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Original Article

Comparison between critical velocity and speed at the anaerobic threshold of moderately trained 5-km runners

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Abstract:
Approach: In recent years, the increase in the number of distance runners in various events worldwide has been evident. Evaluation and control of training with precise variables and easy applicability of the same variables are necessary. *Objective*: The objective of this study was to compare the critical velocity and velocity at the anaerobic threshold of moderately trained runners at 5-km. *Materials and Methods*: A total of 19 male runners with a moderate level of performance participated in the study. The participants performed two procedures to determine the speed of the anaerobic treadmill threshold and the runway critical velocity (maximum performance test of 3000 m and 5000 m). To determine the velocity at the anaerobic threshold, individual blood lactate level assessment was used. For comparison, the t-test was used to determine the Cohen effect size, Pearson linear correlation, and Bland-Altman concordance. *Results*: The average values found in the treadmill anaerobic threshold velocity and the critical velocity were 13.75 ± 1.37 km/h and 13.70 ± 1.33 km/h, respectively. Identification of positive correlations between the blood lactate methods and the critical velocity was possible. *Conclusion*: The study found that the estimated threshold velocities in methods using blood lactate and indirect methods (critical velocity) are in agreement with each other. Therefore, the methods presented are safe for the training prescription.
Key words: running; transition thresholds; lactate; training control.

Introduction

In recent years, the increase in the number of distance runners in various events worldwide is evident (Abadia et al., 2014; Guimarães, Mosqueira, Fernandes-Filho, & da Silva, 2017). Due to this the necessity for the organization, control, and prescription of correct training has also increased, through the loads and physiological indexes that best express the performance prediction (Borresen & Lambert, 2009; Tønnessen et al., 2015) in the diverse characteristics of samples (Shakhlina et al., 2016)

Among the various physiological markers responsible for the control of training intensity, the analysis of blood lactate curves to determine the anaerobic threshold (AT) (Faude, Kindermann, & Meyer, 2009; Svedahl & MacIntosh, 2003) and ventilatory indexes (the minute ventilation/oxygen consumption (VE/VO_2) and minute ventilation/carbon dioxide production (VE/VCO_2)) (Bassett & Howley, 2000; B. S. Denadai, Ortiz, & Mello, 2004; Okano et al., 2006; Vieira et al., 2014) are most frequently found in the literature. In addition, the identification of AT and its respective intensity, along with the velocity corresponding to the maximum volume of oxygen (vVO2max), are widely used in the prescription and control of training loads (Londeree, 1997). In an 8-week study of well-trained distance athletes, Denadai et al. (2003) prescribed a training consisting of 6 weekly sessions, consisting of continuous and interval training, where training intensity was based on AT and vVO2max. The post-training results showed a statistically significant improvement (B. Denadai, Ortiz, Stella, & Mello, 2003). Thus, blood lactate curves were found to play an important role for determining velocity anaerobic threshold (VAT) and consequently in the management of training (Faude et al., 2009).

The results of blood lactate adjustments in incremental tests, mainly verification using the maximal lactate steady state (MLSS), are considered the gold standard for evaluation of AT. However, the difficulty in obtaining the materials and the high cost of this type of test (Garcia□Tabar, Izquierdo, & Gorostiaga, 2017) make it difficult for most coaches to use this (Guimarães, Mosqueira, et al., 2017). This necessitates research into more practical and reliable alternatives of determining speed corresponding to the AT, which is more useful for prescription of training.

Critical velocity (CV), initially proposed by Monod and Scherrer (Monod & Scherrer, 1965) and subsequently revised by Hill (D. W. Hill, 1993), is a method to identify intensities corresponding to AT and with optimal correlations to the analysis of the blood lactate curve (Barker, Bond, Toman, Williams, & Armstrong, 2012; Browne et al., 2015; Ferreira et al., 2015; Penteado et al., 2014). CV can be defined as a maximum effort intensity that can be maintained for a long period of time, corresponding to the AT intensities (Monod &

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Scherrer, 1965); CV is based on the relation between intensity of work and time of execution (D. W. Hill, 1993). Unlike many laboratory tests, CV is a noninvasive method, applicable to a considerable group of people, and by obtaining estimates of field tests, it approximates the specificity of the distance runners (Florence & Weir, 1997). Thus, the ease and reliability of the CV method, provided several researchers with interest in the development of new means of identification, which were reviewed and listed by Pereira-Guimarães et al. (Guimarães, Mosqueira, et al., 2017). However, in spite of the large number of studies related to this subject, no comparisons have been made between CV (using distances of 3000 m and 5000 m) and AT (using protocols with incremental loads on a treadmill), specifically in runners trained at 5-km and with a moderate level of performance. Thus, the objective of this study was to compare the critical velocity and velocity at the anaerobic threshold of moderately trained runners at 5-km.

