Journal Physical Culture and Sports of Guantanamo
ISSN: 2519-9455
RNPS: 2286
Vol.14, No. 23 (2024)
Published online on: November 26. 2024
famadeportes.cug.co.cu

Affordable methods for estimating aerobic and anaerobic thresholds: a review of the scientific literature

Métodos asequibles para la estimación de los umbrales aeróbico y anaeróbico: una revisión de la literatura científica

Carmelo Arriaza-Gil [1], Dorges Heredia-Guilarte [2]

[1] *Ms.Sc. Contemporary University of the Americas. Michoacan, Mexico.*
[2] *Ph.D. CDFIS University. Michoacan, Mexico.*

Email:
carmelo.arriaza@gmail.com
drdorges@gmail.com

Reception date: *October 15, 2024*
Acceptance date: *November 10, 2024*

ABSTRACT

The present research focused on evaluating affordable methods to determine aerobic and anaerobic thresholds without the need for expensive equipment. Alternatives were addressed such as subjective perception of effort, the talk test, critical speed and the heart rate deflection point. After reviewing 13 studies, it was concluded that the talk test is the most consistent and accessible option, with high correlations and no significant differences with aerobic and anaerobic thresholds. Although other tests may be valid, the talk test stood out for its applicability at different levels of physical activity and its consistency in results

Keywords

Anaerobic threshold; Aerobic threshold; Lactic threshold; Aerobic-anaerobic transition; Estimate.

RESUMEN

La presente investigación se centró en evaluar métodos asequibles para determinar los umbrales aeróbico y anaeróbico sin la necesidad de equipos costosos. Se abordaron alternativas como la percepción subjetiva del esfuerzo, el talk test, la velocidad crítica y el punto de deflexión de la frecuencia cardíaca. Tras revisar 13 estudios, se concluyó que el talk test es la opción más consistente y accesible, con correlaciones altas y sin diferencias significativas con los umbrales aeróbico y anaeróbico. Aunque otras pruebas pueden ser válidas, el talk test destacó por su aplicabilidad en distintos niveles de actividad física y su consistencia en resultados.

Palabras clave

Umbral anaeróbico; Umbral aeróbico; Umbral láctico; Transición aeróbica-anaeróbica; Estimación.

INTRODUCTION

The measurement or estimation of aerobic and anaerobic thresholds is one of the essential tasks in the process of controlling sports performance. To this end, various methods and technologies have been developed that measure a series of variables and performance indicators such as maximum oxygen consumption (VO2 max.), heart rate (HR), blood lactate concentration, subjective perception of effort (RPE), power or critical speed, among others.

The control of aerobic and anaerobic thresholds aims to improve sports performance, since from their measurement, coaches dose physical loads in work intensities framed in "zones", each with specific metabolic demands and their corresponding physiological consequences. Wasserman and McIlroy (1964) were the first to use the concept of anaerobic threshold, defining it as the VO2 work rate above which metabolic acidosis occurs. Over the years, this concept has diversified and has given rise to a multiplicity of ambiguous terms. Currently, there is still disagreement among the scientific community regarding these aspects, possibly due to the lack of methodological standardization and the absence of consensus around the theory that underlies them.

This terminological diversity regarding thresholds can be divided into two groups: those that mark the transition from a moderate to a high intensity exercise and those that mark the boundary between high intensity and severe intensity exercise. In the first group, mainly identified by the beginning of the increase in lactate production, we find the terminology such as first ventilatory threshold, lactic threshold, aerobic threshold, OPLA (beginning of lactate accumulation in plasma) or point of optimal respiratory efficiency. In the second group, the terms that fit are: maximum stable state of lactate, second ventilatory threshold, anaerobic threshold, OBLA (beginning of lactate accumulation in blood) or aerobic-anaerobic threshold. (Poole et al., 2021)

After analyzing the articles that have been part of this systematic review, we agree with Fernández et al. (2018), in which the most commonly used term in the scientific literature for the threshold of the first group is “aerobic (lactate) threshold”, while for the second group the term “anaerobic (lactate) threshold” is used.

Despite the importance of the aerobic and anaerobic thresholds, their precise estimation presents significant challenges. Several methodologies have been developed over the last decades to assess the thresholds, but perhaps the most frequently used in scientific research are those based on lactate concentrations, through the obtaining and subsequent analysis of micro blood samples.

In the case of the anaerobic threshold, although there are determination methods based on fixed blood lactate concentrations (with 4 mmol/l being the most commonly used absolute value), this approximation does not seem to be the most accurate, since considerable changes are observed both between individuals and between exercise modalities, as evidenced in the research by Jones et al., (2019) and Vélez & García (2013).

