REVIEW ARTICLE

V-Slope method for ventilatory threshold detection in pediatric cardiopulmonary exercise testing: physiological basis and clinical applications

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Submitted: 20 August 2026
Revised: 05 October 2026
Accepted: 09 October 2026
Online First: 12 October 2026

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Summary

The anaerobic threshold (AT), a widely discussed concept in exercise physiology, is an important parameter in pediatric cardiopulmonary exercise testing (CPET) that reflects a physiological transition toward increased non-oxidative energy metabolism during incremental exercise. The V-Slope method, based on the breakpoint in the relationship between carbon dioxide output (VCO_2) and oxygen uptake (VO_2), is a widely used non-invasive approach for identifying the first ventilatory threshold (VT1), which is commonly used as a gas-exchange correlate of the anaerobic metabolism and associated lactate/H^+ production that begin to increase substantially. In children and adolescents, interpreting VT1 requires particular consideration because cardiovascular, respiratory, metabolic, and neuromuscular responses change substantially during growth and biological maturation. This review summarizes current evidence regarding the physiological basis of the anaerobic threshold, methodological approaches to its determination, and the clinical utility of the V-Slope method in healthy children and in pediatric populations with congenital heart disease, chronic respiratory disorders, obesity, and other conditions associated with impaired exercise capacity. The article also discusses integrating V-Slope analysis with complementary gas-exchange and ventilatory criteria to improve the reliability of VT1 identification and interpretation in pediatric CPET.

Keywords: anaerobic threshold, first ventilatory threshold, V-Slope method, cardiopulmonary exercise testing, children

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Cite this article as: Djelic Blagojevic M, Suzic Lazic J, Maricic J, Zekovic M, Mazic S. V-Slope method for ventilatory threshold detection in pediatric cardiopulmonary exercise testing: physiological basis and clinical applications; Medicinska istraživanja 2026; DOI: 10.5937/medi0-70238

INTRODUCTION

Cardiopulmonary exercise testing (CPET) is a gold-standard, non-invasive method for evaluating the integrative responses of the cardiovascular, respiratory, and metabolic systems during incremental exercise in both healthy and clinical populations (1). In addition to resting parameters, CPET provides dynamic, breath-by-breath analysis of oxygen uptake (VO_2), carbon dioxide production (VCO_2), minute ventilation (VE), heart rate, and other physiological variables during exercise and throughout the recovery phase, allowing precise identification of functional capacity and mechanisms of exercise limitation (2, 3). As a result, CPET plays a pivotal role in both sports science and clinical practice. In athletic populations, it is important to determine endurance capacity through maximal oxygen uptake (VO_2max), ventilatory thresholds, and exercise intensity domains, which are essential for individualized training prescription and performance optimization (4-6). In clinical settings, over the last three decades, CPET has been widely used to evaluate unexplained exercise intolerance in patients with noncommunicable diseases, differentiate cardiac from pulmonary limitations, assess disease severity, and provide prognostic information, particularly in heart failure and chronic respiratory diseases (7-9).

A particularly important and increasingly recognized field in exercise testing and prescriptions is the use of CPET in the pediatric population because of the growing number of children and adolescents participating in organized sports, as well as the rising global prevalence of noncommunicable diseases such as obesity, type 2 diabetes, asthma, and congenital or acquired cardiovascular conditions (10). As athletic involvement begins at younger ages, this vulnerable population needs objective evaluation of functional capacity, performance potential, balance, and safe training prescription. (11, 12). But children are not simply "small adults," as developmental differences in cardiovascular function, ventilatory control, metabolic response, and rapid growth and maturation significantly influence exercise physiology and interpretation of test results (11).

