may contribute to maintaining performance adaptations. Periodic assessment and individualized progression should also be considered as part of a long-term athlete development strategy. In addition, appropriate field-based assessments may help coaches and researchers monitor physical fitness variables in football players. For example, the 20-m multistage fitness test is commonly used to estimate aerobic capacity and requires minimal equipment, making it suitable for team training environments. Anaerobic performance can be effectively assessed using the Running-Based Anaerobic Sprint Test (RAST), which provides indices of peak power and fatigue. Sprint tests over short distances (e.g., 30-40 m) are practical for assessing running speed, while shuttle run tests provide information on agility and change-of-direction

ability. Muscular strength can be assessed using handgrip dynamometry or lower-body resistance tests, and flexibility may be evaluated using the sit-and-reach test. These field-based tests offer practical and accessible tools for monitoring performance adaptations in football training programs.

Limitations

This study contributes to the understanding of how structured training programs influence physical performance in university-level football players. While short-term improvements were observed following the training program, the findings highlight the importance of sustained training efforts to maintain these adaptations. However, several limitations should be acknowledged. First, the relatively small sample size ($N=15$) may reduce statistical power, as smaller samples limit the ability to detect small to moderate effects and increase the risk of Type II error. A post-hoc power analysis indicated that statistical power was acceptable for detecting moderate to large effects; however, the study may have been underpowered to detect smaller effects. Therefore, the findings should be interpreted with caution, particularly for variables that did not show statistically significant changes. Future studies with larger sample sizes would allow for more robust conclusions. Second, the study did not control several external factors, including dietary intake, sleep quality, academic demands, and unmonitored physical activity outside the training program. These factors are known to influence physical performance, recovery, and training adaptations in athletes. However, the present study was conducted under real-world collegiate training conditions, where strict control of these lifestyle variables was not feasible. Future studies may consider monitoring or controlling these factors to further improve internal validity. This study demonstrated acceptable internal validity using standardized training protocols, consistent outcome measurements, and repeated assessments across all time points. However, external validity may be limited due to the relatively small sample size and the inclusion of participants from a single university team. Therefore, caution should be exercised when generalizing the findings to other populations, particularly professional or elite football players. In addition, participants were recruited from a single university football team and represented university-level amateur athletes with limited formal competition exposure (approximately one official tournament per year). Therefore, the findings should be interpreted primarily within the context of collegiate amateur football players, and caution should be exercised when generalizing the results to professional or elite football populations. Future research should investigate the minimal effective training dose required to maintain performance adaptations and explore strategies for optimizing long-term training sustainability in football players.

Conclusion

A structured training program combining multiple exercise modalities over one year significantly improves $VO_2\text{max}$, strength, sprint speed, and anaerobic power in male football players. However, the cessation of training leads to a decline in these adaptations. Incorporating maintenance phases and consistent long-term planning is crucial to sustaining athletic performance.

Ethical approval

The study was performed in compliance with relevant laws and institutional guidelines and that the appropriate institutional committees have approved of them, along with an approval number AMSEC-67EX-040 (date of approval: 26 July 2024), and that participants have signed a written consent form.

Data availability statement

The data presented in this study are available on request from the corresponding authors.

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Conflict of interest

The authors declared no conflicts of interest in this work.

CRedit authorship contribution statement

Busaba Chuatrakoon: conceptualization, methodology, investigation, data curation, writing original draft, review and editing, supervision; **Sothida Nantakool:** conceptualization, methodology, review and editing; **Peerawats Dejprom:** data collection, data curation, writing original draft, review and editing.

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References

- [1] Chen Y, Lo TY, Xu F, Chang JH. Biomechanical characteristics for identifying the cutting direction of professional soccer players. *Appl Sci*. 2021; 11(16): 7193. doi:10.3390/app11167193.
- [2] França C, Gouveia É, Caldeira R, Marques A, Martins J, Lopes H, et al. Speed and agility predictors among adolescent male football players. *Int J Environ Res Public Health*. 2022; 19(5): 2856. doi:10.3390/ijerph19052856.
- [3] Stolen T, Chamari K, Castagna C, Wisløff U. Physiology of soccer. *Sports Med*. 2005; 35(6): 501-36. doi:10.2165/00007256-200535060-00004.

