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Impact of the Integral Method on the Development of Aerobic Endurance in Under-16 Categories

Impacto del método integral en el desarrollo de la resistencia aeróbica en categorías sub-16

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Summary

Introduction: The impact of the integral method on the development of aerobic endurance in under-16 soccer players was determined. Objective: To determine the impact of the integral method on the development of aerobic capacity in U-16 soccer players. Methodology: The research, with a quantitative approach and a pretest-posttest experimental design, was conducted with a sample of 8 players from the Asociación Deportiva Naval (ADN) club. A training program based on the integral method was applied for 4 weeks (3 weekly sessions of 45-60 minutes), combining ball exercises, small-sided games, technical-physical circuits, and high-intensity intervals. Aerobic endurance was assessed using the YoYo Intermittent Recovery Test Level 1 (YoYo IR1) before and after the intervention. The Wilcoxon test for related samples was used. Results: A statistically significant improvement was shown in the distance covered (pretest median: 1950 m; posttest median: 2100 m; p = 0.028; large effect

size, r = 0.78). Discussion: The proportion of players in high levels (Excellent or Good) increased from 75% to 87.5%, with the Average category disappearing. Conclusion: The integral method contributes positively to the development of aerobic endurance in under-16 soccer players, constituting an effective methodological strategy for youth soccer.
Keywords: Aerobic endurance; Under-16 soccer; YoYo test

Resumen

Introducción: Se determinó el impacto del método integral en el desarrollo de la resistencia aeróbica en futbolistas de la categoría sub-16. Objetivo: determinar el impacto del método integral en el desarrollo de la capacidad aeróbica en futbolistas sub-16. Metodología: La investigación, de enfoque cuantitativo y diseño experimental pretest-postest, se realizó con una muestra de 8 jugadores del club Asociación Deportiva Naval (ADN). Se aplicó un programa de entrenamiento basado en el método integral durante 4 semanas (3 sesiones semanales de 45-60 minutos), que combinó ejercicios con balón, juegos reducidos, circuitos técnico-físicos e intervalos de alta intensidad. La resistencia aeróbica se evaluó mediante el YoYo Intermittent Recovery Test Level 1 (YoYo IR1) antes y después de la intervención. Se utilizó la prueba de Wilcoxon para muestras relacionadas. Resultados: Se mostro una mejora estadísticamente significativa en la distancia recorrida (mediana pretest: 1950 m; mediana postest: 2100 m; p = 0,028; tamaño del efecto grande, r = 0,78). Discusión: La proporción de jugadores en niveles altos (Excelente o Bueno) aumentó del 75 % al 87,5 %, desapareciendo la categoría Promedio. Conclusiòn: que el método integral contribuye positivamente al desarrollo de la resistencia aeróbica en futbolistas sub-16, constituyendo una estrategia metodológica eficaz para el fútbol formativo.

Palabras clave: Método integral; Resistencia aeróbica; Fútbol sub-16; YoYo test

Introduction

Soccer is an intermittent sport that alternates between high-intensity efforts and periods of active recovery throughout the game. This dynamic requires the proper development of physical abilities, among which aerobic endurance plays a fundamental role in maintaining physical and technical performance throughout the competition (López & Cuaspa, 2018). Several studies have shown that soccer players cover great distances during a match, alternating between periods of low, moderate, and high intensity. In this context, aerobic capacity allows players to maintain performance for the full 90 minutes and facilitates recovery between explosive actions such as sprints, changes of direction, or challenges for the ball (McMillan, 2005).

Aerobic endurance is the body's ability to perform prolonged physical exertion using oxidative metabolism as its primary energy source. This ability allows athletes to engage in long-duration activities with less fatigue, thereby optimizing athletic performance (Charalampos et al., 2013). In soccer, aerobic endurance affects not only a player's ability to cover ground but also their ability to recover between intense plays. Proper development of this quality

improves physiological efficiency, promotes oxygen delivery to the muscles, and contributes to consistent performance during a game (Lopez & Cuaspa, 2018).

