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Stroking Parameters Patterns in A Training Set Performed at the Critical Velocity

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Abstract: Swimming critical velocity is defined as the maximum velocity that could be maintained during a long period of time without exhaustion, being accepted as a valid parameter to assess aerobic capacity. Our purpose was to observe the patterns of the stroking parameters during a typical aerobic capacity training set conducted at critical velocity. Thirty-six juvenile swimmers performed front crawl 200 and 800 m tests at maximum intensity. Critical velocity and critical stroke rate were assessed as the slope of the regression line obtained between the test distances, and between the total number of stroke cycles in each test distance, and the respective times, respectively. Twenty-four hours after, swimmers performed a typical aerobic capacity training set (8x200 m front crawl, 20s rest). It were observed moderate to high correlation coefficients between critical velocity values and mean velocity of the aerobic training set (r=0.84 and r=0.66, respectively for female and male groups). The same phenomenon was observed when considering the relationship between critical stroke rate and the mean stroke rate obtained in the training set (r=0.93 for both gender groups). Velocity decreased from the 1st to 2nd repetitions, becoming stable in the middle of the set and increasing during the last repetition. Stroke rate was stable during the first seven repetitions and increased from the 7th to the 8th repetition. Stroke length was stable in the female group and, in the male group, increased from the 2nd to the 3rd repetition, followed by a decrease in the final of the training set.

Keywords: Critical velocity, stroking parameters, swimming, young.

INTRODUCTION

The concept of critical velocity was introduced and adapted for swimming by Wakayoshi *et al*. [1] from the original concept of critical power. Critical velocity, defined as the maximum swim velocity that could be maintained during a long period of time without exhaustion, is well related with the swimming velocity corresponding to 4 mmol of blood lactate concentrations [1,2] and to the maximal lactate steady state [3]. Thus, critical velocity is accepted as a valid parameter to assess swimming aerobic capacity.

Closely related to the concept of swimming critical velocity, it hypothesized the existence of a theoretical stroke rate that could be maintained without exhaustion during a long period of time - the critical stroke rate [4]. Knowing that technique has a great influence on the swimmer's energy cost and, therefore, affects its aerobic performance [5], it was suggested that critical velocity and critical stroke rate could be valid parameters to control and evaluate swimming technique as well as the effectiveness of training loads [6].

The main purpose of this study to observe the patterns of the stroking parameters (velocity, stroke rate and stroke length) during a typical aerobic capacity training set conducted at critical velocity.

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METHODS

Thirty-six swimmers (19 females and 17 males) from a juvenile national swimming team volunteered to participate in this study. Subjects, main physical characteristics were, respectively for female and male groups: 14.0±0.5 and 15.0±0.5 years old, 161.0±6.0 and 175.3±6.7 cm, 50.2±6.1 and 62.8±7.3 kg, and 163.2±8.0 and 179.4±9.5 cm of arm span.

Critical velocity was assessed as the slope of the regression line obtained between the 200 and 800 m test distances and the respective times needed to cover them at maximum velocity [2]. Critical stroke rate was considered to be the slope of a regression line between the total number of stroke cycles in each test distance and its respective times [4]. Both time duration and stroke rate were obtained using a chronofrequencimeter (SEIKO base three). Stroke length was obtained, for each test distance, from the product of velocity times stroke rate.

Twenty-four hours after, swimmers performed a typical aerobic capacity training set composed of 8x200 m front crawl, with 20 s rest between repetitions. Swimmers were instructed to maintain a continuous pace during the entire training set.

Mean and SD computations for descriptive analysis were obtained for all variables, being all data checked for distribution normality with the Shapiro-Wilk test. Pearson's correlation coefficient, unpaired samples Student's *t* test and ANOVA for repeated measures were also used. A significant level of 5% was accepted.

RESULTS

Moderate to high correlation coefficients were observed between critical velocity values and mean velocity of the aerobic training set (r=0.84 and r=0.66, respectively for female and male groups, for a $p<0.01$), with no statistical differences between the respective mean values. The same phenomenon was observed when considering the relationship between critical stroke rate and the mean stroke rate obtained in the training set (r=0.93 for both gender groups, $p<0.01$).

Concerning the primary goal of this study, in Figs. (**1** and **2**) the patterns of the studied stroking parameters along the 8x200 m front crawl training set were observed.

For both genders, it was possible to observe that the velocity decreases from the 1st to 2nd repetitions, becoming stable in the middle of the set and increasing the during in the last repetition. Regarding the stroke rate, it is visible, in both groups, the stability during the first seven repetitions and an increase from the 7th to the 8th repetition. Additionally, in the male group, there was a significant decrease in this parameter from the 2nd to the 3rd repetition.

