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Role of Aerobic Training in the Respiratory Functioning of University Football Players

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ABSTRACT

Football is an intense, intermittent sport placing significant demands on the cardiorespiratory system. This study examined the effects of an eight-week aerobic training program on respiratory functioning and body composition in university football players using a pre-post intervention design with a parallel observational control group. Forty male football players from the Bahawalnagar sub-campus of Islamia University Bahawalpur participated; 20 underwent the aerobic training intervention (experimental group), and 20 continued their regular football practice (observational control group). Inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) were assessed using a SP-100 digital spirometer; body mass index (BMI) and body weight were recorded as body composition indices. Data normality was confirmed via the Shapiro-Wilk test before applying paired-sample t-tests ($\alpha = .05$) to compare pre- and post-intervention measurements across the combined sample. Results showed significant improvements: IRV increased from 2240.00 ± 30.88 mL to 2277.50 ± 47.60 mL ($t(39) = -5.674$, $p < .001$; Cohen's $d = 0.94$); ERV increased from 932.88 ± 22.81 mL to 955.88 ± 25.84 mL ($t(39) = -6.064$, $p < .001$; Cohen's $d = 0.94$); body weight decreased from 61.73 ± 2.03 kg to 61.11 ± 2.25 kg ($t(39) = 4.312$, $p < .001$; Cohen's $d = 0.29$); and BMI declined from 22.34 ± 1.57 kg/m² to 22.04 ± 1.61 kg/m² ($t(39) = 2.428$, $p = .020$; Cohen's $d = 0.19$). The *observational control group remained stable across all outcome variables during the same period, providing contextual support for attributing the observed pre-to-post changes to the aerobic training protocol. An eight-week structured aerobic training program was associated with significant improvements in pulmonary function and body composition in university football players. These findings suggest that incorporating aerobic conditioning into university football training programs may benefit cardiorespiratory functioning and sports performance.*

Keywords: *Aerobic Training; Inspiratory Reserve Volume (IRV); Expiratory Reserve Volume (ERV); Respiratory Functioning; Football Players; University Athletes; Spirometry; Body Mass Index*

INTRODUCTION

Background and Rationale

Football is among the most physically demanding team sports globally, requiring players to execute a complex and continuous sequence of high-intensity actions, including sprinting, jumping, tackling, and rapid directional changes, throughout a 90-minute match (Helgerud et al., 2001). The physiological demands of competitive football are well established: elite players cover 10–13 km per match, with approximately 8–18% of that distance performed at high or very high intensity, and average exercise intensity maintained at 80–90% of Maximum Heart Rate (Dellal et al., 2011). These demands place extraordinary stress on the cardiorespiratory system, making aerobic capacity and respiratory efficiency fundamental prerequisites for sustained match performance. The respiratory system serves as the critical gateway for oxygen delivery and carbon dioxide elimination during physical exertion. During high-intensity football activity, ventilation rates can increase more than 20-fold above resting values, and any limitation in respiratory muscle endurance or lung volume capacity may directly impair oxygen supply to working muscles, accelerate peripheral fatigue, and reduce a player's ability to maintain high-intensity efforts in the latter stages of a match (Mackala et al., 2020; Leon-Morillas et al., 2021). Understanding how training interventions influence specific respiratory parameters is therefore of direct practical relevance to player development at all competitive levels.

Aerobic training has been widely recognised as the primary modality for improving cardiorespiratory fitness in football players. Structured aerobic conditioning enhances maximal oxygen uptake (VO_2max), increases stroke volume, improves peripheral oxygen extraction, and stimulates favourable adaptations in respiratory muscle strength and endurance (Impellizzeri et al., 2004; Archiza et al., 2018). However, while the effects of aerobic training on VO_2max and cardiovascular indices in football players are extensively documented, comparatively little research has specifically examined its impact on volumetric respiratory parameters, particularly Inspiratory Reserve Volume (IRV) and Expiratory Reserve Volume (ERV), which provide direct indices of inspiratory and expiratory muscle capacity respectively. This gap is particularly noticeable in the context of university-level football players in Pakistan and broader South Asia, where systematic sports science research remains limited relative to the size and popularity of the sport. The present study was therefore designed to address this gap by examining pre- to post-intervention changes in IRV, ERV, body weight, and BMI following a structured eight-week aerobic training protocol, using a pre-post design with a parallel observational control condition.

The Respiratory System and Exercise

The respiratory system performs a dual role during physical activity: it supplies oxygen to metabolically active tissues and eliminates the carbon dioxide generated by increased cellular respiration (İnce & Dağlioğlu, 2018). Pulmonary function is conventionally assessed through spirometric measurement of lung volumes and capacities, which provide quantitative indices of ventilatory mechanics and respiratory health

(Kalkan & Daglioglu, 2018). Among the key spirometric parameters, Inspiratory Reserve Volume represents the maximum additional air volume that can be inhaled beyond a normal tidal breath, while Expiratory Reserve Volume represents the maximum volume of air that can be forcibly expelled following a normal tidal exhalation (Minaeifar et al., 2020). Aerobic training induces structural and functional changes in the respiratory musculature, thoracic cage compliance, and airway diameter, which are reflected in measurable improvements in IRV and ERV. The diaphragm, which is the primary muscle of inspiration, undergoes hypertrophy and increases in oxidative enzyme activity with endurance training, resulting in greater force-generating capacity and fatigue resistance (Archiza et al., 2018). Similarly, the expiratory musculature, comprising the internal intercostals and abdominal muscles, adapts to the repeated ventilatory demands of sustained aerobic exercise, producing measurable increases in ERV (Campoi et al., 2019).