Furthermore, scientific research has shown that specific training programs aimed at developing aerobic endurance can lead to significant improvements in VO_2max among young soccer players, thereby increasing their work capacity and competitive performance (McMillan, 2005).

In youth categories, the development of physical abilities must be progressive and adapted to the players' growth and biological maturation. Aerobic endurance during the formative stages is the foundational physical capacity upon which other conditional abilities—such as speed, strength, and anaerobic endurance—are built (Teixeira et al., 2015). In particular, the comprehensive training method proposes that exercises include game situations, ball-handling drills, small-sided games, and technical-tactical circuits, which allow for the development of physical fitness while simultaneously working on soccer-specific skills (Davis et al., 2008). The comprehensive method in youth soccer is understood as an effective pedagogical strategy for the simultaneous development of physical abilities and technical-tactical skills, thereby facilitating a more well-rounded development of the soccer player and their adaptation to the demands of the modern game (Perlaza et al., 2025).

Although there is evidence regarding the benefits of aerobic endurance training and the comprehensive method separately, gaps in knowledge remain regarding the specific effectiveness of the comprehensive method for developing aerobic endurance in the U-16 category of Ecuadorian youth soccer (Liu et al., 2026). Few studies have implemented a program based solely on integrated exercises (using a ball and real game situations) and evaluated its impact using standardized tests such as the YoYo test in this population. Therefore, the objective of this study was to determine the impact of the integrated method on the development of aerobic capacity in U-16 soccer players (Böhme, 2004).

Materials and Methods

Type and Design of the Study

A quantitative, applied, and explanatory study was conducted to determine the effect of the comprehensive method on aerobic endurance in U-16 soccer players. A single-group experimental design with pre-post measurements was used. Contrary to what is stated in the original manuscript (which mentions a quasi-experimental design), the random selection of participants (n=8) from

an accessible population allows the design to be classified as pre-experimental (pre-test–post-test with a single group) or, strictly speaking, as an interrupted time-series design without a control group (Sautov et al., 2025). No control group was included due to logistical and ethical considerations (to ensure that no player was excluded from the training program). Variables such as session duration (45–60 minutes), intensity (maximum, adjusted for subjective perception of exertion), and training schedule (always between 4:00 p.m. and 6:00 p.m.) were controlled.

Population and Sample

The population consisted of 24 male soccer players in the U-16 category from the youth divisions of the Asociación Deportiva Naval (ADN) club, aged between 15 and 16 years (Koç et al., 2025). A sample of 8 players was selected using simple random sampling (with a random number table). The inclusion criteria were: (a) being registered in the U-16 category and having regular training attendance (>80% in the previous two months); (b) having no musculoskeletal injuries at the time of the study; and (c) having a signed authorization from a legal guardian (Blechschmied et al., 2024). The exclusion criteria were: (a) having participated in another supplementary training program in the previous 4 weeks; (b) having any cardiovascular or respiratory condition that contraindicates maximal exercise; and (c) failing to complete all program sessions or the pre-test and post-test evaluations. No players were excluded during the study (O'Brien et al., 2024).

Tests and Assessment Tools

The YoYo Intermittent Recovery Test Level 1 (YoYo IR1) was used to measure aerobic capacity. The protocol consisted of 20-meter round-trip runs at progressively increasing speeds signaled by audible cues, with a 10-second active rest period between each repetition (a 5-meter round-trip jog). The test ended when the participant failed to reach the finish line on two consecutive attempts. The primary outcome was the total distance covered, expressed in meters. The players were also classified into the following categories based on the distance achieved: Excellent (≥2200 m), Good (1600–1999 m), Average (1200–1599 m), and Low (<1200 m). The tests were conducted on the same synthetic turf field under similar weather conditions (temperature of 24 to 26 °C, relative humidity of 70 to 75%), at the same time of day from 4:00 p.m. to 5:00 p.m., both for the pretest (one week before the program began) and the posttest (one week after the program ended) (Sorokin, 2026).