Methods

Participants

A total of 19 male runners, with no osteoarticular lesions, who were experienced in track and treadmill training, and with a moderate level of performance, participated in the study. All participants provided informed consent, and the project was approved by the Ethics Committee under the protocol number 53675416.3.0000.5148. Table 1 shows the sampling characteristics.

Table 1. Characteristics of the Sample

N	Age (yrs)	Height (m)	Weight (kg)	Body Fat (%)	Time in 5km (min)	Training time (yrs)
19	29.27± 3.24	1.77 ± 0.04	73.44 ± 4.38	11.33 ± 2.62	20.63 ± 2.35	4,26 ± 0,68

Procedures

The study data were collected in a single week and at standardized times. On the first day of collection, the measurement of the anthropometric data was carried out in the laboratory. Subsequently, the incremental protocol was also recorded using a treadmill. On the second and third day of collection and 48 hours after the first, the 3000-m- and 5000-m-time trial tests were performed on the track (with a 48-h interval between them).

1. Anthropometric evaluation: An anthropometric evaluation was performed for each subject using a weighing scale that had a stadiometer (110 FF, Welmy®, Santa Bárbara d'Oeste, Brazil). The fat percentage estimate was obtained using a 4-terminal sensing device (Quantum BIA-II, RJL Systems®, Clinton Township, USA), and electrodes (Bio Tetronic, Sanny®, São Bernardo do Campo, Brazil) were used for collection. To calculate the fat percentage, the resistance and reactance data obtained by the device were transferred to the Body Composition 2.1 software (Quantum BIA-II, RJL Systems®, Clinton Township, USA).

2. Determination of critical velocity (CV): Two tests were performed on a running time trial on an outdoor 400-m track. The participants were instructed to finish the race as quickly as possible, as in a competitive event. Before the test, the participants warmed up for 10 min at 8 km h−1. One of the tests was of 3000 m and the other of 5000 m, with a 48-h interval between them. In all tests, subjects should travel these distances in the lowest possible time. The sample was randomized to perform the tests. CV was determined through the relation of two distances. The equation proposed by Hill and Hill (Hill, 2001) (D. Hill, 2001) was used to determine the CV: CV = (2nd distance–1st distance)/(2nd time–1st time).

3. Incremental protocol performed on a treadmill: The subjects performed the incremental test on a treadmill (Super ATL, Inbramed®, Amparo, Brazil) with the initial velocity set at 8.0 km·h-1, with increments of 1.2 km·h-1 at each stage and maintaining a slope of 1% until exhaustion. Each stage lasted for 3 min with a 30-sec pause for blood collection (Heck et al., 1985). The maximum effort test ended when the subjects reached inability to maintain the pace despite strong verbal encouragement.

4. Measurement of Blood Lactate: Initially, 1 min after completion of each stage, after asepsis, the assessor, who is responsible for taking blood lactate, used lancets (Accu-Chek Safe-T-Pro Uno, Roche®, Hawthorne, USA) and disposable gloves (Cremer®, Blumenau, Brazil) to collect a blood sample through puncture of the earlobe. The first drop of blood was discarded, and 25 µL of arterialized blood was collected shortly thereafter. Reagent strips (Accusport BM-lactate, Roche®, Hawthorne, USA) were used during collection. A portable lactate analyzer (Accusport, Boehringer Mannheim-Roche ®, Hawthorne, USA), which was previously validated and reliable for use (Bishop, 2001) was used to analyze blood lactate levels.

5. Determination of the lactate threshold: To identify the anaerobic threshold, the individual anaerobic threshold (IAT) method was used, whose criterion used indicates the threshold for the second increase in the [Lac] value of at least 0.5 mmol/l from the previous value, where the value for the second increase was greater than or equal to the first increase (Baldari & Guidetti, 2000). This simple method makes it possible to identify the individual anaerobic threshold, which identifies the values for speed.