Another aspect to consider regarding thresholds is that it has been observed that some athletes can sustain, during long-duration tests, running paces with lactate concentrations higher than the concentration reached at the aerobic lactate threshold, which gave rise to the "maximal lactate steady state (MLSS)", considered by authors such as Faude et al., (2009) and Llodio (2016) as the reference indicator or test. Therefore, MLSS can be defined as the highest exercise intensity that can be maintained for a prolonged period of time without the blood lactate concentration increasing progressively. (López & Fernández, 2023)

It is also important to consider that another of the most popular methods among researchers is the one based on the triphasic model of Skinner and McLellan (1980), to determine the intensities at which the aerobic-anaerobic transition takes place. This method consists of analyzing the behavior of pulmonary ventilation, oxygen consumption, and carbon dioxide production during incremental exercise and is known as the ventilatory threshold method.

Any of the methods described above, along with others such as surface electromyography, saliva analysis or blood ammonia, are expensive, invasive or require a laboratory to perform, thus making it difficult to practice among the population that could benefit from estimating aerobic and anaerobic thresholds.

The complexity of some of the tests, coupled with the availability of human resources, materials (expensive and highly specialized equipment) and time (tests such as MLSS) that require several days to carry out, mean that the assessment of the aerobic-anaerobic transition is not within the reach of any trainer or sports club. However, as mentioned above, its applications are decisive for the prescription of physical exercise and in the planning of sports training. For this reason, in recent years' scientific studies have been emerging that have tried to find alternative methodologies that allow thresholds to be estimated using less demanding protocols and more accessible to the majority of sports professionals.

All of the above leads us to consider the following **research problem**: what accessible methods exist in the scientific literature to estimate the aerobic and anaerobic thresholds and which of them are the most effective?

In order to answer the question of the research problem, the **general objective** of this work was to develop a systematic review of the scientific literature that allows the identification and comparison of the effectiveness of accessible methods for estimating the aerobic and anaerobic thresholds.

DEVELOPMENT

In order to identify potential scientific studies that could be part of this systematic review, a search was carried out in the Ebsco, Pubmed and Google Scholar databases during the month of December 2023. The key terms used for the search were "anaerobic threshold", "ventilatory threshold", "lactate threshold", "maximal metabolic steady state", "test", "determination" and "estimate". Different combinations of the above terms were used by exploring the title, abstract and keyword search fields. In addition, manual searches were carried out in the reference lists of the articles and other sources that could have useful information for this review. The criteria used to select the articles used in this review were based on the following aspects: they must be original research with a longitudinal or cross-sectional design, have the full text available for download, be published in English or Spanish, have elapsed ten years or less since their publication date, include healthy human participants, include comparisons with some reference test to determine the aerobic-anaerobic transition (lactate measurements or respiratory equivalents), propose or analyze some affordable test to estimate the thresholds and include correlation coefficients.

Studies with participants over 40 years of age, studies that included animals as a study sample, or studies in which the participating subjects presented some pathology were discarded. Research in which the threshold estimation tests required some type of expensive or difficult-to-access material or equipment was also eliminated.

A total of 776 potential studies were identified for the purposes of this review. After the filtering process, 59 articles were selected for full-text reading, of which 13 were finally included, from which the characteristics of the participants, the study design and procedures, the description of the intervention, and the results of the correlations were extracted.

Table 1

Studies included in the systematic review of the scientific literature.

Referencia	**Muestra**	**Protocolo**	**Contraste**	**Resultados**
Alajmi et al. (2020)	20 healthy adults (12 women y 8 men) inactives. Middle age: 28.3	- Test increase on walker begining 4.8 km/h with 0% of inclination, increasing the inclination at 2.5%/2'	Talk test and RPE with VTs	Correlation between LP and VT (r=0.76) and between e EQ and the VT (r=0.77). Correlation between RPE 13