One of the most debated parameters derived from CPET is the anaerobic threshold (AT), which reflects the transition from predominantly aerobic energy metabolism to increasing anaerobic contribution and can be identified noninvasively through gas-exchange measures (13, 14). The term "anaerobic threshold" has historically been used to describe this transition. However, several related concepts and terminology have been proposed, including the lactate threshold, ventilatory threshold, respiratory compensation threshold or point (RCT/RCP), and maximal lactate steady state (11, 14). These concepts are related but are not necessarily physiologically identical. In practical exercise testing, the threshold may be estimated from blood lactate measurements or from respiratory variables obtained during cardiopulmonary exercise testing, then specifically as the gas exchange threshold (GET) or ventilatory threshold (VT) (13). For this review, we will use VT1 to refer to the gas-exchange threshold identified by the V-Slope method. The V-Slope method, developed by Beaver, Wasserman, and Whipp, is a widely accepted approach for detecting VT1 by examining the relationship between carbon dioxide production (VCO_2) and oxygen uptake (VO_2) during incremental exercise and CPET (14). Despite its extensive use in adult populations, the physiological basis and clinical applications of the V-slope method in pediatric CPET remain poorly defined in the literature (11, 15). This review synthesizes the physiological explanations and importance, and clinical applications of the AT via the V-slope method in pediatric CPET, emphasizing its critical role in precision care for children with compromised exercise performance.

Physiological basis of the anaerobic threshold: specific considerations in children and adolescents

The historical understanding of anaerobic threshold represents a critical transition point between predominantly aerobic metabolism and progressively greater reliance on anaerobic pathways during physical activity (16). Nowadays, GET or VT may best represent the scientific intent of the AT concept, and it is considered a key indicator of endurance capacity and functional performance in healthy and athletic populations (13, 16).

Muscle contraction requires a continuous supply of adenosine triphosphate (ATP). During exercise, ATP is resynthesized through several interacting metabolic pathways, including the phosphagen system, glycolysis, and mitochondrial oxidative phosphorylation (17). At relatively low exercise intensities, oxidative phosphorylation provides most ATP because oxygen delivery to and utilization by skeletal muscle are sufficient to meet metabolic demand. As exercise intensity increases, the demand for ATP resynthesis progressively increases. When oxidative metabolism cannot supply ATP fast enough to meet total energy demand, anaerobic glycolysis contributes more to ATP production (17, 18). Glycolysis converts glucose or glycogen to pyruvate, which can subsequently enter the mitochondria and undergo oxidative metabolism. When pyruvate production and glycolytic flux exceed the mitochondria's immediate oxidative capacity, more pyruvate is converted to lactate (19). Lactate formation is not synonymous with a complete absence of oxygen, and lactate itself is not simply a metabolic waste product. Lactate can be continuously produced and metabolized during aerobic exercise. It can be transported through circulation and oxidized by skeletal muscle, cardiac muscle, and other tissues (16, 20). Therefore, the rise in blood lactate observed during incremental exercise reflects the balance between lactate production, distribution, oxidation, and

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clearance rather than simply the activation of an independent "anaerobic system" (13). The lactate threshold is generally defined as the exercise intensity at which blood lactate begins to increase systematically above baseline during an incremental test (16). At lower workloads, lactate production and clearance are sufficiently balanced to maintain relatively stable blood lactate concentrations. As exercise intensity increases, glycolytic flux rises and lactate production progressively exceeds the body's ability to remove or oxidize it, raising blood lactate concentration (13, 16). Although lactate itself is not the direct cause of acidosis, its production during exercise is associated with increased proton (H^+) release from ATP hydrolysis, contributing to a progressive decline in intracellular and extracellular pH (14). To buffer the accumulating hydrogen ions, the primary extracellular buffering system—the bicarbonate buffer—becomes increasingly active.

The additional CO_2 produced from this reaction is transported to the lungs and exhaled. This buffering-derived CO_2 represents a non-metabolic source of carbon dioxide and contributes to the observed increase in pulmonary carbon dioxide output (VCO_2) during exercise (21). As lactate accumulation continues, bicarbonate stores gradually decrease, and arterial CO_2 partial pressure ($PaCO_2$) begins to fall as ventilation increases. During high-intensity exercise, increased hydrogen ion (H^+) production associated with metabolic acidosis stimulates peripheral chemoreceptors in the carotid bodies. Activation of these chemoreceptors increases afferent signaling to the respiratory centers in the brainstem, thereby stimulating ventilation (VE) (23). This phase is characterized by the onset of respiratory compensation, during which ventilation increases disproportionately relative to CO_2 production (VCO_2), progressively reducing arterial $PaCO_2$ (21, 22). The accompanying hyperventilation attenuates the exercise-induced decline in blood pH and therefore partially compensates for the metabolic acidosis (22, 24).