Training Plan (Comprehensive Method)

A 4-week program was developed, consisting of 3 sessions per week (Monday, Wednesday, and Friday), each lasting 45 to 60 minutes. All sessions were conducted using a comprehensive methodology that combined aerobic endurance exercises with technical-tactical drills and ball work. The intensity of all exercises was maximal (subjective perception of exertion ≥8 on the Borg CR-10 scale), with the number of sets and repetitions varying over the course of the weeks. No sessions focused solely on physical conditioning without a ball were conducted.

Weekly training content:

Continuous jogging (10 to 15 minutes at a moderate pace) on the playing field, interspersed with dribbling drills.

Running with changes of pace (fartlek) (15–20 minutes): a combination of light jogging (2 minutes), fast pace (1 minute), and short sprints (10 to 15 seconds), always with the ball or in possession situations.

Physical-technical circuit (15 minutes): Stations lasting 30 to 45 seconds each: coordination jumps, skipping with a ball, changes of direction in a slalom course, passing while moving, and finishing with a sprint. Two or three laps.

Small-sided games, 5 vs. 5 (15 to 20 minutes): in 30x20-meter spaces, with an emphasis on maintaining high intensity and quick transitions. Rules were used to encourage continuity (quick throw-ins, forced passes, etc.).

High intensity (10 minutes): 15 seconds of maximum sprint / 15 seconds of active recovery (jogging) for 4–6 repetitions, or 20“/20” for 4–6 repetitions. Always with the ball (sprint dribbling, passing, and running off the ball).

The training progression unfolded as follows: during Week 1, the focus was on continuous jogging and small-sided games; in Week 2, fartlek and circuit training were incorporated; during Weeks 3 and 4, the volume of the intervals was increased and the rest time between sets was decreased.

Statistical Analysis

The data were entered into a Microsoft Excel spreadsheet (version 365) and subsequently exported to the SPSS statistical software package, version 27 (IBM Corp., Armonk, NY, USA). Due to the small sample size (n=8), a nonparametric analysis was performed. To compare the distances covered in the Yo-Yo test between the pretest and posttest, the Wilcoxon signed-rank test for paired samples was used (an alternative to Student’s t-test for data that do not follow a normal distribution). The absolute and relative frequencies (%) of the qualitative

categories (Excellent, Good, Average, Below Average) were also calculated at both time points. A level of statistical significance of $\alpha = 0.05$ was established. The Z-statistic, p-value, and effect size ($r = Z/\sqrt{N}$) are reported. Measures of central tendency (median, interquartile range) for the distance covered are also provided.

Study Limitations

The following limitations are acknowledged: (a) the absence of a control group, which makes it impossible to attribute causality exclusively to the comprehensive method (the changes could be due to the passage of time or to uncontrolled factors); (b) the small sample size (n=8), which limits statistical power and the generalizability of the results; (c) the short duration of the program (4 weeks), which is insufficient to generate structural physiological adaptations in aerobic capacity; (d) the lack of blinding in both assignment and evaluation; (e) the use of a single performance test (YoYo test) without complementary physiological measurements (such as direct VO_2max or ventilatory thresholds); (f) the failure to account for the participants' biological maturation, which could influence their response to training. These limitations must be taken into account when interpreting the results.

Results

The training program based on the comprehensive method was completed with an average attendance rate of 94% for the scheduled sessions, with no injuries or dropouts recorded throughout the 4-week intervention. The results obtained following the assessment of aerobic endurance using the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) are presented below. The absolute and relative frequency distributions of the 8 participants are presented according to performance categories (Excellent, Good, Average, Below Average) at the pretest and posttest time points. This is further supplemented by an inferential statistical analysis comparing the total distances covered (in meters) between the two measurements.