	± 9.37 (women) y 25.2 ± 7.9 (men)	- Talk test of 101 wordswith the same before protocol - Registers of RPE - Test of Rockport		and VT (r=0.74) and between RPE 14 and VT (r=0.71). without significatives differences between LP, EQ, RPE 13, RPE 14 and VT.
Balikian et al. (2022)	8 athletes middle age: 23 ± 3 years	- test of 400, 500 and 800m. VC its calculated with the straight of return obtained by the results. - anaerobic threshold (3.5 mmol/l) - Test of middle speed in a constanteffort of 30'.	VC, V30, and Uan (3.5 mmol/l)	Correlation between the Uan and the VC (r=0.84, p=0.008) and between the Uan and the V30 (r=0.94, p=0.001). without significant differencies between the Uan nd the VC and between the Uan and the V30. Exist significant differences betweent the VC y la V30
Browne et al. (2015)	25 middle and long distance runners (18 men and 7 women) Middle age: 14.7 ± 1.2 years	- 3000m and 1600m tests at maximum speed. The VC is calculated using the slope of the regression line. - VLM test: 500m at maximum speed followed by 6 x 800m between 83 and 98% of the speed of the 3000m test.	VC with VLM	VC its correlate with the VLM (r=0.63, p 0.004). Don't exist significat diferencies between both variables (p=0.305)
Fabre et al. (2013)	13 physically active men and 8 women. Mean age: 20.9 ± 5.9 years	- Cycle ergometer test starting at 70W and increasing by 30W/3'. Respiratory exchange, lactate concentrations and RPE were measured. For the ULa, the Dmax method was used.	RPE with ULa, VT, RCP	RPE is significantly related to La (r=0.97), VT (r=0.95) and RCP (r=0.95). No significant differences between RPE and ULa. Significant differences between VT and RPE, and between RCP and RPE.
Gillespie et al. (2015)	12 highly trained male cyclists Average age: 26.5 ± 4.6 years	- Cycle ergometer test with 60 W starting and increments of 30 W/min. Measurements of ventilatory thresholds.	Talk test con VT	RPE y FC alcanzadas en el VT se correlacionan con RPE y FC en NEG del Talk test (r=0.89, r=0.93,

		- Talk test with the same protocol as above. - RPE and HR recordings.		respectivamente)
Giovanelli et al. (2020)	15 trained runners Average age: 37.9 ± 10.9 years	- Incremental test starting at 70% of personal best speed over 10,000 m, with increments of 0.5 km/h/1'. - Rabit test based on RPE. - HR and respiratory exchange measurements were performed	Test Rabit con Uaer y Uan	Correlation between the Rabit test and the incremental test in Uaer and Uan (r2=0.83 and 0.90, respectively). However, there are significant differences between the speeds of the Uaer (p<0.001) and the Uan (p=0.008)
Kjertakov et al. (2016)	12 highly trained runners (11 men and 1 woman). Average age: 24.1 ± 3.9 years	-Treadmill test. Start at 9 km/h and increments of 0.5 km/h/1'. HR records to determine HRDP. (3 subjects did not present HRDP) - Treadmill test. Start at 9 km/h and increments of 1 km/h/4'. Lactate records to determine ULa	HRDP con ULa	Significant correlation between HR at ULa and HRDP (r=0.84, p=0.005). Non-significant correlation between ULa velocity and HRDP velocity (r=0.63, p=0.07). No significant differences between variables.
Lopes Motoyama et al. (2014)	14 non-athlete males Mean age: 23 ± 3.1 years	- 500 and 3000m tests. VC is calculated using the slope of the regression line. - 2-5 30' tests at a speed 5% below the glucose threshold. Each test increases the speed by 5% up to the MLSS.	VC and speed in 3000 m test with MLSS	Correlation between VC and MLSS (r=0.9). However, there are significant differences (p<0.05) between VC and MLSS. Correlation between V3000 and MLSS (r=0.91, p<0.01). No significant differences between V3000 and MLSS.
Madrid et al. (2016)	11 physically active men Mean age: 24.6 ± 4.7 years	- Three 3-minute cycle ergometry tests. Intensity at RPE 13 compared to ULa and MLSS - Minimum lactate intensity	RPE with minimal lactate intensity and with	Correlation between RPE 13 and minimum lactate intensity (r=0.61, p<0.05). Correlation between RPE 13 and MLSS (r=0.78, p<0.01).

		test: after pedaling to exhaustion and 8 minutes of rest, load at 75W and increase by 25W/3'. - MLSS protocol starting with the minimum lactate intensity load.	MLSS	No significant differences between variables ($p>0.05$)
Pereira Guimaraes et al. (2018)	17 moderately trained runners Average age: 34.36 ± 10.68 years	- 6 x 1000 m with 2' recovery. Start at 75% of the best time in season and the following ones with 5% increments each. Lactate concentrations were analyzed - 1500, 3000 and 5000 m tests at maximum speed. VC between the 1500 and 5000 tests (VCa), and between the 3000 and 5000 (VCb).	2 VC values with UAnI and ULa	Correlation between Dmax and VCa ($r=0.60$, $p<0.01$) and between Dmax and VCb ($r=0.67$, $p<0.01$). Correlation between UAnI and VCa ($r=0.49$, $p<0.05$) and between UAnI and VCb ($r=0.51$, $p<0.05$). There are significant differences ($p=0.035$) between Dmax and VCa. The other pairings do not show significant differences.
Rodríguez Marroyo et al. (2013)	18 elite male cyclists Average age: 20 ± 2 years	- Cycle ergometer test. Start at 75W. Increments of 50W/2'. Respiratory exchange and RPE measurements (10-point Borg scale) - 38-word talk test	Talk test with VTs	Carga en EQ se correlaciona con VT1 ($r=0.86$, $p<0.001$) Carga en NEG se correlaciona con VT2 ($r=0.94$, $p<0.01$)
Schroeder et al. (2017)	6 active men and 12 active women Average age: 29.3 ± 17.97 years (men) and: 22.1 ± 1.56 years (women)	- Test en cicloergómetro. Inicio a 25W. Incrementos de 25W/2'. Mediciones de intercambio respiratorio. - Tres Talk Test (31, 62 y 93 palabras) realizados en días diferentes.	Talk test (31, 62 y 93 word with VT1 y VT2	There are no significant differences ($p>0.05$) between the EQ of the 93-word TT and the VT1. There are no significant differences ($p>0.05$) between the NEG of the 93-word TT and the RCP.