Statistical Analysis

For the statistical analysis, a descriptive analysis was used, with the study of mean and standard deviation. The normality of the data was also verified through the use of Shapiro-Wilk test. To compare the means between VAT and CS, Student's t-test was used for paired data. The effect size (ES) was calculated according to Cohen's d using the following formula: d = (group 1 mean - group 2 mean)/standard deviation. To analyze the relationship between the variables of the study, Pearson's linear correlation coefficient (r) was applied. The correlation interpretation was assessed according to the following criteria: 0–0.30 negligible, 0.30–0.50 weak, 0.50–0.70 moderate, 0.70–0.90 strong, and 0.90–1.00 very strong (Hinkle, Wiersma, & Jurs, 2003). To evaluate the agreement between the methods of identification of the anaerobic threshold, the visual analysis of the Bland-Altman graph was used. For the statistical verification of all the tests, $p \leq 0.05$ was used. The features of the treatments were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 21.0 (Armonk, NY: IBM Corp).

Results

The results of the present study are described below. Table 2 presents the mean and standard deviation (SD) values of the variables collected in the samples. The values of the speeds in km/h of the two methods of identifying the anaerobic threshold are very close. Thus, when comparing the differences between VAT and CS, no significant differences were found (p = 0.215) (ES = 0.07, small).

Table 2. Mean and standard deviation (DS) of values related to the variables of the samples:

VARIABLES	VAT (km/h)	CS (km/h)	Lactate in VAT (Mmol)	Time in 5000 m test (s)	Time in 3000 m test (s)
MEAN SCORES ± SD	13.75 1.37	13.68 1.33	4.6 0.81	1251.68 139.93	722.24 87.77

Moreover, when the variables were correlated, a very strong correlation between VAT and CS (r = 0.988), very strong negative correlation between VAT and time in 3000 m (r = -0.937), very strong negative correlation between VAT and time in 5000 m (r = -0.964), very strong negative correlation between CS and time in 3000 m (r = -0.941), very strong negative correlation between CS and Time in 3000 m (r = -0.969), and very strong correlation between time 3000 m and time 5000 m (r = 0.994) were found. Table 3 shows the values.

Table 3. Correlations with variables

Variables	VAT	CS	Time 3000m	Time 5000m
VAT	-	0.988	-0.937	-0.964
CS	0.988	-	-0.941	-0.969
Time 3000m	-0.937	-0.941	-	0.994
Time 5000m	-0.964	-0.969	0.994	-

Another analysis determined the agreement of Bland-Altman. The interpretation of Figure 1 shows the agreement between the VAT and CS variables with 95% of the data between ± 1.9

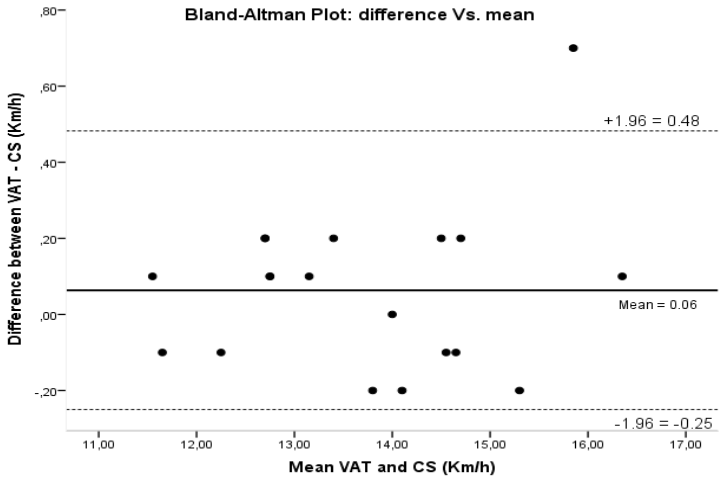

Fig. 1. Concordance between VAT and CS in kilometers per hour (Km/h).

Discussion

The present study aimed to compare the critical velocity and speed at the anaerobic threshold of moderately trained runners at 5-km. The purpose of the study was to validate an accessible and easily applicable method that would reliably measure the intensity corresponding to the anaerobic threshold of the sample in question and, consequently, aid in the prescription of the training. The results showed that, despite the different types of tests, one progressive in the laboratory and the other maximum tests on the track, no significant differences were observed between the velocities found in both variables ($p = 0.215$), and a very strong correlation between the tests ($r = 0.988$) and agreement was found.

