COMPARATIVE METHODOLOGY OF DEVELOPING AEROBIC AND ANAEROBIC ENDURANCE IN STUDENTS AGED 11–14

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Annotation.*This research analyzes the comparative methodology of developing aerobic and anaerobic endurance in students aged 11–14, a period marked by rapid physiological growth and heightened adaptive sensitivity of the cardiovascular and respiratory systems. Aerobic endurance training was examined through continuous running, paced load progression, and oxygen utilization efficiency, while anaerobic training focused on high-intensity interval work, lactate tolerance, neuromuscular activation, and recovery dynamics. Digital heart-rate monitoring, stride-mechanics analysis, and load-feedback platforms were used to assess adaptation accuracy. Findings showed that aerobic training significantly improved lung vital capacity, heart-rate economy, and long-duration effort stability, whereas anaerobic methodology accelerated recovery rate, increased lactate buffering, and enhanced maximal force output. The study concludes that integrating both methods in a balanced, age-appropriate structure offers the highest adaptive benefit, leading to sustainable endurance, efficient energy management, and reduced overload risk in early adolescence.*

Keywords:*aerobic endurance; anaerobic endurance; adolescent physiology; interval training; oxygen uptake; lactate tolerance; cardiovascular adaptation; endurance development; training load regulation; 11–14-year-old students*

Introduction.

The ages between 11 and 14 mark a critical transition phase in biological maturation, during which the cardiovascular, respiratory, and neuromuscular systems undergo accelerated structural and functional transformation. At this developmental threshold, the capacity to endure prolonged aerobic effort and to withstand high-intensity anaerobic load is shaped not by volume of training alone, but by precise regulation of physiological stress. Aerobic endurance in early adolescence relies on the gradual enhancement of oxygen transport efficiency, stroke volume expansion, mitochondrial activation, and respiration economy, whereas anaerobic endurance depends on lactate tolerance, neuromuscular firing speed, phosphagen system efficiency, and post-load metabolic restoration.

In traditional school-based physical education, endurance training often lacks differentiation, resulting in either excessive uniform load or inadequate adaptation. Modern comparative methodology, however, emphasizes load separation: continuous rhythmic movement for aerobic formation and interval-based, high-threshold activation for anaerobic capacity. When monitored through digital heart-rate tracking, recovery indexing, and biomechanical gait analysis, the adolescent body reveals distinct adaptation curves for each endurance type. Aerobic work yields stable pulse decline, deeper respiratory cycles, and prolonged effort tolerance, whereas anaerobic intervals sharpen metabolic resilience, accelerate tissue recovery, and strengthen rapid force output.

The scientific need for comparative examination lies in the adolescent organism’s sensitivity: its lungs are expanding, its myocardium is thickening, yet its regulatory centers remain unfinished. Miscalibrated training risks premature fatigue, cardiac overstrain, and ventilatory imbalance. Balanced dual-method endurance development, aligned with age-specific physiological thresholds, therefore acts not merely as training but as regulated biological guidance. Comparative methodology ensures that the young organism learns to

breathe deeply without collapse, to accelerate without physiological panic, and to recover without metabolic shock. In doing so, endurance becomes not an imposed weight, but a calibrated maturation process embedded in the body's evolving rhythm.

The research was conducted among 11–14-year-old students undergoing structured endurance formation with differentiated aerobic and anaerobic load cycles. A 10–12-week training protocol was applied, integrating continuous aerobic running sequences and high-intensity anaerobic interval sessions. Physiological adaptation was measured through real-time heart-rate telemetry, respiratory cycle frequency, post-load recovery rate, lactate tolerance indicators, and running biomechanics analysis (stride rhythm, contact time, cadence).

Aerobic workload was delivered through rhythmic continuous running, paced distance sessions, 6-minute endurance tracking, and gradual volume progression without exceeding 65–75% of maximum heart-rate threshold. Anaerobic load was administered in short-burst intervals at 85–95% heart-rate range, including shuttle runs, sprint ladders, hill accelerations, and phosphagen-cycle activation drills. Both training modes were digitally monitored, with weekly adaptation curves recorded individually rather than collectively.

Biomechanical gait observations were implemented via video-tracking, allowing step symmetry, muscle coordination, and effort economy to be interpreted not visually, but analytically. Each student's load was recalibrated weekly according to heart-rate recovery index, oxygen uptake pattern, and exertional fatigue profile to prevent premature overload. Psychological indicators of training sustainability—motivation persistence, fatigue reporting, and self-paced regulation—were included to avoid physiological stress dissociation.

No uniform loading was permitted: aerobic and anaerobic cycles alternated to avoid myocardium strain, respiratory imbalance, or

neuromuscular collapse. Digital dashboards identified when aerobic load improved stroke volume efficiency and when anaerobic load accelerated metabolic restoration, circadian recovery dynamics, and lactate clearance. The methodology allowed endurance to become a controlled physiological progression rather than a forced, unregulated exertion.

Conclusion

The comparative analysis of aerobic and anaerobic endurance development in students aged 11–14 shows that both training methods play essential roles in improving overall physical fitness, functional capacity, and health indicators at this age. Aerobic exercises contribute significantly to cardiovascular efficiency, respiratory stability, and long-term stamina, while anaerobic training enhances muscular power, speed, and short-term high-intensity performance.

The study demonstrates that a balanced combination of both methodologies yields the most effective results, ensuring comprehensive physiological development. Integrating structured interval training, age-appropriate workload progression, and regular monitoring of heart rate and recovery indicators increases training efficiency and reduces the risk of fatigue or injury.

In conclusion, the comparative methodology supports the idea that systematic, scientifically grounded endurance training not only strengthens students' physical preparedness but also promotes healthy lifestyle habits, motivation, and long-term interest in physical activity. The findings suggest that educators and coaches should apply differentiated training programs that consider age-specific physiological characteristics to maximize developmental outcomes.

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