Vučetić et al. (2014)	48 national-ranked runners (Croatia) Average age: 21.7 ± 5.1 years	- Test en caminadora. Inicio: 3km/h. Incrementos: 1km/h/1'. - Test rápido inicio a 3 km/h. Incrementos de 1 km/h/30". -Mediciones de intercambio respiratorio y FC.	HRDP y VT2	The HR in the VT correlates with the HRDP in both the standard test (r=0.83, p<0.01) and the rapid test (r=0.88, p<0.01). There are no significant differences between them.

Legend: Dmax: method to obtain the ULa consisting of finding the most distant point between the curvilinear regression of the lactate concentrations and the straight line formed by the first and last samples, EQ: (equivocal) first record in the Talk Test in which the answer to the question can you talk comfortably? is I am not sure, HR: heart rate, HRDP: (heart rate deflection point) HR deflection point, LT: (lactate threshold) lactate threshold, LP: (last positive) last record in the Talk Test in which the answer to the question can you talk comfortably? is positive, MLSS (maximal lactate steady state) maximum lactate steady state, NEG: (negative) first record in the Talk Test in which the answer to the question can you talk comfortably? is no, RCP: (respiratory copensation point) respiratory compensation point, RPE: subjective perception of effort, Uaer: aerobic threshold, Uan: anaerobic threshold, UanI: individual anaerobic threshold, ULa: lactic threshold, V30: average speed in 30-minute test, VC: critical speed, VLM: minimum lactate speed, VT: (ventilatory threshold) ventilatory threshold

In order to facilitate the understanding of the collected data and the subsequent drawing of potential conclusions, we present the main results organized by subgroups.

Subjective perception of exertion subgroup

Subjective perception of exertion (RPE) is a well-known method to determine, guide and monitor exercise intensity. It allows athletes to express how they feel in terms of effort at a given moment (Alajmi et al., 2020). Its assessment consists of numerical scales accompanied by expressions ranging from extremely light to extremely hard effort, passing through intermediate ranges. The most commonly used scales in the scientific literature are the Borg CR10 scale (0-10 points) and the original Borg scale (6-20 points). Both scales have been correlated with objective measures of exercise intensity, such as heart rate and oxygen consumption.

When exercise intensity was associated with an effort value of 13 on the Borg scale of 6-20, Madrid et al. (2016) reported high correlations with the minimum lactate intensity (r = 0.61) and very high correlations with the MLSS (r = 0.78). Alajmi et al. (2020) also observed a very strong correlation (r = 0.74) with the first ventilatory threshold.

Although it was not part of the articles filtered for this systematic review, we would like to highlight the research carried out by Scherr et al. (2012) with more than 2500 subjects in which it was concluded that the RPE values corresponding to the lactate threshold were, on average, 10.8 ± 1.8 on the Borg scale of 6-20. Using an alternative proposal, using the Dmax methodology on a 100-point Borg scale, Fabre et al. (2013) showed that RPE can be a valid alternative to estimate the lactate threshold. However, this methodology differed significantly when compared with the two ventilatory thresholds.

Talk test subgroup

The Talk test is an incremental exercise test whose premise is that, in exercise at an intensity equal to or greater than the ventilatory threshold or lactic threshold, holding a conversation becomes uncomfortable. To carry it out, subjects must recite a text out loud (normally a known passage or one with which they have previously become familiar) during the last 30 seconds of each stage. At the end of the reading, the subject is asked if he or she has been able to speak comfortably with three possible answers: yes, I am not sure or no, at which point the test would be considered finished.

