Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 2, 1463-1472
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i2.4779

Quantitative analysis of athletic performance enhancement: The effects of aerobic training on VO_2 max in young soccer's

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Abstract: Soccer is a high-intensity sport that combines aerobic endurance with agility and neuromuscular coordination to optimize performance. The literature review described the many roles that aerobics play in soccer, from professional performances to youth development, and the range of methods used to evaluate and enhance it. The present study has been designed to examine the impact of incorporating aerobic exercises combined with acrobatic movements into the training regimes of young soccer players and their repercussions on athletic performance as measured by VO_2 Max. A total of 44 male soccer players, aged 18-19, were randomly assigned to either a control group ($n = 22$), following standard soccer training, or an experimental group ($n = 22$) that included aerobic and acrobatic exercises three times per week over an entire competitive season. VO_2 Max was measured in the laboratory at the Sports University of Tirana before and after the intervention. Data analysis included independent samples t-tests and Repeated Measures ANOVA. The baseline, control, and experimental groups were statistically not different in their VO_2 Max values. This therefore means that differences at the start did not obscure findings. After training, the experimental group showed a significant increase in VO_2 Max over the control group, thus confirming the hypothesis that the combined aerobic and acrobatic training has positive effects on endurance and athletic performance. There was a significant interaction effect of training modality and VO_2 Max improvement, $F(1, 42) = 1176.58$, $p < .001$; the experimental group showed a significantly higher increase in VO_2 Max compared to the control group. These findings indicate that the combination of aerobic and acrobatic exercises in soccer training improves cardiorespiratory endurance and possibly contributes to the general development of an athlete. The study has shown the importance of new training methods in optimizing soccer performance and has provided empirical evidence for their effectiveness. The findings of this study confirm the notion that soccer training programs should combine aerobic drills with acrobatic elements to maximize endurance. Further studies should investigate the long-term effects of such training methods and their influence on match performance and the prevention of injuries.

Keywords: *Acrobatic training, VO_2 Max, Aerobic exercise training, Athletic performance, Endurance, Soccer training.*

1. Introduction

Aerobic fitness is an important factor in professional soccer, having a significant influence on both physical and tactical aspects of the game. Modric, et al. [1] researched how aerobic fitness can be related to indicators of game performance, emphasizing differences regarding playing position. It was found that midfielders mostly had higher VO_2 Max values compared with defenders and forwards, reflecting the different physiological demands for each role.

Comparing the methodologies for VO2 Max estimation, Mulazimoglu, et al. [2] investigated three different shuttle run tests. Based on their findings, all these tests are valid; however, some protocols are

History: Received: 13 December 2024; Revised: 23 January 2025; Accepted: 27 January 2025; Published: 14 February 2025
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more reliable for specific athletic populations, which underlines the importance of choosing the appropriate testing methods to get accurate aerobic capacity.

Bidaurrazaga-Letona, et al. [3] focused on youth soccer, studying how aerobic fitness development contributes to talent identification and selection. Their research showed that higher levels of VO_2 Max are related to advanced levels of skills development and selection within competitive youth environments.

On individualized training, Mujika, et al. [4] presented a case study of a youth elite soccer player who was underperforming. Individualized aerobic-power training resulted in great improvement in the VO_2 Max of the player, thus proving the effectiveness of personalized interventions for performance enhancement in youth elite athletes.

Pelliccia, et al. [5] indeed gave comprehensive guidelines on sports cardiology and exercise in athletes with cardiovascular conditions. Recommendations are that regular aerobic fitness assessments should be performed, including VO_2 Max for safe participation in competitive sports.

Lola and Tzetzis [6] have pointed out that young athletes' motor and perceptual skills have been developed, and aerobic conditioning provides the very foundation on which advanced physical and cognitive capabilities are built. Their insights bring into perspective the holistic benefits of aerobic conditioning beyond mere endurance improvements.

Arslanoglu, et al. [7] investigated combined methods of training: with maximal aerobic speed and small-sided games. Indeed, such combined methods were effective in training to improve the level of aerobic capacity among amateur football players, which could later be used for different conditions.

Along the same line, Zaharia, et al. [8] compared the influence of small-sided games with those of conventional training in U18 soccer players. During the eight-week period, small-sided games improved aerobic endurance and added a technical skills advantage, offering dual benefits to youth development programs.