In children, response to physical activity differs from that typically observed in adults. Prepubertal children generally demonstrate lower blood lactate concentrations during high-intensity exercise and a greater relative contribution of oxidative metabolism to ATP production (25). These differences have been attributed to developmental characteristics of skeletal-muscle metabolism, and several physiological mechanisms have been proposed, including lower activity of glycolytic enzymes such as phosphofructokinase and lactate dehydrogenase, differences in skeletal-muscle fiber characteristics, and a relatively high oxidative capacity of skeletal muscle (26). Prepubertal children have been reported to exhibit lower activity of phosphofructokinase-1 and lactate dehydrogenase and a relatively greater contribution from oxidative metabolism. Some studies suggest a relatively greater contribution of type I (slow-twitch) muscle fibers and, consequently, reduced ATP rephosphorylation through anaerobic glycolysis in prepubertal children. However, findings on developmental differences in muscle fiber composition are not entirely consistent (25, 26). Evidence from metabolic and magnetic-resonance studies indicates that prepubertal children rely relatively more on oxidative metabolism during exercise than adults. Using ^31P magnetic resonance spectroscopy, Tonson et al. demonstrated a greater oxidative contribution to ATP production in prepubertal boys than in men, along with faster phosphocreatine recovery during exercise recovery.

Interestingly, the same study did not demonstrate a maturational difference in anaerobic glycolysis activity, suggesting that the lower lactate response in children cannot be explained solely by a reduced glycolytic flux (27). In addition, children generally show a smaller decline in intramuscular pH during high-intensity exercise than adults, which, together with their greater oxidative capacity and faster proton and phosphocreatine recovery, may contribute to faster metabolic recovery following intense exercise (25, 28). Consequently, blood lactate concentrations in children should not be interpreted using adult-derived fixed thresholds without consideration of developmental status. In particular, a fixed blood lactate concentration of 4 $mmol \cdot L^{-1}$ is commonly used to define the onset of blood lactate accumulation (OBLA). However, this threshold may not correspond to the same relative exercise intensity in children and adults. Tolfrey and Armstrong demonstrated that the 4 $mmol \cdot L^{-1}$ criterion corresponded to a higher percentage of peak VO_2 in prepubertal and teenage boys than in adult men (29). These metabolic characteristics contribute to lower lactate accumulation during exercise in children.

Importantly, the lower lactate response in children should not be interpreted as evidence of an inability to utilize anaerobic metabolism. Rather, it reflects a different relative contribution of oxidative, phosphocreatine, and glycolytic pathways to ATP production during exercise (27). With biological maturation, muscle mass, strength, and the capacity to perform high-intensity exercise increase substantially, particularly during puberty. A key developmental change is the progressive increase in muscle mass and shifts in muscle fiber characteristics. Pubertal maturation is associated with increases in muscle cross-sectional area, strength, glycolytic enzyme activity, and anaerobic performance (27, 28). These changes contribute to the progressive increase in the ability to generate ATP through anaerobic glycolysis.

In contrast, prepubertal children tend to rely relatively more heavily on oxidative metabolism during exercise (29). They also recover oxygen consumption and blood lactate faster after intense exercise than adults. This may reflect their high oxidative capacity, enhanced muscle blood flow, and efficient metabolic recovery mechanisms. Consequently, the metabolic response to high-intensity exercise gradually becomes more similar to that of adults (30, 31).

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Methods for determining the ventilatory thresholds in children and adolescents

Several approaches can determine or estimate ventilatory thresholds in children and adolescents, including direct measurement of blood lactate, ventilatory and gas-exchange methods during cardiopulmonary exercise testing, and indirect approaches based on heart rate or exercise performance (32-42). Among these, the most commonly used non-invasive methods in the pediatric population are the V-slope method, based on the disproportionate increase in VCO_2 relative to VO_2, and the ventilatory-equivalent method, which identifies the threshold from an increase in VE/VO_2 without a simultaneous increase in VE/VCO_2. Changes in end-tidal O_2 ($PETO_2$) may provide an additional criterion for identifying the threshold (31).