Of all the exercise intensities at which the subject evaluated answers affirmatively to the question, the one that acquires the greatest relevance is the highest, identified as last positive (last positive) or LP. The lowest intensity at which the subject answers I am not sure is identified as an equivocal response (equivocal) or EQ. Finally, the intensity at which the subject answers negatively is known as negative (negative) or NEG. (Schroeder et al., 2017)

With uniform data, the correlations provided by the investigations that examined the Talk Test range from very high to almost perfect ($0.76 \leq r \leq 0.93$). The comparisons made were not statistically different between the EQ response of the Talk Test and the first ventilatory threshold (Alajmi et al., 2020; Rodríguez-Marroyo et al., 2013; Schroeder et al., 2017) and between the NEG response and the second ventilatory threshold (Gillespie et al., 2015; Rodríguez-Marroyo et al., 2013; Schroeder et al., 2017). These data coincide with the conclusions provided by Reed & Pipe (2014) in a review carried out on this test, in which the loads in EQ and NEG are also correlated with those of the first and second thresholds, respectively.

The Talk Test is based on the complexity of maintaining a conversation when there is an increase in the ratio between ventilation and oxygen consumption, the preferred contrast method is that of ventilatory thresholds. This trend is evident in the four investigations included in this systematic review that deal with the Talk Test since none of them uses methods based on lactate concentrations to compare the measurements performed.

When investigating the Talk Test, based on the search criteria established in this work, no publication from the last 10 years has been found that establishes a relationship between the thresholds determined by lactate measurements with the Talk Test. However, in 2011, Quinn & Coons undertook this task and carried out this comparison, revealing that there were no significant differences between both parameters. A peculiarity of this test is that the passages used for its reading do not always have the same number of words.

On the other hand, Schroeder et al. (2017) compared three different text extensions (31, 62 and 93 words), and concluded that the longer text allows for greater precision in the estimation of ventilatory thresholds. In the same sense, Foster et al. (2018) advocate using longer passages (approximately 100 words) to be more accurate in the estimation.

Subgrupo de velocidad crítica

Derived from the concept of critical power, critical speed is defined, according to Browne et al. (2015), as the highest intensity of exercise that could be maintained for a long period of time without exhaustion. This concept corresponds to the limit intensity that can be tolerated in which there is a stable state in oxygen consumption and lactate concentrations (Pereira-Guimaraes et al., 2018). Exceeding this speed would imply a significant reduction in the time to exhaustion.

Although there are other methods to find critical speed, such as the asymptote of the speed/time to exhaustion relationship proposed by Llodio (2016), the publications addressed in this review opt for an approach in which participants must cover several predefined distances in the shortest possible time, with sufficient recovery time between them. Depending on the protocol selected, a minimum of two tests will be performed, and the results obtained will be used to draw a linear regression line that correlates distance with time. The slope resulting from this regression provides the critical speed, according to Pereira-Guimaraes et al. (2017).

The range of distances used in the articles included in the review carried out ranges from 400 to 5000 meters. To calculate the critical speeds, three articles use two different distances (Browne et al., 2015; Lopes et al., 2014; Pereira-Guimaraes et al., 2018) and one used a third race between its tests (Balikian et al., 2022). Although in the methodology used by Pereira-Guimaraes et al. (2018) the participating subjects cover three distances, since two different values of critical speeds are obtained in this research, they only use two results for each of them.

The critical speed has been used to search for comparisons with the first threshold, revealing correlations ranging from moderate to high ($r = 0.49 – 0.67$); Likewise, high to very high correlations ($r = 0.63 – 0.84$) have been observed when compared with the second threshold. In contrast, two cases have reported significant differences between the data obtained by this test and the aerobic-anaerobic transition (Lopes et al., 2014; Pereira-Guimaraes et al., 2018). A possible explanation for these small discrepancies is that when the distances used in critical speed tests are shorter, there is a more pronounced tendency to overestimate the anaerobic threshold (Llodio, 2016; Pereira-Guimaraes et al., 2017).

Heart Rate Deflection Point Subgroup

In 1982, Conconi et al. developed a test in which experimental subjects were required to complete a track race with speed increments of 0.5 km/h every 200 meters. The authors found a linear increase in heart rate at submaximal speeds and a plateau at near-maximal intensities. In other words, during an incremental test, heart rate increases as activity intensifies.

However, during an incremental test, there comes a point at which, upon reaching a certain intensity, heart rate stops increasing at the same rate and begins to increase at a more moderate rate. Conconi et al. (1982) suggested that this point of behavioral change in heart rate linearity coincided with the intensity of the anaerobic threshold.