Alkhateeb and Donath [9] investigated how soccer compared to traditional aerobic exercise affected muscle structure. Their RCT found that soccer-specific training has an equally positive effect as a training tool in terms of the aerobic improvement but simultaneously introduces muscular adaptations, hence being even more efficient for training.

Michaelides, et al. [10] investigated the effects of an eight-week pre-season training program in professional soccer players in terms of their aerobic fitness. Their results showed significant VO_2 Max enhancements, underlining the crucial contribution that well-planned pre-season conditioning would give to reach an optimal in-season level.

Literature review outlined the multifunctional role that aerobics performs in soccer, from youth development to professional performances, and a variety of approaches to its improvement and assessment. Based on the literature review we proposed the following hypothesis for this study.

Given the deficiencies identified in the traditional soccer training methodologies, the current study introduces a novel approach by incorporating both aerobic and acrobatic exercises. These types of training will interactively influence cardiorespiratory endurance, agility, and overall athletic performance.

The hypothesis formulation, according to the current research available, can be identified as follows:

H_0: Innovative training methods including aerobic and acrobatic exercises will have no significant effect on the athletic performance, as measured by VO_2 Max, in young soccer's.

H_1: Innovative training methods integrating aerobic and acrobatic exercises will significantly enhance the athletic performance of young soccer's as measured by VO_2 Max.

This hypothesis was tested through an empirical analysis involving a structured training program, with pre- and post-intervention measurements of VO_2 Max, enabling a data-driven test of the efficacy of these training modalities.

2. Research Methodology

2.1. Partecipants

This study investigates the impact of integrating aerobic exercises with music and acrobatic movements into the standard training routines of 19-year-old male soccer's in Tirana. The age group selected exhibits significant physical changes, including peak physiological function and enhanced agility. Soccer demands a combination of aerobic and anaerobic strength, agility, and power. Conducted at the gymnastics facilities near the Sports University of Tirana (UST), the research involves 44 participants divided into two groups:

- Control Group: 22 soccer's adhering to standard soccer training.
- Experimental Group: 22 soccer's undergoing additional aerobic and acrobatic training, conducted thrice weekly over the course of a full championship season.

2.2. Procedures

Participants underwent two evaluations—one at the beginning of the experimental phase and another at the end—to measure VO_2 Max in laboratory conditions at UST.

The Treadmill VO_2 Max Test was conducted to evaluate the athlete's aerobic endurance capacity. The test began with a standardized warm-up at a speed of 4.5 km/h and a 0° incline to prepare the athlete physiologically.

Upon receiving the command "START," the athlete initiated the test while the stopwatch was activated. The treadmill's speed and incline were progressively increased at predetermined intervals according to a specific protocol designed to gradually intensify the workload. The athlete continued running until the point of voluntary exhaustion or inability to maintain the required pace, indicating maximal effort. Throughout the test, an assistant monitored performance, adjusted treadmill settings, and ensured safety.

The data collected, including time to exhaustion, speed, incline, and respiratory gas measurements, were used to calculate VO_2 Max, providing critical insights for performance assessment and future training recommendations.

2.3. Statistical Analysis

Data analysis was conducted through the use of IBM SPSS Statistics 26. Repeated Measures ANOVA was used to ascertain the effect of the novel training methods using aerobics exercises on VO_2 Max. The test was intended to ascertain whether the interaction between time-interval (pre- and post-) and group membership-experimental and control significantly influences the values of VO_2 Max.

The following were checked for the dataset before doing the statistical tests: The Shapiro-Wilk test for normal distribution of VO_2 Max values; Homogeneity of Variances where the variances in VO_2 Max were tested using Levene's test; Mauchly's test of sphericity. To examine whether group membership affected the changes in VO_2 Max over time, a 2 (Group: Experimental, Control) × 2 (Time: Pre, Post) Repeated Measures ANOVA was conducted.

3. Results

The data summarizes the age distribution of male soccer's randomly assigned to two groups: control and experimental. The control group (n = 22) had a mean age of *M* = 18.56, *Mdn* = 18.50, with a minimum age of 18.0 and a maximum age of 19.9, *SD* = 0.39, and *SE* = 0.08. The experimental group (n = 22) had a mean age of *M* = 18.37, *Mdn* = 18.30, with a minimum age of 18.0 and a maximum age of 18.9, *SD* = 0.27, and *SE* = 0.06. Across both groups (N = 44), the total sample had a mean age of *M* = 18.47, *Mdn* = 18.50, with a minimum age of 18.0 and a maximum age of 19.9, *SD* = 0.34, and *SE* = 0.05

Table 1.
Descriptive statistics for participants' age by group.

