Original Article

"Anaerobic" critical velocity and swimming performance in young swimmers

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ABSTRACT

Marinho DA, Amorim RA, Costa AM, Marques MC, Pérez-Turpin JA, Neiva HP. "Anaerobic" critical velocity and swimming performance in young swimmers. *J. Hum. Sport Exerc.* Vol. 6, No. 1, pp. 80-86, 2011. Recent studies explored a new trend of critical velocity as a parameter to evaluate and monitor anaerobic training. The aim of this study was to analyse the relationship between anaerobic critical velocity and short distances performances in the four swimming techniques, in young swimmers. 12 male and 8 female swimmers (mean ±SD; age 12.10 ± 0.72 years old) performed maximal 10, 15, 20 and 25 m in the four conventional swimming techniques to determine critical velocity from the distance-time relationship. 50, 100 and 200 m individual best performances of the season were used to compare with the critical velocity assessed. The mean ± SD values of anaerobic critical velocity ($m.s^{-1}$) were 1.10 ± 0.22, 1.07 ± 0.10, 0.89 ± 0.16 and 1.27 ± 0.16, for butterfly, backstroke, breaststroke and front crawl, respectively. Anaerobic critical velocity was correlated with the 50 and 100 m swimming event velocities in backstroke (r = 0.85; r = 0.86), breaststroke (r = 0.92; r = 0.90) and front crawl (r = 0.85; r = 0.91). Considering the 200 m swimming performance, relationships were found in front crawl (r = 0.90) and in breaststroke (r = 0.89). Differences ($p<0.05$) between anaerobic critical velocity and swimming performance were observed in all swimming techniques for the 50 m and in breaststroke, front crawl and backstroke for the 100m. There were no differences regarding the 200 m swimming performance. These findings suggest that anaerobic critical velocity may be managed as a control parameter and even to prescribe training for young swimmers. **Key words**: TRAINING, EVALUATION, ANAEROBIC, SWIMMING.

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INTRODUCTION

The development in swimming performance over the years can be explained by better training control and evaluation of the swimmers, leading to a more efficient training process (Smith et al., 2002; Olbrecht & Mader, 2006). Like any other sport, swimming training must be appropriately specific, even for young swimmers. This concern with specificity should also be maintained during the evaluation and monitoring of training (Wells et al., 2006).

Off all known swimming performance determinants, the bioenergetical factors seem to be one of the most important (Hohmann, 1999; Vilas-Boas, 2010). Therefore, and considering the full range of competitive events are equal to or less than 200m, the anaerobic metabolism appears to be quite preponderant for the performance of the swimmer (Troup & Trappe, 1994). Indeed, the practical application of anaerobic training emerges as a necessity to enhance swimmers performance in short events (Olbrecht, 2000).

The critical velocity concept, an extension of the critical power concept originally introduced by Monod and Scherer (1965), has been recovered and adapted for swimming (Wakayoshi et al., 1992). The critical swimming velocity (CV) is defined as the maximal swimming velocity that can be maintained without exhaustion for a long time. It is expressed by the slope of the regression line between different distances performed at maximum velocity and the corresponding times (Wakayoshi et al., 1992). This aerobic ability indicator can provide the basis to analyze the effects and trends brought about through training and predict future competitive performance (Dekerle, 2006). Indeed, over the years, critical velocity has been progressively more used by swimming coaches (di Prampero et al., 2008) as an indicator of the swimmer's functional aerobic capacity as measured through the anaerobic threshold, or equivalent measurement (Wakayoshi et al., 1992; Wakayoshi et al., 1993; Wright & Smith, 1994; Martin & Whyte, 2000; Dekerle et al., 2002; Soares et al., 2003; Greco et al., 2007).

However, some authors reported that swimming critical velocity does not represent the maximal velocity that can be maintained without an increase of the lactate concentration (Dekerle et al., 2005) but it could corresponds to the velocity at the maximum oxygen consumption (di Prampero et al., 2008). Actually, we must recall that the original expression of critical velocity was associated with the velocity sustainable on the basis of maximal oxygen consumption during a running exercise (Lloyd, 1966).