The heart rate deflection point, or HRDP, has been identified as the intensity where the linear slope values begin to decrease and there is an evident loss of linearity in the heart rate behavior. Najera-Longoria et al. (2017) suggest that although visual inspection may be a good method to determine this breaking point, mathematical procedures can offer greater precision.

Another issue to consider, according to Llodio (2016), is that the moment at which the heart rate depletion point appears depends on the protocol used. The reviewed articles support this idea, since one publication relates the HRDP with the aerobic threshold (Kjertakov et al., 2016) and another does the same with the anaerobic threshold (Vučetić et al., 2014). The comparisons made between the second ventilatory threshold and the HRDP did not show significant differences, presenting very high correlations in two protocols with different degrees of demand (r = 0.83 and 0.88). In the case of the first threshold, the results are ambiguous: when the HRDP HR is compared with the lactic threshold HR, a very high significant correlation is found (r = 0.84). However, when the variable compared was the speed at which these points were reached, the correlation is reduced (r = 0.63) and is no longer significant. One point to note about this methodology is that HRDP is not present in all subjects and seems to depend on the protocol used.

Although Vučetić et al. (2014) do not seem to have this problem in their 48 subjects studied, Kjertakov et al. (2016) mention that three of the twelve subjects did not present HRDP. There are several bibliographic sources that have reported for some years now the non-appearance of HRDP in all subjects (Bodner & Rhodes, 2000; Sentija et al., 2007; Van Schuylenbergh et al., 2004).

RABIT Test Subgroup

The Running Advisor Running Training (RABIT) is a running test developed by the Billat Training Institute in Paris, based on the concepts of aerobic threshold and anaerobic threshold. It consists of four running phases at paces based on the participants' subjective perception of effort.

The first phase involves ten minutes of warm-up at a free speed, the second consists of five minutes at a medium pace (RPE = 13), the third is three minutes at an intense pace (RPE = 15) and the last phase comprises ten minutes at an easy pace (RPE = 11). Between each phase, participants have one minute of passive recovery. The fourth segment (easy pace) is compared to the aerobic threshold and the second segment (medium pace) to the anaerobic threshold, as described by Giovanelli et al. (2020).

The results found by Giovanelli et al. (2020) through their proposal with 15 trained subjects, state that the Rabit test is not a valid alternative to estimate the thresholds. Although they present almost perfect correlations with both thresholds, the significant differences reported in the group comparisons suggest that they are different variables.

CONCLUSIONS

The determination of the aerobic-anaerobic transition plays a key role in sports performance, but many of the existing tests for its assessment are inaccessible to a large part of the athlete population. Fortunately, over the years, easily accessible alternatives have emerged. In this review, we investigated the scientific literature for the different options available and found alternatives such as subjective perception of effort, the Talk test, critical speed or the heart rate deflection point, which have proven to be valid alternatives for estimating thresholds, although they are not free of weaknesses.

The HRDP does not seem to be applicable to all subjects or protocols used. Therefore, the Talk test and the RPE have proven to be practical, valid and accessible tools for estimating aerobic and anaerobic thresholds. However, when analyzing the data, we conclude that the Talk Test presents more consistent results compared to the other alternatives, showing no significant differences in any of the comparisons made with the thresholds and, in addition, having been applied to non-active, trained and highly trained subjects.

BIBLIOGRAPHIC REFERENCES

Alajmi, R. A., Foster, C., Porcari, J. P., Radtke, K., & Doberstein, S. (2020). Comparison of non-maximal tests for estimating exercise capacity. *Kinesiology, 52*(1), 10–18. https://doi.org/10.26582/k.52.1.2

Balikian, P., Marinho, A. H., Gomes De Araujo, G., Prado, E. S., Mendes, E. V., & Ryan Geraldes, A. A. (2022). Anaerobic Threshold in Stand-up Paddle: Comparison Between Direct and Alternative Methods. *Journal of Strength and Conditioning Research, 36*(7), 1896-1900. https://doi.org/10.1519/JSC.0000000000003718

Bodner, M. E., & Rhodes, E. C. (2000). A review of the concept of the heart rate deflection point. *Sports Medicine, 30*(1), 31-46. https://doi.org/10.2165/00007256-200030010-00004

Browne, R. A. V., Sales, M. M., Da Costa Sotero, R., Asano, R. Y., De Moraes, J. F. V. N., De França Barros, J., Campbell, C. S. G., & Simões, H. G. (2015). Critical velocity estimates lactate minimum velocity in youth runners. *Motriz: Revista de Educação Física, 21*(1), 1-7. https://doi.org/10.1590/S1980-65742015000100001