Group	N	Mean	Median	Min	Max	SD	SE Mean
Control	22	18.56	18.50	18.0	19.9	0.39	0.08
Experimental	22	18.37	18.30	18.0	18.9	0.27	0.06
Total	44	18.47	18.50	18.0	19.9	0.34	0.05

Table 2.
Descriptive statistics for VO_2 Max (ml/min/kg) Pre- and post-intervention.

Group	N	Mean	Median	SE Mean	Min	Max	Range	SD
Control (Pre)	22	58.40	58.73	1.03	46.08	68.64	22.56	4.83
Control (Post)	22	60.42	60.57	1.06	47.58	71.00	23.42	4.97
Exp. (Pre)	22	59.01	59.86	1.10	48.60	68.32	19.72	5.17
Exp. (Post)	22	66.97	67.14	1.01	57.76	75.50	17.74	4.73
Total (Pre)	44	58.70	59.13	0.75	46.08	68.64	22.56	4.95
Total (Post)	44	63.69	63.67	0.88	47.58	75.50	27.92	5.83

Regarding VO_2 Max (ml/min/kg) measured at the pre-test, the control group had a mean value of 58.40 (=4.83) with a 95% confidence interval (CI) ranging from 56.25 to 60.54, while the experimental group demonstrated a higher mean of 59.01 (SD=5.17) with a 95% CI of 56.72 to 61.30.

Figure 1 illustrates the distribution of VO_2 Max values for the control group before the intervention. The shape of the distribution provides insights into the variability and skewness of the baseline fitness levels in this group.

The post-intervention histogram (Figure 2) for the control group shows any shifts in the distribution of VO_2 Max scores, reflecting the changes in VO_2 Max due to the intervention.

Histogram of VO_2 Max (ml/min/kg) Pre-Intervention for Experimental Group is presented in Figure 3, displaying the initial VO_2 Max distribution for the experimental group. The distribution helps compare baseline VO_2 Max levels before applying the intervention and after intervention (Figure 4).

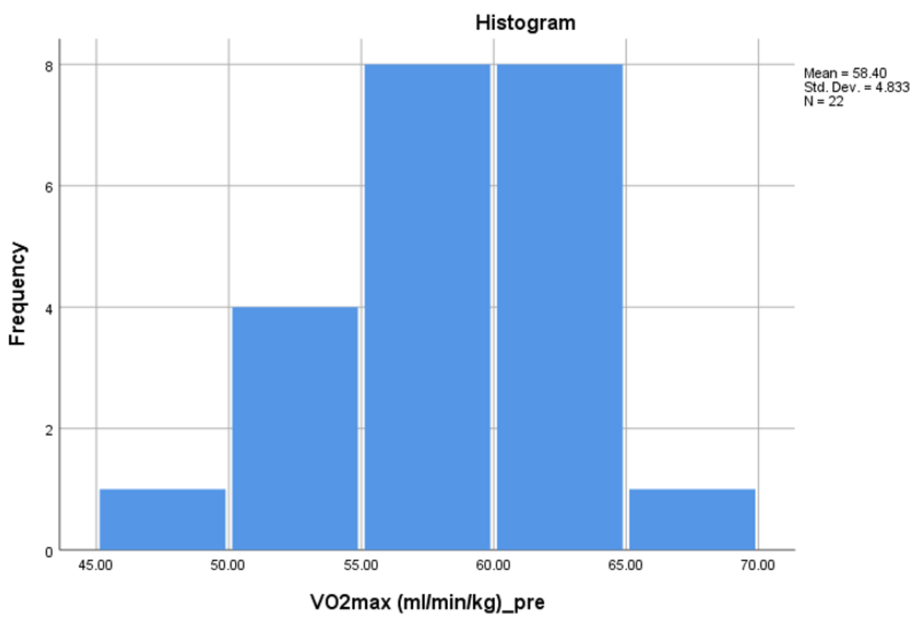

Figure 1.
Histogram of VO_2 Max (ml/min/kg) pre-intervention for control group.