Fernandes et al. (2008) suggest that the different methodologies used to access critical swimming velocity could explain the different results: the longer the distances used for critical velocity assessment, the higher its relationship with the aerobic capacity of the swimmer, and the shorter the distances, the higher its relationship with more powerful efforts. Furthermore, from a theoretical point of view, the more distances that are included the better, because this minimizes possible errors, increasing the strength of the regression line equation (Costa et al., 2009).

Recently, some authors have introduced a new trend of critical velocity, associating it with anaerobic performances (Abe el al., 2006; Fernandes et al., 2008). Based upon sprint swimming distances (below 50 m) and the respective time durations, this anaerobic critical velocity (AnCV) seems to represent the functional anaerobic capacity of swimmers, highly associated with the performance of 100 m swimming events (Fernandes et al., 2008; Neiva el al., 2011). This suggests that AnCV can be a significant parameter for monitoring anaerobic training and for predicting swimming performance in short-term events.

Nevertheless, AnCV related studies are very scarce, so that further investigations are needed to better understand the real meaning and application of this indicator. Moreover, given the methodological and ethics problems of using invasive methods to evaluate the anaerobic function in younger ages, the attempt to clarify this non-invasive parameter is of great importance. Therefore, the aims of the present study were to determine and analyze AnCV in young swimmers comparing it with short distances performances in the four swimming techniques.

MATERIAL AND METHODS

Subjects

A sample of 20 young swimmers (12 males and 8 females) participated in the study. Their mean (SD) age, height, body mass and training experience were 12.10 (0.72) years old, 1.56 (0.10) m, 45.49 (11.75) kg and 3.70 (1.26) years, respectively. All the swimmers belonged to the same swimming club and were trained by the same coach in the last two years. The sample was studied according to the swimmers' best technique (identified by their coach): front crawl (the total sample, n = 20), backstroke (n = 6), breaststroke (n = 6) and butterfly (n = 7). The local Ethics Committee approved the procedures and all swimmers signed a consent form in which the present protocol was explained.

Testing procedure

For each swimmer, the personal best in the 50, 100, 200 m (short course) in their finest swimming technique (including front crawl) was registered and corresponding velocities were calculated. The mean (SD) time gap between the swimmers personal records (the difference between the oldest and the most recent personal best) was 3.0 ± 0.8 months.

To assess AnCV, each swimmer performed four distances (10, 15, 20 and 25 m with in-water starts) in front crawl and plus other premium swimming technique, trying to swim as fast as possible. Warm-up was made before the AnCV protocol (600 m and 10 min rest). A 30-minute rest interval was applied between each trial, during which the swimmers performed low intensity freestyle swim. Two stopwatches were used to record times (Seiko stopwatches, Japan); the average result was chosen for analysis.

AnCV was calculated using the slope of the distance-time relationship, plotting the following swimming performances over time: 10, 15, 20 and 25 m. The equation of the regression line obtained was of $y = ax + b$ type, where here y is distance swam, x is time and a = AnCV, b is y-interception value. The standard error of AnCV (slope of the equation line) was calculated to determine the strength of the regression line equation.

The data collection was carried out near immediately before main national competition to ensure that all swimmers would be in a state of good overall performance. The measurements were performed in a 25 m indoor swimming pool, with 28ºC water temperature and less than 75% of humidity.

Statistics

All data for this study were analyzed using SPSS computer software for Windows (version 18.0). The normality and homocedasticity assumptions of all distributions were verified using a Shapiro-Wilk and Levene tests. Standard descriptive statistical methods were used for the calculation of means and standard deviations. The Pearson product moment correlation coefficient was used to verify the relationships between each velocity that was considered. In order to compare mean values of each velocity (AnCV, 50, 100 and 200 m personal best), a repeated–measures analysis of variance with Bonferroni adjustment was used. Statistical significance for all analyses was as accepted at $p \leq 0.05$.