Analyzing the results, we can see that along with the study in question, there are studies in the literature with high correlations between the different methods of anaerobic threshold evaluation (de Lucas, Dittrich, Junior, de Souza, & Guglielmo, 2012; Fraga et al., 2014; Llodio, Gorostiaga, Garcia-Tabar, Granados, & Sánchez-Medina, 2016). In the recent study published by Guimaraes et al. (Guimarães, Campos, de Souza, & da Silva, 2017), the authors found agreement between the methods of determination of anaerobic threshold velocity using blood lactate through the Dmax method and anaerobic threshold velocity using the heart rate deflection point. In addition, although a difference was observed between the speeds (explained by the authors by the progressive protocols used, which may have overestimated the values of the heart rate threshold), the values were found to be very close (16.2 km/h to the heart rate deflection and 15.2 km/h for lactate estimated using the Dmax method). On the other hand, other studies verified the existence of significant differences between maximal stable phase of lactate, according to ventilatory threshold and critical velocity in trained cyclists (Dekerle, Baron, Dupont, Vanvelcenaher, & Pelayo, 2003). Thus, a relationship between modality, specificity, and anaerobic threshold assessment method was found.

Another factor that should be highlighted is the methods of analyzing the anaerobic threshold through the blood lactate curves. The progressive treadmill tests that are used to measure this intensity are often used for distance and middle distance runners (Bertuzzi, Nascimento, Urso, Damasceno, & Lima-Silva, 2013b; Fraga et al., 2014). In addition, the interpolation of the lactate values by the individual identification method also significantly expresses the intensity values referring to the anaerobic threshold, which obtains numbers close to the maximum stable lactate phase (Baldari & Guidetti, 2000), which justifies its use in the present study.

Another important point is the contributions of the energy systems of the distances used for critical velocity analysis and the incremental tests for determination at the anaerobic threshold. Studies show that at the distances chosen for the study methodology (3000 m and 5000 m), the aerobic contribution is 90% and 95%, respectively (Billat, 2001). In the incremental tests on a treadmill, with progressive protocols, the aerobic contribution is also around 90% (Bertuzzi, Nascimento, Urso, Damasceno, & Lima-Silva, 2013a). These findings allow us to interpret that aerobic metabolism is predominant in the tests in question and, in turn, express the relationship between the preponderant metabolism and the anaerobic threshold. Therefore, the study variables play important roles in the prescription and control of aerobic capacity.

In order to elucidate the validity of CS in the parameters of the study, the different forms of evaluation of this variable seem to be sensitive to the individual characteristics of the samples. In our study, we found high correlations between CS and VAT measured using the individual identification method, time in the 3000-m test, and time in the 5000-m test ($r = 0.988$; -0.941; -0.969, respectively) and agreement between CS and VAT. No significant differences were found in the velocity values of CS and VAT. Classical studies such as the one by Monod and Scherrer (Monod & Scherrer, 1965) and Hill (D. W. Hill, 1993) already demonstrated the concepts of CS based on the intensity of exercise corresponding to the anaerobic threshold. In addition, current studies (Barker et al., 2012; Browne et al., 2015; Ferreira et al., 2015; Nimmerichter, Novak, Triska, Prinz, & Breese, 2017; Penteado et al., 2014; Poole, Burnley, Vanhatalo, Rossiter, & Jones, 2016) also highlight this good relationship between CS and VAT. Specifically, the study by Ferreira et al. (Ferreira et al., 2015) compared different predictor distances of CS with the VAT established by the lactate minimum test in middle distance runners. The results did not show differences between the methods used. However, in the recent review by Guimaraes et al. (Guimarães, Mosqueira, et al., 2017), the authors indicated that the different methodologies to predict SC can be a limiting factor and cause divergences between results. All this confirms the strong relationship between specificity of the training at 5 km and the distances chosen for the determination of the critical velocity, which further reinforces the results found in the present study.

Finally, the study confirms the significant correlation and agreement between the methods of identification of the anaerobic threshold. In addition, it provides a reliable method of determining a variable that is important for training prescription, easy to apply, and accessible to any coach.