Edelweiss Applied Science and Technology
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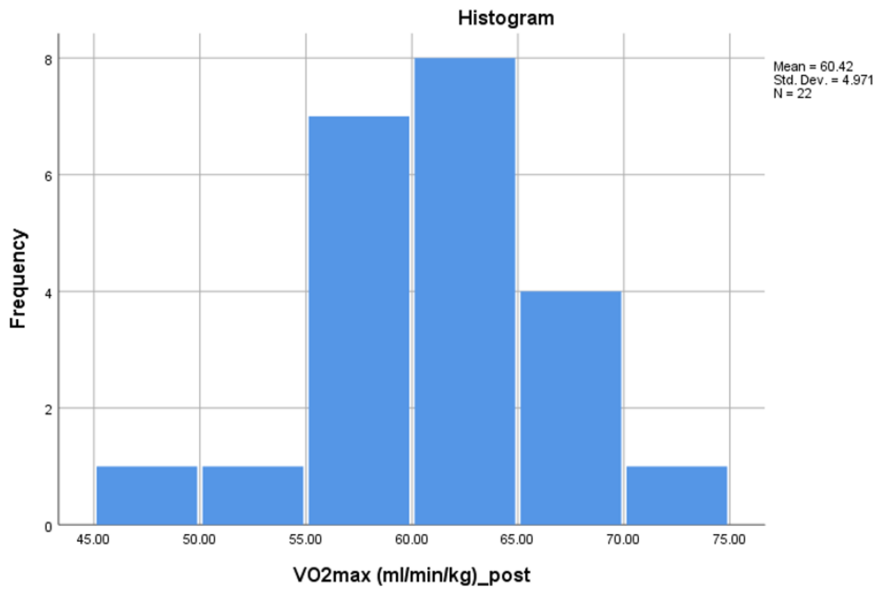

Figure 2.
Histogram of VO_2 Max (ml/min/kg) post-intervention for control group.

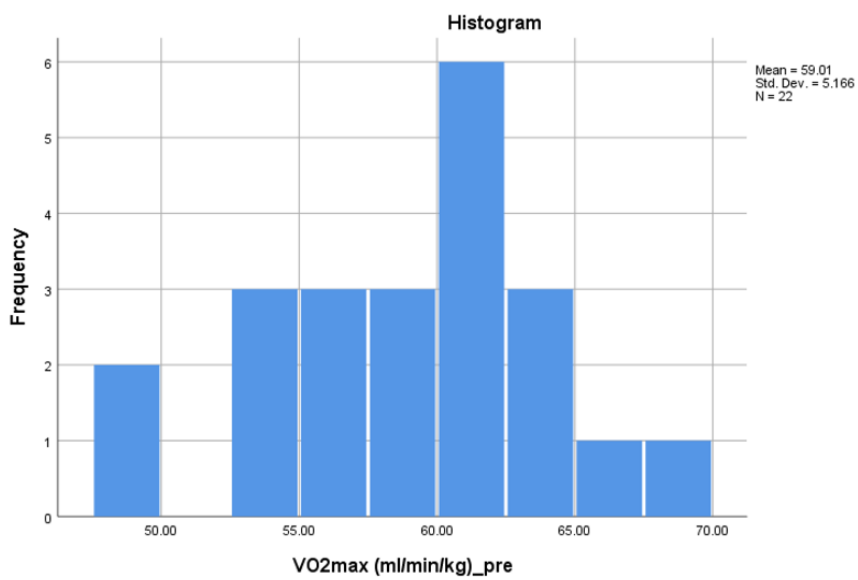

Figure 3.
Histogram of VO_2 max (ml/min/kg) Pre-intervention for experimental group.