The blood lactate method involves obtaining capillary or venous blood samples during an incremental exercise test (32). Researchers plot lactate concentration against exercise intensity and identify the threshold using a predefined criterion or mathematical approach. This method provides direct information about the blood lactate response. Still, it is invasive and can be affected by the sampling site, timing, exercise protocol, and the criterion used to define the threshold (32, 33). It also depends on the type of exercise test protocol (33). A key distinction in the scientific literature is between the threshold identified during an incremental test and the maximal lactate steady state (MLSS). During incremental exercise, a rise in blood lactate can identify a lactate threshold; however, this threshold does not necessarily represent the highest exercise intensity that can be sustained without progressive lactate accumulation. MLSS is generally defined as the highest constant exercise intensity at which blood lactate concentration remains relatively stable over a prolonged period (34). Determining it requires multiple constant-work-rate tests on separate occasions, making it time-consuming and less practical for routine clinical use, particularly in pediatric populations. In children, the relationship between conventional anaerobic-threshold measurements and MLSS may be particularly complex (35, 36). For example, a study of prepubertal boys found that the conventional anaerobic threshold and ventilatory anaerobic threshold did not closely correspond to maximal steady-state blood lactate (35).

The ventilatory method determines the ventilatory thresholds from respiratory gas-exchange responses during CPET. Variables such as minute ventilation, oxygen uptake (VO_2), carbon dioxide output (VCO_2), ventilatory equivalents for oxygen and carbon dioxide (VE/VO_2 and VE/VCO_2), and end-tidal gas concentrations can be evaluated to identify the ventilatory threshold (14, 37). This approach is particularly valuable in pediatric populations because it is non-invasive and can be performed simultaneously with standard CPET measurements (30). However, accurate threshold determination requires an appropriate exercise protocol and careful interpretation of the ventilatory responses. The protocol should be tailored to age, body size, fitness level, and expected exercise capacity, aiming for approximately 8–12 minutes of incremental exercise. Among treadmill protocols used in pediatric CPET, the ramped modified Bruce protocol described by Dubowy et al. and recommended by the German Society for Pediatric Cardiology provides a practical approach for determining ventilatory thresholds (31). In pediatric CPET, an experienced interpreter traditionally determines the V-Slope breakpoint by visually inspecting the VCO_2–VO_2 relationship. This assessment may be challenging in children and adolescents because of variable exercise performance, age-dependent developmental differences, and greater variability in ventilatory responses (11). Automated or semi-automated software algorithms may assist with breakpoint detection and improve reproducibility; nevertheless, interpret their results alongside other ventilatory and gas-exchange parameters, and do not replace expert interpretation. Importantly, a ventilatory threshold determined from respiratory gas exchange should not automatically be considered physiologically identical to a lactate threshold, as the two thresholds may be influenced by different methodological and physiological factors (15, 38).

Researchers have also investigated heart rate as a non-invasive method for estimating the anaerobic threshold. Earlier pediatric studies reported that changes in the linearity of the heart-rate response during incremental exercise could correspond with lactate-derived threshold measurements (39). However, heart rate is influenced by numerous factors, including temperature, hydration, emotional state, fatigue, medications, and autonomic regulation (40, 41). Therefore, interpret heart-rate-based threshold estimates cautiously, and do not use them to replace physiological measurements when precise threshold determination is required (42).

Determination of ventilatory threshold using the V-Slope method in children and adolescents

The V-slope method is a widely used non-invasive technique for objectively determining the VT1 during incremental cardiopulmonary exercise testing (31). Karlman Wasserman, a pioneer in exercise physiology, refers to nine key graphical plots derived from ergospirometry data (Figure 1). These plots visualize relationships between gas exchange variables—oxygen uptake (VO_2), carbon dioxide output (VCO_2), and minute ventilation (VE)—to identify the ventilatory threshold, assess ventilatory efficiency, and detect abnormalities (43). They are essential for interpreting exercise responses in both adults and children and can be used for determining the ventilatory threshold (14, 31).