Aerobic Training and Respiratory Adaptations in Athletes

The relationship between aerobic training and respiratory function has been examined across a range of athletic populations over several decades. Reviews of exercise physiology literature confirm that regular aerobic training produces durable structural and functional adaptations in the respiratory system, including improvements in lung volumes, respiratory muscle strength, and ventilatory efficiency (Şaklıca, 2023). Collectively, this body of research demonstrates that trained athletes exhibit significantly greater lung volumes, higher respiratory muscle strength, and more efficient ventilatory patterns than untrained individuals matched for age, sex, and body size *(Mackała et al., 2020)*. In football-specific research, Helgerud et al. (2001) demonstrated that high-intensity aerobic interval training significantly improved VO_2max and enhanced football-specific performance markers including distance covered and number of sprints performed during match play. Impellizzeri et al. (2004) further established that training load calibrated to approximately 90–95% MHR produces superior aerobic adaptations compared to lower-intensity protocols, emphasizing the importance of exercise intensity in driving respiratory and cardiovascular improvements. More recently, Mackala et al. (2020) found that an eight-week respiratory muscle training program in young soccer players produced significant improvements in pulmonary function indices including FVC, FEV_1, and lung ventilation efficiency, alongside improvements in endurance performance. Ozmen et al. (2017) similarly demonstrated significant improvements in respiratory muscle endurance and pulmonary function in soccer players following structured training, with particular gains observed in expiratory reserve capacity.

Aerobic Training and Body Composition in Football Players

Beyond its respiratory effects, aerobic training exerts well-documented influences on body composition. Regular aerobic exercise increases total daily energy expenditure, enhances fat oxidation during and after training sessions, and stimulates favourable shifts in the ratio of lean mass to fat mass (Fritzen et al., 2020). Kerkeni et al., (2025) demonstrated significant reductions in body mass and body fat percentage in football players following an aerobic training intervention, attributing the changes to increased metabolic rate and elevated post-exercise oxygen consumption. Mathur et al., (2009) similarly reported that physically active athletes maintain significantly lower BMI and body fat levels than sedentary peers, with regular aerobic participation identified as the primary determinant of body composition maintenance. These findings provide a theoretical basis for anticipating body weight and BMI reductions following a structured eight-week aerobic protocol in this population.

Research Gap

Despite the extensive literature on aerobic training and cardiovascular fitness in football, several important gaps remain. First, the majority of existing studies have focused on VO_2max, FVC, and FEV_1 as primary respiratory outcomes, with comparatively little attention paid to IRV and ERV as sensitive, trainingresponsive indices of inspiratory and expiratory muscle capacity, respectively. Second, most intervention studies have been conducted with elite or professional football players from European contexts, with limited representation of university-level athletes from South Asian settings, where training environments, baseline fitness levels, and sport participation patterns may differ meaningfully. Third, few studies have simultaneously examined respiratory and body composition outcomes within a single experimental framework in this population, limiting understanding of the integrated physiological effects of aerobic conditioning. The present study addresses these gaps by employing a pre-post intervention design with a parallel observational control group, using validated digital spirometry to measure IRV and ERV alongside body composition indices in a sample of male university football players from Pakistan.

Objectives and Hypotheses

The primary objective of this study was to evaluate the role of an eight-week aerobic-based training protocol in the respiratory functioning of university football players, as measured by Inspiratory Reserve Volume (IRV) and Expiratory Reserve Volume (ERV).

H1: There will be a statistically significant improvement in respiratory functioning, as measured by IRV and ERV, following the eight-week aerobic training intervention, with post-intervention values significantly greater than baseline values across the combined study sample.

H2: There will be a statistically significant reduction in body weight and BMI following the eight-week aerobic training intervention compared to baseline values.

MATERIALS AND METHODS

Research Design

A pre-post intervention design with a parallel observational control group was adopted to examine the effects of a structured aerobic training program on respiratory function and body composition in university football players. This design involved measuring all dependent variables at baseline and again following the eight-week intervention period, allowing within-sample pre-to-post comparisons to be made. The independent variable was the eight-week aerobic training program, administered to the intervention group (n = 20). The dependent variables included inspiratory reserve volume (IRV), expiratory reserve volume (ERV), body weight, and body mass index (BMI), all assessed at both time points. A parallel observational control group (n = 20) continued their regular football training without any additional aerobic protocol during the same eight-week period. This group served an observational function: to confirm that the testing environment, seasonal training cycle, and maturation effects did not independently produce changes in the measured variables during the intervention window, thereby providing contextual support for interpreting pre-to-post changes as training-related (Thomas et al., 2023). Formal between-group inferential comparisons were not the primary analytical approach of this study; pre-to-post changes within the combined sample were the primary focus of statistical analysis.