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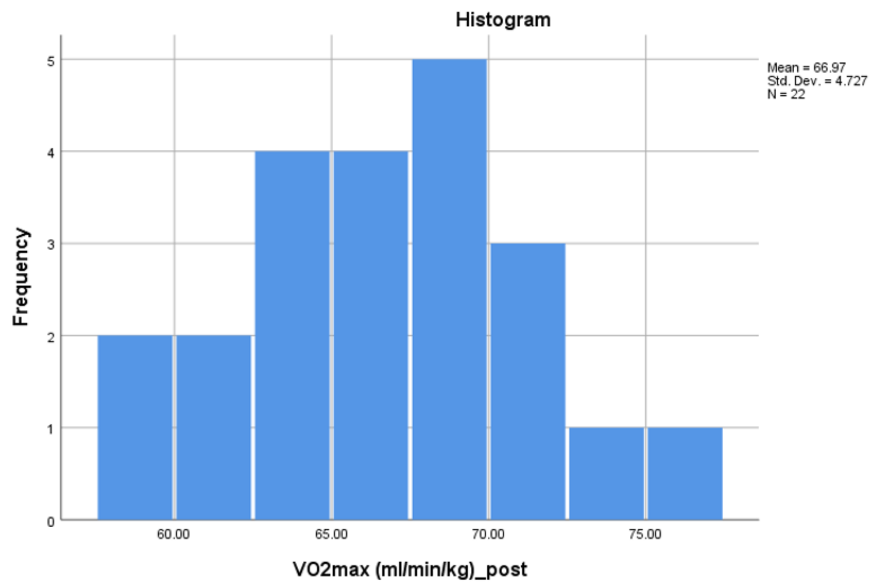

Figure 4.
Histogram of VO_2 Max (ml/min/kg) post-intervention for experimental group.

Despite the difference in means, an independent samples t-test (Table 3) revealed no statistically significant difference between the groups, (t (42) =0.41, p=.69) at the start point.

An independent samples t-test was conducted on the pre-intervention VO_2 Max scores to establish if the groups were equivalent on the outcome measure. As indicated in Table 3, there was no significant difference in the pre-test VO_2 Max values between the control and experimental group,

Table 3.
Independent samples t-test for VO_2 Max (ml/min/kg) pre-intervention

Assumption	**F**	**Sig.**	**t**	**df**	**p (2-tailed)**	**Mean difference**	**SE difference**	**95% CI lower**	**95% CI upper**
Equal variances assumed	0.31	0.58	0.41	42	0.69	0.61	1.51	-2.43	3.66
Equal variances not assumed			0.41	41.82	0.69	0.61	1.51	-2.43	3.66

These results suggest that the control and experimental groups were comparable in baseline physical performance metrics.

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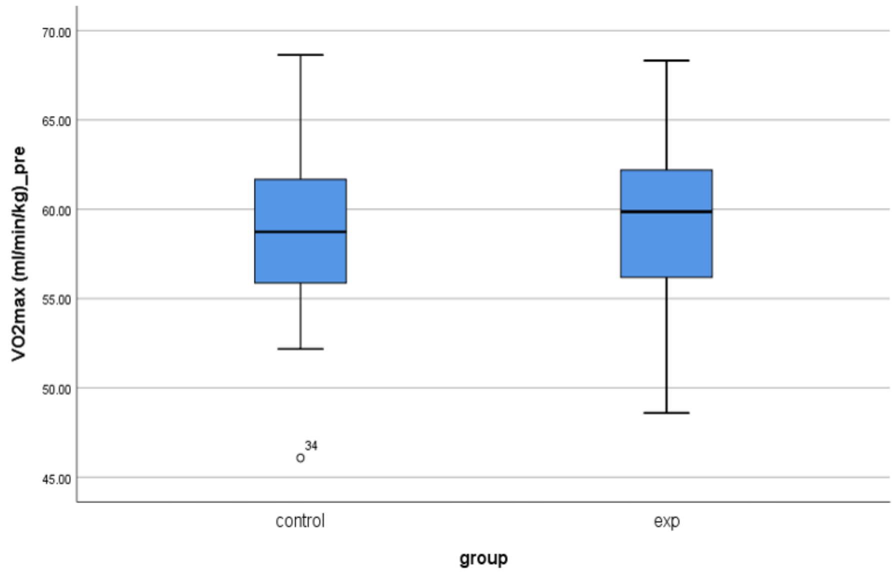

Figure 5.
Boxplot of VO_2 Max (ml/min/kg) Pre-Intervention for Experimental and Control groups.