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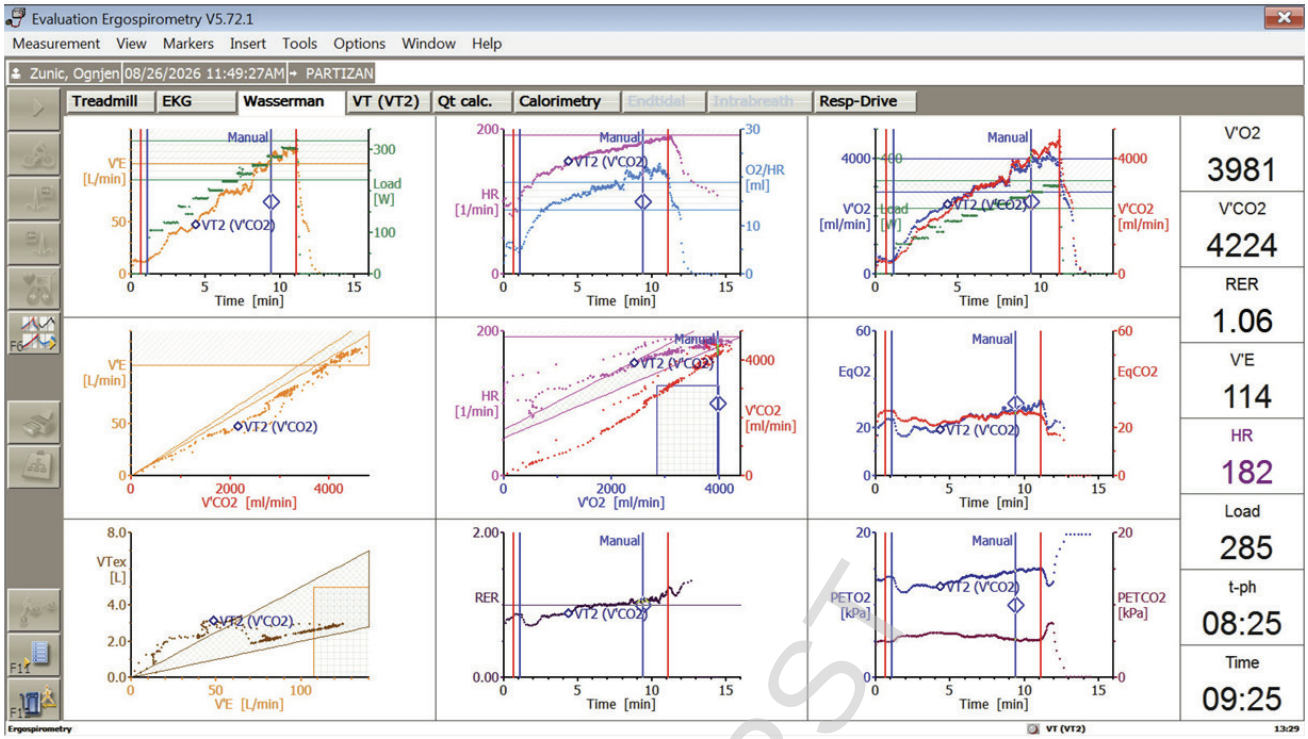


Figure 1. Wasserman nine-panel display of cardiopulmonary exercise testing (CPET)– original data from Laboratory for Sports Medicine and Exercise Therapy, Faculty of Medicine, University of Belgrade.

Abbreviations: VE, minute ventilation; VO_2, oxygen uptake; VCO_2, carbon dioxide output; $EqVO_2$, ventilatory equivalent for oxygen; $EqVCO_2$, ventilatory equivalent for carbon dioxide; $PETO_2$, end-tidal oxygen partial pressure; $PETCO_2$, end-tidal carbon dioxide partial pressure; RER, respiratory exchange ratio; HR, heart rate; O_2/HR, oxygen pulse.