RESULTS

In Table 1 the mean ± SD values of AnCV and the best performances times attained at the 50, 100 and 200 m swimming events in butterfly, backstroke, breaststroke and front crawl are presented. As noted, significant differences (p<0.05) are signed between AnCV and swimming performance. AnCV values are lower than the 50 and 100 m swimming event velocity in all four swimming techniques. It is interesting to note that the 200 m swimming performance ($m \cdot s^{-1}$) seems to be similar to AnCV.

Table 1. *Mean ± SD values of anaerobic critical velocity (AnCV), 50 m, 100 m and 200 m swimming event velocities at each studied swimming technique.*

Parameters	Butterfly (n=7)	Backstroke (n= 6)	Breaststroke (n=6)	Front Crawl (n=20)
AnCV ($m \cdot s^{-1}$)	1.10 ± 0.22]*	1.07 ± 0.10]]	0.89 ± 0.16]]	1.27 ± 0.16]]
50 m event ($m \cdot s^{-1}$)	1.36 ± 0.18	1.21 ± 0.09]*	1.09 ± 0.16]*	1.45 ± 0.18]*
100 m ($m \cdot s^{-1}$)	1.23 ± 0.14	1.17 ± 0.09	1.04 ± 0.13	1.39 ± 0.17
200 m ($m \cdot s^{-1}$)	1.08 ± 0.11	1.13 ± 0.09	0.93 ± 0.11	1.29 ± 0.14

** represents significant differences between velocities in each swimming technique (p≤0.05)*

Table 2 shows the correlation coefficient values obtained between the AnCV and the 50, 100 and 200 m swimming performances. The higher value of correlation is presented between AnCV and the 50 m in breaststroke swimming technique. AnCV in the butterfly swimming technique is not correlated with swimming performance in the three distances (50, 100 and 200 m) analyzed.

Table 2. *Correlation matrix obtained between anaerobic critical velocity (AnCV) and 50 m, 100 m and 200 m swimming event velocities (v 50 m, v 100 m and v 200 m)*

	v 50 m	v 100 m	v 200 m
AnCV Butterfly	0.30 (p=0.52)	0.35 (p=0.44)	0.45 (p=0.45)
AnCV Backstroke	0.85 (p=0.03)	0.86 (p= 0.03)	0.82 (p=0.09)
AnCV Breastroke	0.92 (p=0.01)	0.90 (p=0.01)	0.88 (p=0.05)
AnCV Front Crawl	0.85 (p=0.00)	0.91 (p=0.00)	0.90 (p= 0.00)

DISCUSSION AND CONCLUSION

The aim of the present study was to analyze AnCV in young swimmers, comparing this anaerobic indicator with the best swimming performances of short-distance events (50, 100 and 200 m). The results showed a strong relationship between AnCV and swimming performance in 50 and 100 m in backstroke, breaststroke, and front-crawl, and between AnCV and swimming performance in the 200 m in breaststroke and front crawl. Additionally, no differences were found between 200 m swimming event velocity and the AnCV in all four swimming techniques. These findings allow us to suggest that AnCV could be a relevant parameter for providing recommendations for continued directional training of young swimmers.

In competitive swimming, the faster times are obtained in front crawl, then in butterfly, followed by backstroke and, finally, in breaststroke. As expected this was the order observed in the AnCV assessed being in line with the recent literature on this matter (Neiva et al., 2011). Regarding swimming performance velocity, this distribution remains in the same order, with the exception of the 200 m, being the events in backstroke usually faster than in butterfly. This could be due to the performance level and training experience of the young swimmers presented in this study, which tended to demonstrate lower performances times in butterfly swimming technique.