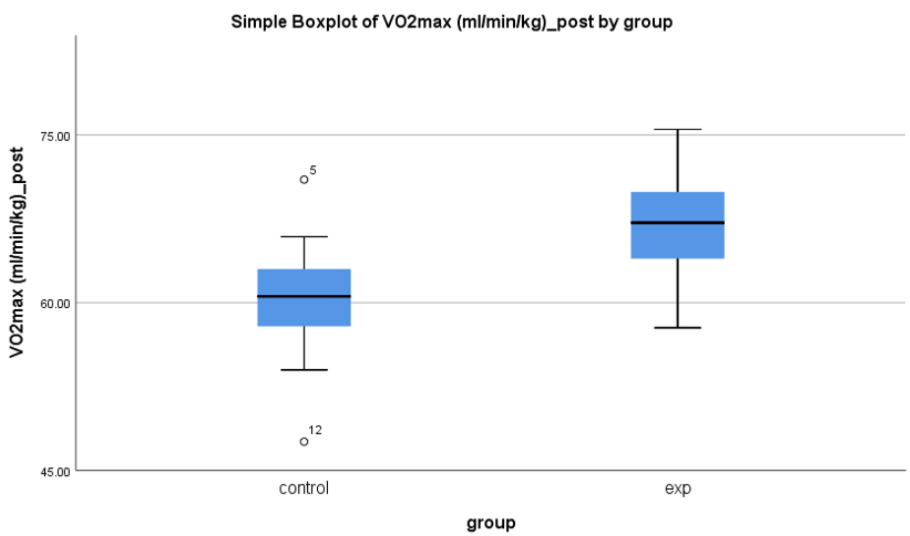

Figure 6.
Boxplot of VO_2 Max (ml/min/kg) post-intervention for experimental and control groups.

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Vol. 9, No. 2: 1463-1472, 2025
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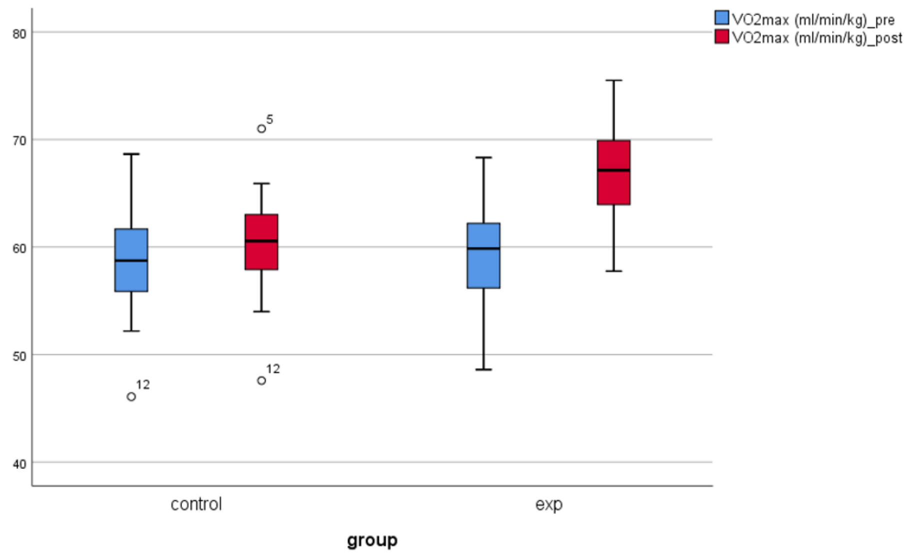

Figure 7.
Boxplot of VO_2 Max (ml/min/kg) Pre and Post Intervention for both groups.

3.1. Repeated Measures ANOVA Results

A repeated measures ANOVA was conducted to examine the effect of group membership on VO_2 Max. The results demonstrated a significant multivariate effect for VO_2 Max, Pillai's Trace = 0.988, $F(1, 42) = 3331.08$, $p < .001$, $\eta^2_p = .988$, indicating that VO_2 Max significantly changed across measurements. Mauchly's test was not significant thus indicating no violation of sphericity ($W = 1.000$, $p = 1$. The analysis revealed there was a significant main effect of VO_2 Max, $F(1, 42) = 3331.08$, $p < .001$, which suggested that the training had a strong influence on VO_2 Max. Additionally, the interaction of VO_2 Max and Group was significant, $F(1, 42) = 1176.58$, $p < .001$, indicating that group membership influenced change in VO_2 Max.

Table 4.
Multivariate test results for the effect of group on VO_2 max.