Study Setting

This study was conducted at the Bahawalnagar sub-campus of Islamia University of Bahawalpur, as the institution has a vibrant Department of Sport Sciences and Physical Education where approximately 400 students are studying and regularly participate in sports activities. The location was selected keeping in mind the availability of adequate academic and sports infrastructure, availability of a football team in the university and equitable access to educational resources.

Participants and Sampling Technique:

This study included 40 male football players aged 18 to 24 years from Islamia University of Bahawalpur, Bahawalnagar sub-campus; athletes were selected voluntarily. Purposive sampling was chosen because it is considered suitable for intervention research requiring participants with common characteristics, similar training exposure, and active sports participation (Etikan et al., 2016). Participants were allocated to two conditions: an intervention group (IG, n = 20) who completed the aerobic training protocol, and a parallel observational control group (CG, n = 20) who maintained their regular football training. Both conditions comprised 50% of the total sample. To determine the sample size, previous research was studied in the sports science literature. Previous intervention studies in comparable populations have employed group sizes ranging from 5 to 20 participants and produced meaningful findings (Campoi et al., 2019; Helgerud et al.,2001; Muhammad et al.,2021; Ozmen et al., 2017). Therefore, it was considered appropriate for the present study to have 20 participants in each group.

Eligibility Criteria

Inclusion Criteria

Participants were considered eligible to participate in the study if they fulfilled the criteria:(1) students of Bahawalnagar sub-campus of the Islamic University of Bahawalpur (2) Male football players, (3) Had been participating in regular football training and sports activities for at least one year (4) Between the ages of 18 and 24 years (5) willing to complete the eight-week training program and provided written consent.

Exclusion Criteria

Participants were excluded from the study if they had any of the following conditions:(1) Current or past smoking, as this can negatively affect the mucociliary clearance, and pulmonary volumes (2)Active participation in any other organized sports during the study period, as this would impose additional training stress that could affect the results (3)Presence of any respiratory disease, such as asthma or chronic obstructive pulmonary disease (4) Unwillingness to continue the eight-week training program or withdrawal of consent at any time.

Ethical Considerations

The study was conducted in accordance with the ethical principles and regulations for research on human subjects as codified in Helsinki (World Medical Association, 2013) and the institutional guidelines of the Islamic University of Bahawalpur**.** Before participation, all athletes were informed verbally and in writing about the study procedures, potential risks and their rights as participants. Written consent was obtained from the participants before any data collection commenced. The identity of the participants was kept confidential throughout the study; numerical codes were used to identify their names and other identifying information. All data were stored in a password-protected digital system, and access to them was limited. Participation was voluntary, and all participants were informed that they could withdraw from the study at any time without penalty. No financial inducements or rewards were offered for participating.

Intervention Protocol

Experimental Group

The experimental group participated in an eight-week aerobic training program, which was conducted five days a week from 4:00 PM to 5:00 PM at the university's Sports campus**.** This training program was adapted from (Impellizzeri et al., 2004; Helgerud et al., 2001) and included six exercises: plyometric training, 30-meter sprint race, lateral hurdle drills, zig-zag running, single-leg squat, and fartlek training. These exercises were chosen because they help improve aerobic endurance, neuromuscular and muscular strength and agility at the same time, which simulates the multi-dimensional movements occurring in football (Hasan et al., 2022; Impellizzeri et al., 2004). All training sessions were divided into three parts: the first was a 10-minute warm-up, which consisted of low-to moderate- intensity exercises to elevate body temperature, muscle movement, and prepare the respiratory musculature for the next main training session (McGowan et al., 2015). The second main training phase was 30 to 35 minutes long, and two sets of each exercise were performed. The maximum heart rate (MHR) was kept between 70% and 85 % during each exercise. Training intensity was monitored via heart rate, with coaches providing verbal cues and adjustments to maintain target zones throughout each session. Sixty seconds of rest were provided between repetitions and between exercises. The 70–85% MHR target zone was selected because it corresponds to moderate-to-high intensity aerobic training, a range shown to significantly improve VO_2max and respiratory muscle endurance in football players (Helgerud et al., 2001; Nobari et al., 2022). The cooldown consisted of five minutes of low-intensity exercises to bring the heart rate and breathing rate back to normal. The total duration of each session was 45 to 50 minutes. To develop the aerobic adaptation process, it is important to change training exercise intensity in a systematic manner so that the adaptation process in the body does not stagnate (Impellizzeri et al., 2004). The first two weeks were the adaptation phase, in which the maximum heart rate was kept at 70 to 75%; the third through sixth weeks were basic training weeks, and the intensity was kept at 75 to 82% of the maximum heart rate (MHR). The seventh and eighth weeks were the consolidation phase, in which the intensity was kept at 82 to 85 % of the maximum heart rate (MHR) (Appodia et al., 2018).

Control Group

The control group was instructed to maintain their normal football training schedule and not participate in any additional organized exercise other than university football practice during this eight-week intervention period. This approach, in which a parallel group maintains habitual activity while the intervention group undergoes structured training, is commonly used in sports intervention research (Campoi et al., 2019; Ndlomo, 2022). During the intervention period, participants in the control group were monitored to ensure that they were not engaging in any additional aerobic training and that they were following the prescribed instructions.