Conclusions

To conclude, the different methods of determining the anaerobic threshold, one directly with individual measurement through measuring the blood lactate levels and another indirectly through the maximum performance test in track are not statistically different and have a high correlation with each other, reflecting the significant validity of critical velocity as an anaerobic threshold predictor. Thus, CS can be an instrument with great reliability in the prescription and control of training.

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References

Abadia, S., Medina, F. X., Sánchez, R., Bantulà, J., Fornons, D., Bastida, N., . . . Pujadas, X. (2014). Entre el boom atlético y la cooperación social: Las carreras solidarias y el ejemplo de la Trailwalker España 2013. *Península, 9*(1), 105-124.

Baldari, C., & Guidetti, L. (2000). A simple method for individual anaerobic threshold as predictor of max lactate steady state. *Medicine and science in sports and exercise, 32*(10), 1798-1802.

Barker, A. R., Bond, B., Toman, C., Williams, C. A., & Armstrong, N. (2012). Critical power in adolescents: physiological bases and assessment using all-out exercise. *European journal of applied physiology, 112*(4), 1359-1370.

Bassett, D., & Howley, E. T. (2000). Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine and science in sports and exercise, 32*(1), 70-84.

Bertuzzi, R., Nascimento, E. M., Urso, R. P., Damasceno, M., & Lima-Silva, A. E. (2013a). Energy System Contributions during Incremental Exercise Test. *Journal of Sports Science and Medicine, 12*, 454-460.

Bertuzzi, R., Nascimento, E. M., Urso, R. P., Damasceno, M., & Lima-Silva, A. E. (2013b). Energy system contributions during incremental exercise test. *Journal of sports science & medicine, 12*(3), 454.

Billat, L. V. (2001). Interval training for performance: a scientific and empirical practice. *Sports medicine, 31*(1), 13-31.

Bishop, D. (2001). Evaluation of the Accusport® lactate analyser. *International journal of sports medicine, 22*(7), 525-530.

Borresen, J., & Lambert, M. I. (2009). The quantification of training load, the training response and the effect on performance. *Sports medicine, 39*(9), 779-795.

Browne, R. A. V., Sales, M. M., Sotero, R. d. C., Asano, R. Y., Moraes, J. F. V. N. d., Barros, J. d. F., . . . Simões, H. G. (2015). Critical velocity estimates lactate minimum velocity in youth runners. *Motriz: Revista de Educação Física, 21*(1), 1-7.

de Lucas, R. D., Dittrich, N., Junior, R. B., de Souza, K. M., & Guglielmo, L. G. A. (2012). Is the critical running speed related to the intermittent maximal lactate steady state? *Journal of sports science & medicine, 11*(1), 89.

Dekerle, J., Baron, B., Dupont, L., Vanvelcenaher, J., & Pelayo, P. (2003). Maximal lactate steady state, respiratory compensation threshold and critical power. *European journal of applied physiology, 89*(3-4), 281-288.

Denadai, B., Ortiz, M., Stella, S., & Mello, M. (2003). Validade da velocidade crítica para a determinação dos efeitos do treinamento no limiar anaeróbio em corredores de endurance. *Revista Portuguesa de Ciências do Desporto, 3*(1), 16-23.

Denadai, B. S., Ortiz, M. J., & Mello, M. d. (2004). Índices fisiológicos associados com a performance aeróbia em corredores de endurance: efeitos da duração da prova. *Revista Brasileira de Medicina do Esporte, 10*(5), 401-404.

Faude, O., Kindermann, W., & Meyer, T. (2009). Lactate threshold concepts. *Sports medicine, 39*(6), 469-490.

Ferreira, C., De Olivaira, V. M., Cavazzotto, T. G., Queiroga, M. R., Tartaruga, L. A. P., & Tartaruga, M. (2015). Comparação entre velocidade no limiar anaeróbico e velocidade crítica em corredores meio-fundistas. *Acta Brasileira do Movimento Humano, 4*(5), 17-31.

Florence, S.-l., & Weir, J. P. (1997). Relationship of critical velocity to marathon running performance. *European journal of applied physiology and occupational physiology, 75*(3), 274-278.

Fraga, C. H. W., Bianco, R., Serrão, J. C., Greco, C. C., Amadio, A. C., & Gonçalves, M. (2014). Comparação de protocolos de corrida para determinação de diferentes limiares. Revista Braileira de Medicina do Esporte, 20(2), 92-96.