Table 1 Distribution of soccer players by aerobic endurance level (YoYo IR1) before and after implementation of the comprehensive method (n=8)

Category	Pretest (n=8)	Postest (n=8)	Change (p.p.)
Excellent (≥2200 m)	4 (50,0%)	4 (50,0%)	0
Good (1600-1999 m)	2 (25,0%)	3 (37,5%)	+12,5

Average (1200-1599 m)	1 (12,5%)	0 (0,0%)	-12,5
Below average (<1200 m)	1 (12,5%)	1 (12,5%)	0
Total	8 (100%)	8 (100%)	

Note: p.p. = percentage points

Source: Compiled by the author

In the pretest, 75% of the soccer players (6 out of 8) scored in the high ranges of aerobic endurance (Excellent or Good), while the remaining 25% (2 players) scored Average or Below Average. In the post-test, the proportion of players in the high categories increased to 87.5% (7 out of 8), as one player moved from the Average category to the Good category. There were no changes in the Excellent (4 players) and Below Average (1 player) categories. The only player remaining in the Average category moved up to Good, causing this category to disappear in the final assessment.

Analysis of Distance Covered (Inferential)

Although the table above presents results qualitatively, recording the total distances covered (in meters) allowed for a quantitative comparison of the pretest results with those of the posttest. Due to the small sample size (n=8) and the non-normal distribution of the differences (Shapiro-Wilk, $p > 0.05$), the Wilcoxon test for paired samples was used.

Wilcoxon Test Results

Pre-test median (interquartile range): 1,950 m (1,675 – 2,100 m)

Median (interquartile range): 2,100 m (1,850 – 2,200 m)

Z-statistic: -2.201

p-value (two-tailed): 0.028

Effect size ($r = Z/\sqrt{N}$): 0.78 (large effect, according to Cohen: >0.5)

The results show that the improvement in aerobic capacity following the application of the comprehensive method is statistically significant ($p < 0.05$) with a large effect size.

The application of the comprehensive method over 4 weeks produced a significant improvement in the aerobic endurance of the U-16 soccer players at the ADN club. Notably, the "Average" category was eliminated (one player moved up to "Good"), and the "Excellent" levels were

maintained. Although the number of players in the "Excellent" category did not increase, the median distance covered increased by 150 meters, and the nonparametric test confirmed the statistical significance of the changes.

Discussion

The objective of this study was to determine the impact of a training program based on the comprehensive method on the aerobic endurance of U-16 soccer players. The results showed a statistically significant improvement in the distance covered in the YoYo IR1 test (pre-test median: 1,950 m; post-test median: 2,100 m; $p = 0.028$; large effect size, $r = 0.78$). It was also observed that one player moved from the "Average" category to the "Good" category, causing the percentage of soccer players at high levels ("Excellent" or "Good") to rise from 75% to 87.5%. These results confirm that the comprehensive method—based on ball exercises, small-sided games, and real-game situations—positively influences the development of aerobic capacity in young soccer players. The results are consistent with those reported by McMillan et al. (2005), who demonstrated that a specific training program for aerobic endurance (combining continuous running, intervals, and technical exercises) produced significant improvements in VO_2max and performance on field tests in youth soccer players. Furthermore, Teixeira et al. (2015) emphasized that during the developmental stages (primarily between the ages of 14 and 16), aerobic endurance is highly trainable through strategies that incorporate the ball, due to the increased motivation and sport-specificity this provides for the players. Deprez et al. (2014) and Castillo et al. (2024) also noted that soccer requires a solid aerobic foundation to maintain performance throughout the game and facilitate recovery between high-intensity actions, a finding supported by the results of the present study, which provide empirical evidence that the comprehensive method meets this requirement.

The comprehensive method offers pedagogical advantages over other forms of training. Perlaza et al. (2022) argued that incorporating technical-tactical tasks into real-game scenarios promotes the transfer of physical skills to competitive performance. In line with this, the program implemented (featuring 5-on-5 small-sided games, technical-physical circuits, and interval training with the ball) was able to generate physiological adaptations similar to or greater than those obtained through exclusively conditioning-based training, as the players maintained high intensity without perceiving the training as

monotonous. Indeed, Praça, G. M. (2022) found that integrated methods reduce dropout rates and improve adherence, which was reflected in the high average attendance (94%) in this study.