Outcome Measures and Instrumentation

Respiratory Function Assessment

The SP-100 digital spirometer was used to assess pulmonary function, a clinically reliable tool widely used in many medical and sports-related research studies to measure different lung volumes (Appodia et al., 2018; Minaeifar et al., 2020). This study examined two important variables related to breathing: inspiratory reserve volume (IRV), the maximum amount of air that a person can inhale after taking a normal inspiration. Its normal value is 1900 to 3300 millilitres in a healthy person, while in trained athletes, this amount is usually close to the upper limit of this normal value (Yılmaz & Dağlıoğlu, 2018). Expiratory reserve volume (ERV) refers to the maximum amount of air that can be forcefully exhaled after a normal exhalation. Normal values of ERV range in a healthy person are 700 to 1200 millilitres. All measurement of spirometry was performed in a standardised manner. The participants were seated upright, and a nose-clip was placed over their nose to ensure oral airflow. This procedure is in accordance with the American Thoracic Society and European Respiratory Society (Miller et al., 2005). All participants performed at least three attempts for each variable; the most reproducible value was recorded. Participants were instructed to avoid strenuous physical activity for 24 hours prior to the testing session, to avoid using caffeine for four hours before the test, and to wear comfortable clothing that did not restrict thoracic expansion (Kalkan & Daglioglu, 2018). All assessments were performed by the same certified assessor to avoid possible variation inter-ratter variability.

Anthropometric Measurements

Participants' weight was measured using an accurate digital weighing machine with an accuracy of 0.1 kg. During weighing, participants wore light sportswear and no shoes, and participants had fasted overnight for eight hours prior to measurement**.** The stadia meter was used for height measurement with an accuracy of 0.01 feet at baseline only because height is a stable anthropometric variable not affected by an eight-week aerobic training program. Body mass index was calculated by dividing body weight in kilograms by height in meters squared (kg/m^2).

Data Collection Procedure

A week before the training program, all participants in the experimental group and the control group had their baseline measurements of all outcome variables. To reduce changes in lung function caused by diurnal variation, all spirometry assessments were performed between 3:00 PM and 4:00 PM as this time period is associated with relatively stable pulmonary function across the circadian cycle (Yılmaz & Dağlıoğlu, 2018). The post-intervention assessment were performed within 48 hours of the last training session of the eighth week and the same procedure was used for the measurements as was adopted initially. Temperature and humidity were also recorded during each session. If the weather was extremely hot, cold, or humid, the test was postponed to another appropriate time so that weather would not affect the results.

Statistical Analysis

All data were analysed in SPSS Statistics version 23. Demographic outcome-related data, including mean and frequency distribution, were calculated. Before inferential statistics, the normality of the data for each dependent variable was examined using the Kolmogorov-Smirnov test and the Shapiro-Wilk test, which is recognised as reliable for testing the normality of the sample below 50 (Ghasemi & Zahediasl, 2012; Razali & Wah, 2011). To assess the changes before and after the intervention, a paired sample t-test was applied to all four dependent variables, as it is considered appropriate for comparing pre-post intervention measurements involving a single sample obtained at two different times (Cohen, 2013; Field, 2024). Analyses were conducted on the combined sample ($n = 40$) to assess the overall pre-to-post effect of the intervention period. Observational control group data were examined descriptively to confirm the absence of meaningful change during the eight-week period in the non-training condition, providing contextual support for attributing pre-to-post changes to the aerobic training protocol rather than temporal or environmental factors. The statistical significance was $\alpha = 0.05$. The results were reported with the mean, standard deviation, T-statistics, degree of freedom and exact p-values. The result was interpreted in the light of existing studies on aerobic training and respiratory adaptation in football players (Campoi et al., 2019; Muhammad et al., 2021).

Validity and Reliability

Internal Validity

Several design features were implemented to support the interpretability of findings. A parallel observational control group maintained their regular football training without additional aerobic conditioning during the intervention period. Descriptive monitoring of this group confirmed the absence of substantial change in outcome variables over the eight-week window, supporting the interpretation that pre-to-post changes observed in the combined sample were attributable to the aerobic training protocol rather than seasonal fitness variation, test familiarity, or maturation effects (Thomas et al., 2023). All measurements were conducted under standardised conditions by the same examiner, using the same instrument, to minimise measurement errors. Uniform eligibility criteria were applied to all participants, while those with respiratory diseases, tobacco use, and concurrent training in other sports were excluded from the study to maintain sample homogeneity.

Construct Validity

To maintain construct validity, outcome variables were selected that were directly related to the research objectives, including inspiratory reserve volume (IRV), expiratory reserve volume (ERV), body weight, and body mass index (BMI). Previous studies have shown that these variables are influenced by aerobic training (Campoi et al., 2019; Mackała et al., 2020), so they were considered for the study. Furthermore, the SP-100 digital spirometer was used to measure respiratory function, a reliable instrument with documented test-retest reliability coefficients exceeding .90 (Appodia et al., 2018)

RESULTS

This study examined the effects of an eight-week aerobic training intervention on the respiratory and physical performance of university male football players. Demographic characteristics are presented first, followed by assessment of data normality, and pre-to-post intervention comparisons for all four dependent variables: IRV, ERV, body weight, and BMI. All statistical analyses were performed in IBM SPSS version 23.0 with the significance level.05 set for all tests.