Garcia□Tabar, I., Izquierdo, M., & Gorostiaga, E. M. (2017). On□field prediction vs monitoring of aerobic capacity markers using submaximal lactate and heart rate measures. Scandinavian journal of medicine & science in sports, 27(5), 462-473.

Guimarães, M. P., Campos, Y. d. A. C., de Souza, H. L. R., & da Silva, S. F. (2017). Is there a concordance between the lactate threshold and the heart rate deflection point during a progressive field test in moderately trained distance runners? *Journal of Exercise Physiology Online, 20*(5), 60-68.

Guimarães, M. P., Mosqueira, C. M. H., Fernandes-Filho, J., & da Silva, S. F. (2017). Métodos de determinación de la velocidad crítica en corredores. *CienciaUAT, 11*(2), 46-53.

Heck, H., Mader, A., Hess, G., Mücke, S., Müller, R., & Hollmann, W. (1985). Justification of the 4-mmol/l lactate threshold. *International journal of sports medicine*(6), 117-130.

Hill, D. (2001). Aerobic and anaerobic contributions in middle distance running events. *Motriz, 7*(1), S63-S67.

Hill, D. W. (1993). The critical power concept. *Sports medicine, 16*(4), 237-254.

Hinkle, D. E., Wiersma, W., & Jurs, S. G. (2003). Applied statistics for the behavioral sciences. *Journal of Educational Statistics, 15*(1), 84-87.

Llodio, I., Gorostiaga, E., Garcia-Tabar, I., Granados, C., & Sánchez-Medina, L. (2016). Estimation of the Maximal Lactate Steady State in Endurance Runners. *International journal of sports medicine*.

Londeree, B. R. (1997). Effect of training on lactate/ventilatory thresholds: a meta-analysis. *Medicine & Science in Sports & Exercise, 29*(6), 837-843.

Monod, H., & Scherrer, J. (1965). The work capacity of a synergic muscular group. *Ergonomics, 8*(3), 329-338.

Nimmerichter, A., Novak, N., Triska, C., Prinz, B., & Breese, B. C. (2017). Validity of treadmill-derived critical speed on predicting 5000-meter track-running performance. *The Journal of Strength & Conditioning Research, 31*(3), 706-714.

Okano, A. H., Burini, R. C., Altimari, L. R., Moraes, A. C. d., Nakamura, F. Y., Cyrino, E. S., & Simões, H. G. (2006). Comparação entre limiar anaeróbio determinado por variáveis ventilatórias e pela resposta do lactato sanguíneo em ciclistas. *Revista Brasileira de Medicina do Esporte, 12*(1), 39-44.

Penteado, R., Salvador, A., Corvino, R., Cruz, R., Lisbôa, F., Caputo, F., & de Lucas, R. (2014). Physiological responses at critical running speed during continuous and intermittent exhaustion tests. *Science & Sports, 29*, e99-e105.

Poole, D. C., Burnley, M., Vanhatalo, A., Rossiter, H. B., & Jones, A. M. (2016). Critical power: an important fatigue threshold in exercise physiology. *Medicine Science and Sports Exercise, 48*(11), 2320-2334.

Shakhlina, L., Roda, O., Kalytka, S., Romaniuk, O., Matskevych, N., & Zakhozhyi, V. (2016). Physical performance during the menstrual cycle of female athletes who specialize in 800 m and 1500 m running. *Journal of Physical Education and Sport, 16*(4), 1345.

Svedahl, K., & MacIntosh, B. R. (2003). Anaerobic threshold: the concept and methods of measurement. *Canadian Journal of Applied Physiology, 28*(2), 299-323.

Tønnessen, E., Svendsen, I. S., Rønnestad, B. R., Hisdal, J., Haugen, T. A., & Seiler, S. (2015). The annual training periodization of 8 world champions in orienteering. *International journal of sports physiology and performance, 10*(1), 29-38.

Vieira, D. C. L., Prestes, J., Tibana, R. A., Teixeira, T. G., Tajra, V., Farias, D. L. d., . . . Pires, F. d. O. (2014). Respostas da percepção subjetiva de esforço em teste incremental de mulheres idosas sedentárias. *Revista Brasileira de Cineantropometria e Desempenho Humano, 16*(1), 106-115.