Despite the positive results, they must be interpreted with caution, as there are several limitations. First, the lack of a control group prevents us from establishing an exclusive causal relationship between the comprehensive method and the observed improvements; part of the change could be due to the test-familiarization effect or the biological maturation of the participants (although the 4-week duration makes significant maturational changes unlikely). Second, the sample size is very small (n=8), which limits statistical power and the ability to generalize the results to other populations or situations. Third, the intervention was of short duration (4 weeks); previous studies with positive results on aerobic endurance typically last ≥ 6–8 weeks (McMillan et al., 2005; Clemente et al., 2024). Therefore, the improvements observed, although significant, could be considered of moderate magnitude from a clinical standpoint (a 150-meter increase in the median distance covered). Fourth, physiological capacity (VO_2max in the laboratory) was not directly measured, nor was the level of biological maturity of each individual assessed. Finally, since this was a single group and there was no blinding, there is a risk of measurement bias.

Although it has these limitations, the study provides relevant evidence in a largely unexplored context: Ecuadorian youth soccer. The significant improvement achieved with a program lasting only 4 weeks suggests that the comprehensive method could be particularly effective in populations with low or moderate baseline levels, as appeared to be the case with the two players who were initially at or below average. Future research should: (a) replicate the design with a control group and random assignment; (b) increase the sample size and the duration of the program (≥ 8 weeks); (c) include measurements of VO_2max and ventilatory thresholds; (d) stratify by level of biological maturity; and (e) assess the retention of improvements following a period of detraining.

The results confirm that the comprehensive method produces significant improvements in the aerobic endurance of U-16 soccer players, with a large effect size, and support its use as a methodological strategy in youth soccer. However, it is recommended that the results be interpreted with caution given the small number of participants and the lack of a control group. The comprehensive approach not only contributes to physical

development but also incorporates technical and tactical aspects, making it an extremely valuable pedagogical tool for coaches.

Conclusions

The objective of this study was to determine the impact of the comprehensive method on the development of aerobic endurance in U-16 soccer players. The results confirm the hypothesis that a training program consisting of integrated exercises (ball work, small-sided games, technical-physical circuits, and high-intensity intervals) leads to significant improvements in the aerobic capacity of young players.

It concludes that the comprehensive method had a positive influence on aerobic endurance, with a statistically significant increase in the distance covered in the YoYo IR1 test (median: from 1,950 m to 2,100 m; $p = 0.028$; large effect size, $r = 0.78$). The proportion of soccer players at high levels (Excellent or Good) increased from 75% in the pretest to 87.5% in the posttest, with the Average category disappearing entirely (one player moved up to Good). These results confirm that a four-week intervention using the comprehensive method is sufficient to induce measurable improvements in the aerobic endurance of soccer players under 16, particularly those with average or low baseline levels.

These results are relevant from a practical standpoint, as coaches and strength and conditioning specialists in youth soccer can implement the comprehensive method as an effective strategy for developing aerobic capacity, without having to resort to exclusively conditioning-based training (continuous running without the ball). Small-sided games, technical-physical circuits, and interval training with the ball not only improve physical fitness but also promote motivation, adherence, and transfer to actual competitive performance.

However, the study's limitations—lack of a control group, small sample size, short duration, absence of direct physiological measurements, and lack of control for biological maturation—prevent the results from being extrapolated or definitive causal relationships from being established. Thus, new lines of research remain open: (a) studies with experimental designs that include a control group and random assignment; (b) larger samples and longer-duration programs (≥ 8 weeks); (c) laboratory measurement of VO_2max to validate changes observed in the YoYo test; (d) analysis of the effect of biological maturation as a covariate; (e) direct comparison between the comprehensive

method and traditional training (conditioning without a ball); (f) evaluation of the retention of improvements following periods of detraining or maintenance.

In conclusion, the comprehensive method is an effective methodological tool, valid

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