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During incremental exercise, pulmonary ventilation (VE), oxygen consumption (VO_2), and carbon dioxide production (VCO_2) normally increase in a relatively coordinated manner. Below the anaerobic threshold, VO_2 and VCO_2 increase linearly and proportionally with rising workload, reflecting steady-state aerobic metabolism and stable acid–base balance. The respiratory exchange ratio (RER = VCO_2/VO_2) typically remains below 1.0 under these conditions. At higher exercise intensities, ventilation increases disproportionately (44). One mechanism behind this response is bicarbonate buffering of hydrogen ions. As hydrogen-ion concentration increases, bicarbonate buffering produces additional carbon dioxide. The increased carbon dioxide stimulates ventilation, resulting in a disproportionate increase in VE relative to VO_2. At the anaerobic threshold, the buffering of lactate-derived hydrogen ions generates excess CO_2, resulting in a disproportionate rise in VCO_2 relative to VO_2. The slope of the VCO_2 versus VO_2 plot becomes steeper, reflecting the additional CO_2 derived from bicarbonate buffering rather than oxidative metabolism alone. Consequently, the differential rise in VCO_2 compared with VO_2 serves as a quantifiable physiological marker of metabolic stress. It forms the theoretical foundation of the V-Slope method for first ventilatory threshold determination, as referred to in the literature as AT (14). The first ventilatory threshold, or anaerobic threshold, is commonly identified through changes in variables such as the ventilatory equivalents for oxygen and carbon dioxide. As exercise testing progressed, a second physiological transition occurs, known as the respiratory compensation point (RCP), also referred to as the second ventilatory threshold (VT2, marked as Manual on Figure 1). At this stage, minute ventilation increases disproportionately relative to carbon dioxide output, reflecting an augmented ventilatory response to the progressive metabolic acidosis associated with intense exercise. The increase in hydrogen-ion concentration stimulates peripheral chemoreceptors, particularly the carotid bodies, which increase ventilatory drive. The resulting hyperventilation progressively reduces arterial and end-tidal PCO_2 ($PaCO_2$ and $PETCO_2$) and contributes to respiratory compensation for metabolic acidosis through a respiratory alkalotic response (45). Thus, the sequence of physiological events during incremental exercise can be summarized as: 1. linear VO_2–VCO_2 relationship (aerobic metabolism predominates), 2. breakpoint in VCO_2 vs. VO_2 (anaerobic threshold; bicarbonate buffering begins), and 3. disproportionate increase in ventilation relative to VCO_2 (respiratory compensation phase) (40-45).

The anaerobic threshold or VT1 is often expressed as a percentage of maximal oxygen uptake (VO_2max or VO_2peak) or in relation to the corresponding workload and heart rate. However, interpret this percentage cautiously in children because maximal oxygen uptake changes with age, body size, sex, and maturation. Moreover, pediatric exercise testing often uses VO_2peak rather than VO_2max because a clear physiological plateau in

oxygen consumption is not always achieved during maximal exercise tests (11).

Practical clinical significance of ventilatory threshold and V-slop method in pediatric exercise physiology

Determination of the anaerobic or first ventilatory threshold can provide useful information about aerobic fitness and exercise tolerance. It can characterize physiological responses to exercise, monitor training adaptations, assist in exercise prescription, and evaluate functional capacity in selected pediatric patients (46). Despite its extensive use in adult populations, the literature has not fully consolidated the physiological basis and clinical applications of the V-Slope method in pediatric CPET (15, 31, 46). In pediatric exercise testing, determination of VT1 requires careful interpretation because breathing pattern, test protocol, developmental characteristics, and the criteria used to identify the breakpoint can influence the result (31). A major factor distinguishing children from adults is their relatively high oxygen consumption relative to body mass. Children generally demonstrate a high aerobic capacity relative to their body size. This is reflected in relatively high mass-specific VO_2 values and is associated with a high capacity for oxidative metabolism and a relatively high cardiac output relative to body mass. However, when interpreting VO_2 expressed per kilogram, consider the effects of body size and biological maturation (47). Two adolescents of the same chronological age may exhibit substantially different anaerobic-threshold responses because they are at different stages of biological maturation. This is particularly relevant in research studies involving adolescent athletes, where differences in maturity status can be misattributed to training status or physiological ability. Nevertheless, interpretation must account for exercise modality, protocol, biological maturation, sex, body size, training status, and the specific threshold definition used. Understanding these factors is essential for accurate interpretation and application of ventilatory thresholds in children and adolescents, particularly in fitness assessment and rehabilitation (11).