Effect	Value	F	Hypothesis df	Error df	Sig.
VO_2 Max.					
Pillai's Trace	0.988	3331.084[b]	1.000	42.000	0.000
Wilks' Lambda	0.012	3331.084[b]	1.000	42.000	0.000
Hotelling's Trace	79.312	3331.084[b]	1.000	42.000	0.000
Roy's Largest Root	79.312	3331.084[b]	1.000	42.000	0.000
VO_2 Max × Group					
Pillai's Trace	0.966	1176.579[b]	1.000	42.000	0.000
Wilks' Lambda	0.034	1176.579[b]	1.000	42.000	0.000
Hotelling's Trace	28.014	1176.579[b]	1.000	42.000	0.000
Roy's Largest Root	28.014	1176.579[b]	1.000	42.000	0.000

Note: Design: Intercept + Group. Within-Subjects Design: VO_2 Max.
[b] Exact statistic.

Table 5.
Within-subjects contrasts for VO_2 max.

Source	Type III sum of squares	df	Mean square	F	Sig.
VO_2 max. (Linear)	547.902	1	547.902	3331.084	0.000
VO_2 max. × Group	193.526	1	193.526	1176.579	0.000
Error (VO_2 max.)	6.908	42	0.164		

Table 6.
Between-subjects effects for VO_2 max.

Source	Type III sum of squares	df	Mean square	F	Sig.
Intercept	329,586.480	1	329,586.480	6811.674	0.000
Group	282.032	1	282.032	5.829	0.020
Error	2032.192	42	48.386		

The intercept was very significant, $F(1, 42) = 6811.67$, $p < .001$, reflecting overall magnitude of VO_2 Max values. More importantly, a main effect of group was significant, $F(1, 42) = 5.83$, $p = .020$. This suggests that VO_2 Max levels in groups were significantly different. These results indicate that group membership significantly influenced VO_2 Max changes across measurements (pre and post intervention).

Figure 7 illustrates the distribution of VO_2 Max (ml/min/kg) before and after the intervention for both groups, highlighting the changes in aerobic capacity over time and the differing effects of the intervention on the control and experimental groups.

4. Discussion

The study explored whether an innovative training approach encompassing aerobic and acrobatic exercises can effectively enhance young soccer's' VO_2 Max, thus significantly impacting their athletic performances. Based on the results, there is considerable support to ground that such training, in fact, enhances endurance capacity beyond what can be typically achieved with regular soccer conditioning.

In fact, at baseline, control and experimental groups were statistically not different in their VO_2 Max values. This therefore, means that differences at the start did not obscure findings. After training, the experimental group increased in VO_2 Max highly over the control group, thus confirming the hypothesis that the combined aerobic and acrobatic trainings have positive effects on endurance and athletic performance.

These findings are in agreement with previous studies that have established the role of structured aerobic training in soccer. Indeed, earlier studies have documented that high-intensity interval training improves endurance and repeated sprint ability, while agility-based exercises enhance balance and lower-body power. The findings of this study confirm the notion that soccer training programs should combine aerobic drills with acrobatic elements to maximize endurance and agility.

5. Conclusion

These results indicate a significant effect of group membership on VO_2 Max and a strong interaction between VO_2 Max and group. This suggests that the experimental condition significantly influenced VO_2 Max changes over time. Practical implications of these findings are of practical interest for the soccer coaches, trainers, and sports scientists. Soccer conditioning training in the form of combined aerobic and acrobatic training can be highly valuable in trying to develop physiological performance and endurance in soccer players. Monitored VO_2 Max can enable tracking of training effectiveness and adjustments in individual conditioning programs accordingly. Further, the described training modes can be widely applied to all age groups of soccer's who compete at different levels to ensure continuous overload and to maintain athletic advancement.

Despite the fact that this study produced numerous noteworthy findings, it is necessary to note a number of limitations. For instance, the generality of this result is limited to just 44 subjects. Multiple teams or clubs may be included in a larger sample to confirm how these techniques might work on a broader scale. Furthermore, additional research on long-term aerobic and acrobatic training interventions across seasons is necessary, even though this study focused on short-term physiological changes.

Lastly, individual variability in response to training was not considered, which presupposes the genetic predisposition or training history that may affect the magnitude of improvement in VO_2 Max.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Acknowledgement:

This research was performed in the frame of the doctoral study at the Sports University of Tirana. I would like to thank my academic advisors, colleagues, and all participants who contributed to this study. Special thanks go to the young soccer players who have dedicated their time and effort to this research, and also the coaching staff for their collaboration. I would like to thank the university's research department for all the facilities needed in conducting this study.

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