Group Distribution

The study included 40 male university football players, selected from the Bahawalnagar sub-campus of the Islamia University of Bahawalpur. Participants were allocated to two conditions: an intervention group (IG, n = 20) assigned to the eight-week aerobic training protocol, and a parallel observational control group (CG, n = 20) who continued regular football practice. Each condition comprised 50% of the total sample (n = 40). Equal group allocation supports comparability of baseline characteristics and minimises the risk of systematic differences between conditions before the intervention (Thomas et al., 2023). The age of the participants was between 18 and 24 years, with the mean age of 21.1 years representing the young athletes of the university, The largest age cohort were 22 years (20.0%) and 23 years (20.0%), while the other age groups included 19 years (17.5 %), 21 years (15.0%), 20 years (12.5%), 24 years (10.0%), and 18 years (5.0%). This age distribution corresponds to the age profile for football university players in Pakistan. In the initial measurements, the height of the players ranged from 152.4 cm to 179.8 cm (5.0–5.9 feet). The highest number of players was 5.6 feet (17.5%), followed by 5.3feet (15.0%), 5.7 feet (15.0%) and 5.8 feet (15.0%). Height was measured at baseline only because it is not expected to change with an eight-week training program.

Assessment of Data Normality

Tests of Normality	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
IRV	.122	40	.134	.967	40	.284
ERV	.105	40	.200*	.987	40	.926
W	.101	40	.200*	.976	40	.542
BMI	.106	40	.200*	.981	40	.727

Note: *IRV = Inspiratory Reserve Volume; ERV = Expiratory Reserve Volume; BMI = Body Mass Index*

Before applying inferential statistics, normality of data was examined for dependent variables including inspiratory reserve volume (IRV), expiratory reserve volume (ERV), body weight and body mass index (BMI) across the combined sample (n = 40) by using the Kolmogorov-Smirnov test with Lilliefors significance correction and the Shapiro-Wilk test.

All four variables had p-values greater than .05 in Shapiro-Wilk test as IRV (W = .967, p = .284), ERV (W = .987, p = .926), body weight (W = .976, p = .542), and BMI (W = .981, p = .727). The Kolmogorov-Smirnov results were similar to these findings; the significant value of IRV is .134 points, while for all the other variables, returning significant at or above.200 values , which is the maximum limit of reporting with the Lilliefors correction in SPSS. Furthermore, the visual inspection of Q.Q plots for all four variables showed normality, which verified these findings; data points appear closely aligned with the diagonal reference line, which suggests that the data is generally normally distributed with no significant deviation in the tails. The results show that the data for all these dependent variables were normally distributed and therefore the use of a paired sample t-test was justified to compare the results before and after the intervention. While formal inferential analysis of control group data was not conducted in this study, the control group was monitored throughout the intervention period and no clinically notable variation was observed in any outcome variable, consistent with the expectation that regular football practice alone would not substantially alter IRV, ERV, or body composition over an eight-week period in already-active university athletes.

Pre- to Post-Intervention Change in Body Weight

Paired Sample t-test: Body Weight Pre- and Post-Intervention (n = 40)

Variable	Mean (kg)	SD	T	Df	p
Weight Pre	61.73	2.03	4.312	39	<.001
Weight Post	61.11	2.25			

Note: SD = Standard Deviation.

Descriptive statistics showed a reduction in body weight, with the pre-intervention mean body weight of 61.73 ± 2.03 kg decreased to 61.11 ± 2.25 kg following the intervention. This represented an absolute loss of 0.62 kg compared to the initial weight. Furthermore, the paired sample t-test confirmed that this loss was statistically significant, $t(39) = 4.312$, $p < .001$. This indicates that the eight-week aerobic training program was associated with a significant reduction in body weight in the overall sample.

The modest weight reduction is consistent with the participants' lean baseline profile: a mean of 61.73 kg is typical of physically active young male athletes in South Asian university settings. In the South Asian context, a young male university football player is considered to be lean and physically active. Furthermore, the intervention period was too short to expect a significant weight change. During aerobic training, energy expenditure increases, creating a negative energy balance which induces the body to burn more calories. Therefore, individuals who are already physically active and lean generally lose less body weight than observed in sedentary or obese ones. These results are consistent with Zouhal et al. (2020) and Trexler et al. (2017), who reported that aerobic training induces incremental rather than dramatic body composition changes in college football players.

Pre- to Post-Intervention Change in Inspiratory Reserve Volume

Table 4. Paired Sample t-test: Inspiratory Reserve Volume (IRV) Pre- and Post-Intervention (n = 40)

Variable	Mean (mL)	SD	T	Df	p
IRV Pre	2240.00	30.88	−5.674	39	<.001
IRV Post	2277.50	47.60			

Note: *Negative t-value indicates a pre-to-post increase. IRV = Inspiratory Reserve Volume; SD = Standard Deviation.*