The clinical interpretation of the anaerobic or first ventilatory threshold in children and adolescents extends beyond assessing aerobic fitness alone **(Table 1)**. In healthy children and adolescents, VT1 is generally observed during submaximal exercise, often occurring at approximately 40–60% of peak VVO_2. However, its precise position varies with age, sex, body size, biological maturation, exercise modality, and the method used to identify the threshold (15). In pediatric patients, CPET provides an integrated assessment of cardiovascular, pulmonary, and metabolic responses to exercise and may help identify the physiological mechanisms underlying exercise intolerance (31). In children with surgically repaired congenital heart disease, a reduced exercise capacity and an earlier onset of the anaerobic threshold may reflect residual hemodynamic abnormalities and impaired cardiovascular reserve, supporting the use of CPET for functional assessment, risk stratification, and rehabilitation planning. Recent evidence indicates that children with congenital heart disease may also exhibit an increased VE/VCO_2 slope, reflecting impaired ventilatory efficiency and abnormal pulmonary blood-flow distribution during exercise (31, 48). In respiratory disorders, interpret VT1 alongside ventilatory efficiency and breathing-reserve parameters. In children with cystic fibrosis, for example, reduced anaerobic-threshold and peak-exercise responses may coexist with ventilatory limitation, dynamic hyperinflation, and impaired ventilatory efficiency; consequently, a low VT1 should not be interpreted as an isolated marker of metabolic limitation (49, 50). Similarly, children with juvenile idiopathic arthritis may demonstrate an earlier ventilatory anaerobic threshold, lower peak VO_2, and reduced oxygen uptake

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Table 1. Clinical Interpretation of Ventilatory Threshold and Related CPET Parameters in Pediatric Conditions

Condition	Key V-Slope Findings	Clinical Implications
Congenital heart disease (post-repair)	Reduced exercise capacity and, in some lesions, earlier VT1; increased $\dot{V}E/\dot{V}CO_2$ slope may indicate impaired ventilatory efficiency (48)	Risk stratification and rehabilitation planning
Exercise-induced bronchoconstriction	VT1 may be relatively preserved, while ventilatory limitation, breathing reserve and exercise-induced airflow obstruction help identify the pulmonary limitation (50)	Differentiation between ventilatory and metabolic limitation
Juvenile idiopathic arthritis	Earlier VT1, reduced $\dot{V}O_2$ peak and reduced OUES (51)	Guidance for individualized physical activity prescription
Cystic fibrosis	Reduced VT1/GET and $\dot{V}O_2$ peak in some patients, with ventilatory limitation and impaired ventilatory efficiency depending on disease severity (49)	Monitoring of disease progression and functional decline
Obesity and deconditioning	Reduced VO_2 at VT1 and/or reduced OUES; submaximal CPET parameters may be particularly useful when maximal effort is not achieved (52)	Evaluation of training responsiveness and fitness level

Note. VT = ventilatory threshold; VO_2peak = peak oxygen uptake; VE/VCO_2 slope = ventilatory efficiency slope; OUES = oxygen uptake efficiency slope; GET = gas exchange threshold.

efficiency, reflecting impaired overall cardiorespiratory fitness and reduced functional capacity (51). In children with obesity or physical deconditioning, VT1 and other submaximal CPET variables can provide clinically useful information when maximal exercise performance is difficult to achieve. Recent pediatric data indicate that children with obesity may have lower VVO_2 at the anaerobic threshold and a lower oxygen uptake efficiency slope, while exercise training can improve submaximal exercise responses (52). Taken together, these findings emphasize that VT1 should be interpreted as one component of an integrated CPET profile rather than as an isolated indicator of disease severity. The clinical meaning of the threshold depends on the underlying condition. It should be considered together with VO_2peak, VE/VCO_2 slope, oxygen uptake efficiency, breathing reserve, heart-rate response, exercise protocol, and the child's age, sex, body size, and developmental status. This integrated approach is particularly important in pediatric populations, in whom normal exercise responses change substantially with growth and maturation (53).