Conconi, F., Ferrari, M., Ziglio, P. G., Droghetti, P., & Codeca, L. (1982). Determination of the anaerobic threshold by a noninvasive field test in runners. *Journal of Applied Physiology Respiratory Environmental and Exercise Physiology, 52*(4), 869-873. https://doi.org/10.1152/jappl.1982.52.4.869

Fabre, N., Mourot, L., Zerbini, L., Pellegrini, B., Bortolan, L., & Schena, F. (2013). A Novel Approach for Lactate Threshold Assessment Based on RPE. *International Journal of Sports Physiology and Performance, 8*(3), 263–270. https://doi.org/https://doi.org/10.1123/ijspp.8.3.263

Faude, O., Kindermann, W., & Meyer, T. (2009). Lactate threshold concepts: How valid are they? *Sports Medicine, 39*(6), 469–490. https://doi.org/10.2165/00007256-200939060-00003

Fernández Rodríguez, E., Romero Ramos, O., Merino Marbán, R., & Cañas del Palacio, A. (2018). Umbral Anaeróbico. Problemas conceptuales y aplicaciones prácticas en deportes de resistencia (Anaerobic Threshold. Conceptual problems and practical applications in endurance sports). *Retos, 36*, 521–528. https://doi.org/10.47197/retos.v36i36.61883

Foster, C., Porcari, J. P., Ault, S., Doro, K., Dubiel, J., Engen, M., Kolman, D., & Xiong, S. (2018). Exercise prescription when there is no exercise test: The talk test. *Kinesiología, 50* (1), 33–48. https://hrcak.srce.hr/ojs/index.php/kinesiology/article/view/6349

Galán-Rioja, M. Á., González-Mohíno, F., Poole, D. C., & González-Ravé, J. M. (2020). Relative Proximity of Critical Power and Metabolic/Ventilatory Thresholds: Systematic Review and Meta-Analysis. *Sports Medicine, 50*(10), 1771-1783. https://doi.org/10.1007/s40279-020-01314-8

Gillespie, B. D., McCormick, J. J., Mermier, C. M., & Gibson, A. L. (2015). Talk test as a practical method to estimate exercise intensity in highly trained competitive male cyclists. *Journal of Strength and Conditioning Research, 29*(4), 894-898. https://doi.org/10.1519/JSC.0000000000000711

Giovanelli, N., Scaini, S., Billat, V., & Lazzer, S. (2020). A new field test to estimate the aerobic and anaerobic thresholds and maximum parameters. *European Journal of Sport Science, 20*(4), 437-443. https://doi.org/10.1080/17461391.2019.1640289

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise, 41*(1), 3-12. https://doi.org/10.1249/MSS.0b013e31818cb278

Jones, A. M., Burnley, M., Black, M. I., Poole, D. C., & Vanhatalo, A. (2019). The maximal metabolic steady state: redefining the 'gold standard'. *Physiological Reports, 7*(10). https://doi.org/10.14814/phy2.14098

Kjertakov, M., Dalip, M., Hristovski, R., & Epstein, Y. (2016). Prediction of lactate threshold using the modified Conconi test in distance runners. *Physiology international, 103*(2), 262–270. https://doi.org/10.1556/036.103.2016.2.12

Llodio Uribeetxebarria, I. (2016). Determinación de condición física de deportistas: diferencias entre futbolistas y determinación indirecta de la velocidad de máximo estado estable de lactato [Tesis de Doctorado. Universidad del País Vasco]. https://ekoizpen-zientifikoa.ehu.eus/documentos/5ecb7f6a2999521315202b6c

Lopes Motoyama, Y. Y., Pereira, P. E. de A. P., Esteves, G. de J., Duarte, J. M. P., Carrara, V. C. P., Mello, G., Azevedo, & Azevedo, P. H. S. M. de. (2014). Alternative methods for estimating maximum lactate steady state velocity in physically active young adults. *Revista Brasileira de Cineantropometria e Desempenho Humano, 16*(4), 419–426. https://doi.org/ttps://doi.org/10.1590/1980-0037.2014v16n4p419

López Chicharro, J., & Fernández Vaquero, A. (2023). *Fisiología del ejercicio (4a ed.).* Médica Panamericana.

López Chicharro, J., & Vicente Campos, D. (2017). *Umbral láctico.* Médica Panamericana.