IRV increased from 2240.00 ± 30.88 mL at baseline to 2277.50 ± 47.60 mL at post-intervention, indicating that the ability of the lungs to inhale air increased by 37.50 mL (1.67%). According to the paired sample t-test, $t(39) = -5.674$, $p < .001$, indicating a significant difference. The negative t-value is due to the order of subtraction used in the paired sample t-test, showed expected pre-to-post increase. The effect size (Cohen's $d \approx 0.94$) was large, meaning that the effect of aerobic training is strong and clear. The increase in respiration is an indication of enhanced function of the respiratory musculature, such as the diaphragm and external intercostal muscles. Together, these muscles increase greater thoracic volume, resulting in holding more air beyond normal tidal volume. This improvement was seen after eight weeks of aerobic training (Mackała et al., 2020). Physically, aerobic exercise causes many changes in the body, such as increased oxygen utilisation, strengthening of the diaphragm, and increased thoracic compliance. All of these changes enable the body to inhale more air into the lungs during maximal respiratory effort (Archiza et al., 2018; Leon-Morillas et al., 2021). Furthermore, the standard deviation value of IRV after aerobic training was increased relative to baseline (47.60 vs. 30.88 mL), indicating that the amount of improvement varied among individuals, with some improving more than others. This variability may be attributable to individual differences in baseline body composition and respiratory fitness, so in the future, these factors can be studied in more detail with a larger sample.

These results are consistent with (Muhammad et al., 2021), who describe an increase in IRV after moderate-intensity training for the same duration among athletes in Pakistan. Similarly,(Durmic et al., 2017) also reported that competitive athletes' respiratory function enhances due to training periods. In football, increased IRV is considered important, as a high inhalation rate supports continued oxygen delivery for working muscles; player performance improves as a result, fatigue in the body occurs later, and the player can perform better for a long duration during a match (Di Paco et al., 2014).

Pre- to Post-Intervention Change in Expiratory Reserve Volume

Table 5. Paired Sample t-test: Expiratory Reserve Volume (ERV) Pre- and Post-Intervention (n = 40)

Variable	Mean (mL)	SD	T	Df	p
ERV Pre	932.88	22.81	−6.064	39	<.001
ERV Post	955.88	25.84			

Note: *Negative t-value indicates a pre-to-post increase. ERV = Expiratory Reserve Volume; SD = Standard Deviation.*

The mean value of ERV in pre-intervention was 932.88 ± 22.81 mL, which increased to 955.88 ± 25.84 mL at post-intervention, an absolute increase of 23.00 mL (2.47%). According to the paired sample t-test, this increase is statistically significant, $t(39) = -6.064$, $p < .001$. In particular, the t-value for ERV was the highest compared to the other dependent variables, indicating that the most robust improvement was shown in the expiratory reserve volume after intervention. The effect size was large (Cohen's $d \approx 0.94$), and equal to the effect size of IRV, which makes it clear that the intervention led to a significant improvement in both the inspiratory and expiratory parameters.

An increase in ERV indicates that muscles involved in the process of expelling air increased their endurance and flexibility, including the rectus abdominis, internal intercostals and the internal and external oblique muscles, which together produce a compressive pressure needed to expel air below the resting expiratory level (Campoi et al., 2019). Aerobic training places progressive load on pulmonary muscles, leads to increased ability of muscle fibre to utilize oxygen, improved neuromuscular coordination, and an increased resistance to fatigue (Leon-Morillas et al., 2021; Ozmen et al., 2017). Increased ERV is important in football because it enhances ventilation capacity of the lungs and the ability to expel carbon dioxide efficiently. The acid--base system is maintained in balance during intense physical exertion(Archiza et al., 2018). This is important for football players because they have to sprint repeatedly in a 90-minute match (Helgerud et al., 2001). These results are consistent with Di Paco et al. (2014) and Muhammad et al. (2021), who reported that athletes have better ERV after regular physical training. Further, Campoi et al. (2019) stated that football players have higher ERV than sedentary individuals because aerobic training induces a constant challenge on the respiratory system to meet respiratory demands.

Pre- to Post-Intervention Change in Body Mass Index

Table 6. Paired Sample t-test: Body Mass Index (BMI) Pre- and Post-Intervention (n = 40)

Variable	Mean (kg/m²)	SD	T	Df	P
BMI Pre	22.34	1.57	2.428	39	.020
BMI Post	22.04	1.61			

Before the intervention, the BMI mean value was 22.34 ± 1.57 kg/m², which decreased to 22.04 ± 1.61 kg/m² after the intervention. The BMI decreased by 0.30 kg/m^2. This decrease was 1.34% compared to the initial BMI. According to the paired sample t-test, the reduction in BMI was statistically significant, $t(39) = 2.428$, $p = .020$, since the p-value was less than 0.05. The effect size (Cohen's $d \approx 0.19$) was small, indicating that the practical magnitude of the BMI reduction was modest, which is consistent with the fact that participants' BMI remained normal before and after intervention. According to the World Health Organisation, the normal BMI range is 18.5–24.9 kg/m² (Organisation, 2000). The participants were already at a normal weight. The goal of reducing BMI was not to lose weight but to improve body composition, which suggests that the participants in the sample were already physically fit. These results are consistent with the already existing fact that when a slim and physically active person exercises regularly, they experience a small but positive decrease in BMI, but sedentary populations tend to experience greater weight loss (Koehler et al., 2017; Milanese et al., 2013). As a previous study has proven, people who participate in regular sports have significantly lower and healthier levels of BMI (Cairney & Veldhuizen, 2017). Furthermore, continuous structure exercises combined with regular physical activity plays an important role in maintaining a healthy body composition and improving physical fitness (Murphy et al., 2019).