CONCLUSION

The anaerobic or first ventilatory threshold represents an important physiological marker of exercise response and aerobic function in children and adolescents. Determining it using the V-Slope and other gas-exchange methods provides a non-invasive approach to assessing exercise capacity and identifying physiological changes during incremental exercise. However, pediatric interpretation requires particular consideration of growth, biological maturation, body size, exercise modality, and the criteria used for threshold identification. Compared with adults, children generally rely more on oxidative metabolism, accumulate less blood lactate, and recover more efficiently after intense exercise; they also show distinct metabolic and ventilatory responses to exercise that may influence the expression and interpretation of the anaerobic threshold. Therefore, VT1 should be interpreted as part of an integrated CPET profile rather than as an isolated measure, with potential applications in pediatric fitness assessment, sports performance, exercise prescription, clinical evaluation of pediatric patients, and rehabilitation.

Acknowledgments: N/A

Funding Information: The authors declare that the study received no funding

Conflicts of interest: The authors have no conflicts of interest to report.

Author Contributions: The idea development and design of the review, critical intellectual input, the findings interpretation, and the final revisions of the manuscript, M.DJB.; the selection and organization of relevant literature and participation in manuscript editing, J.M. and M.Z.; the critical review of the revised manuscript and providing feedback on its final structure, J.SL. and S.M. All authors reviewed and approved the final version of the manuscript.

Ethical approval: N/A

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V-SLOPE METODA U ODREĐIVANJU VENTILATORNOG PRAGA TOKOM ERGOSPIROMETRIJSKOG TESTIRANJA KOD DECE: FIZIOLOŠKA OSNOVA I KLINIČKA PRIMENA

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Sažetak

Anaerobni prag (AT), kao široko razmatran koncept u fiziologiji napora i sportskim naukama, predstavlja važan parametar u ergospirometrijskom testiranju kod dece i adolescenata i odražava fiziološku tranziciju ka sve većem učešću anaerobnih energetskih procesa tokom progresivnog fizičkog opterećenja. *V-Slope* metoda, zasnovana na identifikaciji tačke promene u odnosu između oslobađanja ugljen-dioksida (VCO_2) i potrošnje kiseonika (VVO_2), predstavlja široko primenjivanu neinvazivnu metodu za određivanje prvog ventilatornog praga (VT1), koji se uobičajeno koristi kao pokazatelj gasne razmene povezan sa anaerobnim metabolizmom. Kod dece i adolescenata interpretacija VT1 zahteva posebnu pažnju, imajući u vidu da se kardiovaskularni, respiratorni, metabolički i neuromišićni odgovori značajno menjaju tokom rasta i biološkog sazrevanja. Ovaj pregled prikazuje aktuelna saznanja o fiziološkoj osnovi anaerobnog praga, metodološkim pristupima njegovom određivanju i kliničkoj primeni *V-Slope* metode kod zdrave dece, kao i kod pedijatrijskih pacijenata sa urođenim srčanim manama, hroničnim respiratornim oboljenjima, gojaznošću i drugim stanjima povezanima sa smanjenom sposobnošću podnošenja fizičkog opterećenja. Posebna pažnja je posvećena činjenici da *V-Slope* metod zajedno sa drugim parametrima gasne razmene može biti pouzdan parametar određivanja i interpretacije VT1 tokom kardiopulmonalnog testiranja opterećenjem u pedijatrijskoj populaciji.

Ključne reči: anaerobni prag, prvi ventilatorni prag, *V-Slope* metoda, ergospirometrija, deca

Primljen: 20. 08. 2026. I **Revidiran**: 05. 10. 2026. I **Prihvaćen:** 09. 10. 2026. I **Online First:** 12. 10. 2026.

Medicinska istraživanja 2026

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