As one would expect, the AnCV values were lower than those obtained by Neiva et al. (2011) with swimmers of higher age and performance level (butterfly: 1.61 ± 0.07 $m \cdot s^{-1}$; backstroke: 1.53 ± 0.05 $m \cdot s^{-1}$; breaststroke: 1.33 ± 0.05 $m \cdot s^{-1}$; front crawl: 1.75 ± 0.05 $m \cdot s^{-1}$). These values remain low even in comparison with those published by Fernandes et al. (2008) for front crawl (1.62 ± 0.06 $m \cdot s^{-1}$). Although the identical age, the subjects of the present study were from a local club and were analyzed without separation of genders. In Fernandes et al. (2008) study only male swimmers participated, belonging to a regional elite, selected to join technical and conditional evaluations. The values of AnCV closer to ours were presented by Abe et al. (2006) in breaststroke (0.86 ± 0.11 $m \cdot s^{-1}$), and these used longer distances to calculate critical velocity (50, 100 and 150 m).

When comparing the values of AnCV with swimming performance, there were found differences between the critical velocity assessed and the velocity of 50 m event, in the four conventional swimming techniques. The velocity of 100 m event was also different of the values of AnCV in backstroke, breaststroke and front crawl. Neiva et al. (2011) found differences between AnCv and 100 m swimming velocity (and the first 50 m of the 100 swimming event) in all the four swimming techniques and suggested that the exclusion of starting action (which allows the swimmer to achieve higher speeds), in the protocol for AnCV determination can explain the differences between the AnCV and the swimming performance of 50 m and 100 m, in the four swimming techniques. However, these data is relatively different than the results obtained by Fernandes et al. (2008) that found no differences between the AnCV and the 100 m front crawl event, in young swimmers, for each gender group. In the present study it also was observed that there is no differences between the 200 m swimming event velocity and AnCV, in the four swimming techniques. To our knowledge there is no study that compares this critical velocity assessed using short distances of swimming and the 200 m swimming performance.

Additionally, high direct relationships were found between the values of AnCV and the 50 and 100 m swimming event velocity in backstroke, breaststroke and front crawl, which is in accordance with several authors (Abe et al., 2006; Fernandes et al., 2008; Neiva et al., 2011). However, our correlation coefficient values were slight higher than those presented by the existing literature. Regarding the relationships between AnCV and the velocity of 100 m swimming event, Neiva et al., (2011) obtained values of r = 0.81

($p \leq 0.01$) in backstroke, r = 0.83 ($p \leq 0.05$) in breaststroke, r = 0.78 ($p \leq 0.01$) in front crawl. Fernandes et al. (2008) referred values of r = 0.84 ($p < 0.01$) in front crawl swimming technique. Complementarily, Abe et al. (2006) reported a strong association between the AnCV and the 50 m performance in breaststroke (r = 0.85, $p \leq 0.05$). In the present study, AnCV is related with 200 m swimming performance in breaststroke (r = 0.88, p=0.05) and front crawl (r = 0.90, p= 0.00). It was also observed that the coefficient values of correlation between the AnCV and swimming performance decrease as the distance increases until the 200 m (exception of front crawl). These results were expected since AnCV was assessed using short testing distances. The preponderance of anaerobic metabolism in maximal efforts, decrease over time), and so, the performance of the swimmers is increasingly influenced by the aerobic metabolism (Olbrecth, 2000; Gastin, 2001; Ogita, 2006). From this, the relationship between AnCV and the 200 m swimming event velocity should be less significant.

In summary, the CV assessed by short testing distances is similar to the 200 m swimming event velocity, in the four conventional swimming techniques. So, AnCV seems to be an important indicator of the performance in the 200 m swimming events, and could be used as a race-pace training reference. Linear relationships between AnCV and performance in the 50 m and 100 m were found. Therefore, these results suggest that AnCV could be an important parameter of monitoring and prescribing anaerobic training in young swimmers.

To our knowledge, the present study is the first to analyze this recent functional parameter of training control in young swimmers. The literature is very scarce in this matter, and further investigation is needed to better understand this concept, mainly because of setting up as an inexpensive and non-invasive method of training control and evaluation in swimming.

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