Madrid, B., Pires, F. O., Prestes, J., Vieira, D. C. L., Clark, T., Tiozzo, E., Lewis, J. E., Campbell, C. S. G., & Simoes, H. G. (2016). Estimation of the maximal lactate steady state intensity by the rating of perceived exertion. *Perceptual and Motor Skills, 122*(1), 136–149. https://doi.org/10.1177/0031512516631070

Moxnes, J. F., & Sandbakk, Ø. (2012). The kinetics of lactate production and removal during whole-body exercise. *Theoretical Biology and Medical Modelling, 9*(1), 7. https://doi.org/10.1186/1742-4682-9-7

Najera-Longoria, R., Ortiz, G., Lopez, A., Kandia-Lujan, R., Njunjez, E., Gutierez, M., & Rajkovic, Z. (2017). Non spirographic or noninvasive methods to estimate anaerobic treshold. *Fizicka kultura, 71*(1), 55-62. https://doi.org/10.5937/fizkul1701055n

Pereira-Guimaraes, M., Campos, Y., Almeida, P., Domínguez, R., Pussieldi, G., & Silva, S. (2018). Relationship between direct and indirect methods for determination of anaerobic running speed. 7, 7–15. https://doi.org/10.30472 /ijaep.v7i4.300

Pereira-Guimaraes, M., Hernández-Mosqueira, C. M., Fernandes-Filho, J., & Fernandes-da-Silva, S. (2017). Métodos de determinación de la velocidad crítica en corredores. *CienciaUAT, 11*(2), 46-53. https://doi.org/10.29059/cienciauat.v11i2.821

Poole, D. C., Rossiter, H. B., Brooks, G. A., & Gladden, L. B. (2021). The anaerobic threshold: 50+ years of controversy. *The Journal of Physiology, 599*(3), 737–767. https://doi.org/10.1113/JP279963

Quinn, T. J., & Coons, B. A. (2011). The talk test and its relationship with the ventilatory and lactate thresholds. *Journal of Sports Sciences, 29*(11), 1175-1182. https://doi.org/10.1080/02640414.2011.585165

Reed, J. L., & Pipe, A. L. (2014). The talk test: A useful tool for prescribing and monitoring exercise intensity. *Current Opinion in Cardiology, 29(5), 475-480*. https://doi.org/10.1097/HCO.0000000000000097

Rodríguez-Marroyo, J. A., Villa, J. G., García-López, J., & Foster, C. (2013). Relationship between the talk test and ventilatory thresholds in well-trained cyclists. *Journal of Strength and Conditioning Research, 27*(7), 1942–1949. https://doi.org/10.1519/JSC.0b013e3182736af3

Scherr, J., Wolfarth, B., Christle, J. W., Pressler, A., Wagenpfeil, S., & Halle, M. (2012). Associations between Borg's rating of perceived exertion and physiological measures of exercise intensity. *European Journal of Applied Physiology, 113*(1), 147-155. https://doi.org/10.1007/s00421-012-2421-x

Schroeder, M. M., Foster, C., Porcari, J. P., & Mikat, R. P. (2017). Effects of speech passage length on accuracy of predicting metabolic thresholds using the talk test. *Kinesiology, 49*(1), 9-14. https://doi.org/10.26582/k.49.1.14

Sentija, D., Vucetic, V., & Markovic, G. (2007). Validity of the modified conconi running test. *International Journal of Sports Medicine, 28*(12), 1006-1011. https://doi.org/10.1055/s-2007-965071

Skinner, J. S., & McLellan, T. H. (1980). The Transition from Aerobic to Anaerobic Metabolism. *Research Quarterly for Exercise and Sport, 51*(1), 234-248. https://doi.org/10.1080/02701367.1980.10609285

Van Schuylenbergh, R., Vanden Eynde, B., & Hespel, P. (2004). Correlations between lactate and ventilatory thresholds and the maximal lactate steady state in elite cyclists. *International Journal of Sports Medicine, 25*(6), 403-408. https://doi.org/10.1055/s-2004-819942

Vélez Medina, M. A., & García González, O. (2013). El umbral anaeróbico como herramienta en el control del entrenamiento deportivo. *Revista Cubana de Medicina del Deporte y la Cultura Física, 8*(3). https://revmedep.sld.cu/index.php/medep/article/view/232/249

Verkhoshansky, Y. (2007). The training system in middle distance running. *Sport Strength Training Methodology, 3*. https://www.verkhoshansky.com/LinkClick.aspx?fileticket=4jXTgyX%2fSYw%3d&tabid=80&mid=426

Vučetić, V., Šentija, D., Sporiš, G., Trajković, N., & Milanović, Z. (2014). Comparison of ventilation threshold and heart rate deflection point in fast and standard treadmill test protocols. *Acta Clin Croat, 53*(2), 190–203. https://pubmed.ncbi.nlm.nih.gov/25163235/

Wasserman, K., & McIlroy, M. B. (1964). Detecting the threshold of anaerobic metabolism in cardiac patients during exercise. The American Journal of Cardiology, 14(6), 844–852. https://doi.org/10.1016/0002-9149(64)90012-8