- [4] Zaharia G, Badau D, Tudor V, Costache R, Geambasu A, Damian M, et al. The effects of 8 aerobic endurance training weeks of 4vs.4+GK small-sided games versus traditional training on physical fitness and skills among U18 football players. *Appl Sci*. 2023; 13(13): 7963. doi:10.3390/app13137963.
- [5] Hoff J, Helgerud J. Endurance and strength training for soccer players: physiological considerations. *Sports Med*. 2004; 34(3): 165-80. doi: 10.2165/00007256-200434030-00003.
- [6] Chmura P, Chmura J, Chodor W, Drozdowski A, Rokita A, Konefał M. The effects of high-intensity interval training at the anaerobic and psychomotor fatigue thresholds on physiological parameters in young soccer players: a prospective study. *Front Physiol*. 2023; 14: 1221121. doi:10.3389/fphys.2023.1221121.
- [7] Díaz-Hidalgo S, Ranchal-Sanchez A, Jurado-Castro JM. Improvements in jump height, speed, and quality of life through an 8-week strength program in male adolescent soccer players. *Sports*. 2024; 12(3): 67. doi:10.3390/sports12030067.
- [8] Wisløff U, Castagna C, Helgerud J, Jones R, Hoff J. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *Br J Sports Med*. 2004; 38(3): 285-8. doi: 10.1136/bjsm.2002.002071.
- [9] Owen AL, Wong DP, Paul D, Dellal A. Effects of a periodized small-sided game training intervention on physical performance in elite professional soccer. *J Strength Cond Res*. 2012; 26(10): 2748-54. doi: 10.1519/JSC.0b013e318242d2d1.
- [10] Sousa H, Gouveia ÉR, Marques A, Sarmento H, Pestana M, Quintal T, et al. The influence of small-sided football games with numerical variability in external training load. *Sustainability*. 2022; 14(2): 1000. doi:10.3390/su14021000.
- [11] Helgerud J, Engen LC, Wisløff U, Hoff J. Aerobic endurance training improves soccer performance. *Med Sci Sports Exerc*. 2001; 33(11): 1925-31. doi: 10.1097/00005768-200111000-00019.
- [12] Jackson AW, Baker AA. The relationship of the sit and reach test to criterion measures of hamstring and back flexibility in young females. *Res Q Exerc Sport*. 1986; 57(3): 183-6. doi: 10.1080/02701367.1986.10605395.
- [13] Markovic G, Dizdar D, Jukic I, Cardinale M. Reliability and factorial validity of squat and countermovement jump tests. *J Strength Cond Res*. 2004; 18(3): 551-5. doi: 10.1519/1533-4287(2004)18<551:RAFVOS>2.0.CO;2.
- [14] Heyward VH, Gibson AL. Advanced fitness assessment and exercise prescription. 7th Ed. Champaign, IL: Human Kinetics; 2014.
- [15] Little T, Williams AG. Specificity of acceleration, maximum speed, and agility in professional soccer players. *J Strength Cond Res*. 2005; 19(1): 76-8. doi: 10.1519/14253.1.
- [16] Miller MG, Herniman JJ, Ricard MD, Cheatham CC, Michael TJ. The effects of a 6-week plyometric training program on agility. *J Sports Sci Med*. 2006; 5(3): 459-65.
- [17] Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci*. 1988; 6(2): 93-101. doi: 10.1080/02640418808729800.
- [18] Zagatto AM, Beck WR, Gobatto CA. Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. *J Strength Cond Res*. 2009; 23(6): 1820-7. doi: 10.1519/JSC.0b013e3181b3df32.
- [19] Slimani M, Nikolaidis PT. Anthropometric and physiological characteristics of male soccer players according to their competitive level, playing position and age group: a systematic review. *J Sports Med Phys Fitness*. 2019; 59(1): 141-63. doi: 10.23736/S0022-4707.17.07950-6.
- [20] Suchomel TJ, Nimphius S, Stone MH. The importance of muscular strength in athletic performance. *Sports Med*. 2016; 46(10): 1419-49. doi: 10.1007/s40279-016-0486-0.
- [21] Buchheit M, Mendez-Villanueva A, Delhomel G, Brughelli M, Ahmaidi S. Improving repeated sprint ability in young elite soccer players: repeated shuttle sprints vs. explosive strength training. *J Strength Cond Res*. 2010; 24(10): 2715-22. doi: 10.1519/JSC.0b013e3181bf0223.
- [22] Silva JR, Nassis GP, Rebelo A. Strength training in soccer with a specific focus on highly trained players. *Sports Med Open*. 2015; 1(1): 17. doi:10.1186/s40798-015-0012-8.
- [23] Mujika I, Halson S, Burke LM, Balagué G, Farrow D. An integrated, multifactorial approach to periodization for optimal performance in individual and team sports. *Int J Sports Physiol Perform*. 2018; 13(5): 538-61. doi: 10.1123/ijsspp.2018-0093.
- [24] Grgic J, Schoenfeld BJ, Davies TB, Lazinica B, Krieger JW, Pedisic Z. Effect of resistance training frequency on gains in muscular strength: a systematic review and meta-analysis. *Sports Med*. 2018; 48(5): 1207-20. doi: 10.1007/s40279-018-0872-x.
- [25] Faigenbaum AD, Kraemer WJ, Blimkie CJ, Jeffreys I, Micheli LJ, Nitka M, et al. Youth resistance training: updated position statement paper from the National Strength and Conditioning Association. *J Strength Cond Res*. 2009; 23(5 Suppl): S60-S79. doi:10.1519/JSC.0b013e31819df407.
- [26] Loturco I, Pereira LA, Kobal R, Zanetti V, Kitamura K, Abad CCC, et al. Transference of strength and power training to sports performance: a meta-analytical review. *Sports Med*. 2019; 49(2): 215-36. doi: 10.2478/hukin-2014-0054. eCollection 2014 Jun 28.