Summary of Findings

Table 7. Summary of Pre- and Post-Intervention Outcomes for All Variables (n = 40)

Variable	Pre Mean ± SD	Post Mean ± SD	Change	T	Df	p	Cohen's d
IRV (mL)	2240.00 ± 30.88	2277.50 ± 47.60	+37.50	−5.674	39	<.001	0.94
ERV (mL)	932.88 ± 22.81	955.88 ± 25.84	+23.00	−6.064	39	<.001	0.94
Weight (kg)	61.73 ± 2.03	61.11 ± 2.25	−0.62	4.312	39	<.001	0.29
BMI (kg/m²)	22.34 ± 1.57	22.04 ± 1.61	−0.30	2.428	39	.020	0.19

Note: *All comparisons statistically significant at p < .05. IRV = Inspiratory Reserve Volume; ERV = Expiratory Reserve Volume; BMI = Body Mass Index; SD = Standard Deviation. Positive change indicates increase; negative change indicates decrease.*

After eight weeks of the training program, statistically significant differences were observed among all four dependent variables. Significant increases were observed in both IRV and ERV, which were the primary dependent variables of this study. The effect sizes of both variables were large (Cohen's d ≈ 0.94 for both), indicating that the training had a practical effect on the inspiratory and expiratory capacity of the lungs. Significant decreases were also observed in both body weight and BMI, but their effect sizes were small (Cohen's d ≈ 0.29 and 0.19, respectively), indicating that although there was an improvement in body composition, the amount was relatively small, which is consistent with the fact that participants were already physically active and in good physical condition. The overall direction of the results for all variables is consistent with the research hypothesis. Furthermore, the results are consistent with previous research evidence on the effects of aerobic training in football players' respiratory system and body composition. It should be noted that formal between-group inferential testing was not conducted in this study; the paired t-test analyses reflect pre-to-post changes across the combined sample. The observational control group served a contextual monitoring function, and its stability across the intervention period strengthens the interpretability of the observed training effects.

DISCUSSION

This study examined the effects of an eight-week aerobic training program on the respiratory function and body composition of university football players. The results showed statistically significant pre-to-post improvements in all four outcome variables: IRV and ERV increased significantly, while body weight and BMI decreased, reflecting favourable changes in both respiratory capacity and body composition.

Effect of Aerobic Training on Inspiratory Reserve Volume

The results showed a significant improvement in inspiratory reserve volume, from a pre-intervention mean of 2240.00 ± 30.88 mL to a post-intervention mean 2277.50 ± 47.60 mL, $t(39) = -5.674$, $p < .05$. These improvements were observed in the context of a pre-post intervention design; the parallel observational control group showed no comparable change over the same period, providing contextual confidence that the improvements reflect training adaptation rather than seasonal variation. These findings indicated that the training program improved the ability of the respiratory muscles, such as the diaphragm and external intercostal muscles, to inhale more air. From a physiological standpoint, repeated aerobic exercise places progressive demand on the respiratory muscles, improving their fibre endurance, flexibility, and neuromuscular efficacy (Mackała et al., 2020). These results are consistent with previous research that reported an increase in IRV in young players due to moderate intensity training and was associated with diaphragm strength and respiratory endurance (Muhammad et al., 2021). Similarly, another study also observed positive changes in the respiratory system as a result of structured aerobic training (Durmic et al., 2017). Increasing IRV has applied significance in football because it helps athletes take in more air, which increases oxygen delivery to muscles and reduced onset fatigue (Helgerud et al., 2001; Leon-Morillas et al., 2021). The increase in the standard deviation of IRV value (47.60 vs. 30.88) in the post-test indicates that individuals responded differently, possibly due to differences in initial fitness levels and variations in anthropometric characteristics. Larger-scale samples and better monitoring in future studies may elucidate these inter-individual differences.

Effect of Aerobic-Based Training on Expiratory Reserve Volume (ERV)

A significant increase in ERV was observed from baseline 932.88 ± 22.81 mL to post-intervention 955.88 ± 25.84 mL, with $t(39) = -6.064$, $p < .05$. The t-statistic for ERV was the highest among all measured variables, suggesting that expiratory reserve volume was the outcome most robustly influenced by the aerobic training intervention. These improvements were observed in the context of a pre-post intervention design; the parallel observational control group showed no comparable change over the same period, providing contextual confidence that the improvements reflect training adaptation rather than seasonal variation. Aerobic training increases the strength and endurance of the expiratory muscles, especially the internal intercostal muscles and abdomen muscular structure. As a result, a greater amount of residual air can be expelled after a normal exhalation(Campoi et al., 2019). Improvement in ERV has vital practical implications in football. Improved expiratory capacity helps in ventilation in the lungs, facilitating carbon dioxide removal during strenuous physical activities and maintaining acid-base balance (Archiza et al., 2018). Increasing ERV helps football players during repeated sprints in a match; their breathing recovers more quickly, which can help them maintain better performance during a 90-minute match. Ozmen et al. (2017) also showed that eight weeks of respiratory muscle training increased ERV in football players. Similarly, Campoi et al. (2019) reported that ERV was higher in soccer players than in sedentary individuals, indicating that the sport has a continuous improvement effect on the respiratory system.

Effect of Aerobic Training on Body Weight

A significant decrease in body weight was observed, reduced from a pre-intervention mean of 61.73 ± 2.03 kg to a post-intervention mean value of 61.11 ± 2.25 kg. Although the absolute reduction of 0.62 kg was modest, it is noteworthy given the short intervention period and the already lean baseline profile of the athletes. These improvements were observed in the context of a pre-post intervention design; the parallel observational control group showed no comparable change over the same period, providing contextual confidence that the improvements reflect training adaptation rather than seasonal variation. Aerobic training creates a negative energy balance, accelerating fat oxidation while preserving lean body mass (Thomas et al., 2023). Present findings are also consistent with the study of Provencher et al. (2018), who reported that even a small reduction in body weight among already trained athletes carries significant implications for locomotor efficiency and cardio-muscular workload during matches.

Effect of Aerobic-Based Training on Body Mass Index (BMI)

There was a significant decrease in BMI from a pre-intervention 22.34 ± 1.57 kg/m² to a post- intervention 22.04 ± 1.61 kg/m², with $t(39) = 2.428$, $p = .020$. Both values were within the clinically healthy and normal range (18.5–24.9 kg/m², indicating that the participants were already at a healthy weight; a reduction in BMI does not indicate a cure for obesity but a positive change in body composition. These improvements were observed in the context of a pre-post intervention design; the parallel observational control group showed no comparable change over the same period, providing contextual confidence that the improvements reflect training adaptation rather than seasonal variation. These results are consistent with previous research that suggests a reduction in BMI in healthy individuals occurs with aerobic training, which is associated with fat loss (Lafontant et al., 2025). Furthermore, physical activity helps maintain BMI-appropriate levels in healthy individuals; regular exercise also improves physical fitness (Pettersson et al., 2021). These findings are supported by the results of the present study, in which adding a structured aerobic training program to regular football training produced a small but statistically significant BMI reduction.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, a pre-post intervention design with a parallel observational control group was employed rather than a fully randomized controlled trial with formal between-group inferential analysis. While the stability of control group values across the eight weeks provides contextual support for the training effect, between-group ANCOVA or independent samples analysis on change scores would provide stronger causal evidence and are recommended for future research. Second, the study recruited only male football players from a single university campus, limiting generalizability to female athletes, elite-level players, or other sports contexts. Third, dietary intake was not monitored during the intervention period; it is possible that changes in eating habits contributed to the observed body composition changes alongside the training effect. Fourth, environmental conditions including air temperature and humidity were recorded but not experimentally controlled, which may have introduced minor variation in spirometric readings across sessions. Fifth, the eight-week intervention period, while sufficient to detect significant short-term changes, does not allow conclusions about the durability of training adaptations; follow-up assessment at 12 to 24 weeks post-intervention is recommended. Sixth, heart rate monitoring method and individual session attendance rates were not reported in detail, limiting the precision with which training dose can be characterized.

CONCLUSION

The study showed that eight weeks of aerobic training improved the respiratory performance and physical fitness of university football players, as the results showed that inspiratory reserve volume (IRV) and expiratory reserve volume (ERV) significantly increased, which indicates an improvement in the respiratory muscles to inhale and exhale air. Similarly, body weight and BMI also significantly decreased. The pre-post design with observational control represents a preliminary level of evidence. Nevertheless, the consistency of findings across all four outcome variables, combined with large effect sizes for respiratory parameters (Cohen's d = 0.94 for both IRV and ERV) and the absence of notable change in the control group, supports a cautious conclusion that structured aerobic training meaningfully improves cardiorespiratory functioning in university football players. The results of this study are important for coaches, sports administrators, sports psychologists and sports scientists who design training programs for university and recreational football players. If systematic aerobic exercises such as fartlek training, plyometrics, sprint intervals, and agility exercises are included in football training, the respiratory performance of the players will increase, which will lead to better performance in the match. These results further add to the research evidence and support the evidence that structured aerobic training programs should be integrated with football training, especially at university and elite levels, where the focus is often on techniques and tactical training while the nature of respiratory discipline is ignored.

RECOMMENDATIONS

The following recommendations for sports coaches and trainers that can be applied to university football players.

1. Coaches should include at least an eight-week aerobic training plan for football players during the pre-season and in-season. Training intensity should target 70–85% of maximum heart rate to achieve the aerobic adaptations demonstrated in this study.

2. Digital spirometers should be used to check athletes' respiratory progress, such as IRV and ERV, so that fitness programs can be recommended for athletes with suboptimal respiratory functions.

3. Future research could use a fully controlled between-group design, in which each group is analysed separately and then an independent samples t-test or ANCOVA can be used to determine the differences between groups. This method will more accurately determine whether the changes were due to training alone or to some other unrelated factors. In addition, a longer follow-up of at least 12 to 24 weeks should be kept to see how long the effects of training last.

4. Future research should include female athletes and elite-level athletes to improve the generalizability of the findings. Furthermore, studies should include other aspects of respiratory function, such as forced expiratory volume and forced vital capacity, to provide a more complete picture of the changes in the lungs that result from exercise training.

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