What concerns the stroke length, is that no significant changes were observed during the test in the female group. In the male group, stroke length increased significantly from the 2nd to the 3rd repetition, but decreased in the final of the 8x200 m front crawl training set.

DISCUSSION

Since the pioneer study of East [7], the analysis of the stroking parameters is one of the major points of interest in the biomechanical analysis of swimming. Thus, critical stroke rate was proposed as a new technical criterion for coaches to monitor aerobic performance in competitive swimming [4] and even, in combination with critical velocity, to set the intensities of aerobic training loads [6]. In the present study, we tried to go further in this analysis and observe the behavior of the stroking parameters during a front crawl typical training set for aerobic capacity development performed at a previous assessed critical velocity.

Significant relationships between critical velocity and critical stroke rate and the mean values of velocity and stroke rate obtained in the aerobic training set were observed. Additionally, no differences between means were observed. These facts seem to confirm that critical velocity and critical stroke rate values have good applicability for aerobic training regimens in swimming, as previously proposed [4, 6].

Regarding the patters of the stroking parameters during the training set, strong stability of the swimming velocity during the training set were observed (namely from the 2nd to the 7th repetition), being this maintenance of velocity a common pre-requisite to develop the aerobic capacity of swimmers. The exceptions to this behavior occurred in two moments: (i) from the 1st to 2nd repetition, in which a decrease of velocity took place simultaneously with a decrease in SR (although not significant for a $p<0.05$) and (ii) from the 7th to the 8th repetition, exiting an increase of v coincident with a significant increase of SR and a decrease in SL (only in the male group). This direct relationship between v and SR is in accordance with the specialized literature [e.g. 8]. However, the velocity increase in the last repetition implied a drop of SL (only statistically significant for the male group), which could be related to the accumulation of fatigue in the last steps of the training set [cf. 9].

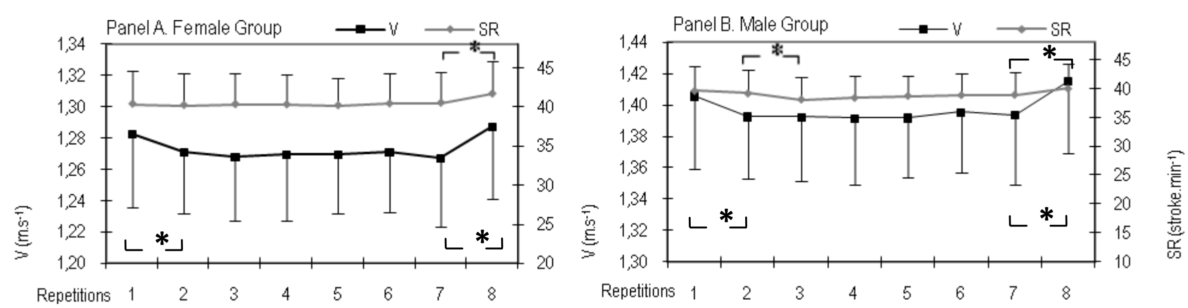

Fig. (1). Patterns of velocity and stroke rate along the training set of 8x200 m front crawl in female and male groups (**A** and **B** panels, respectively).

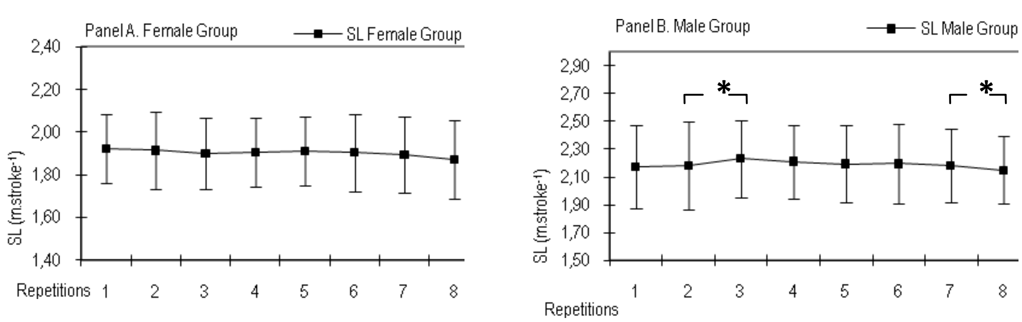

Fig. (2). Patterns of stroke length along the set of 8x200 m front crawl in female and male groups (**A** and **B** panels, respectively).

Nonetheless the patterns above-observed, it is important to underline that the complex inter-relationships between v, SR and SL are quite individualized, depending on several factors (e.g. gender, anthropometric variables, training status, swimming technique and swimming distance) [10], reflecting the swimming efficiency of each swimmer [5]. Thus, when involved in a program of training monitoring, evaluation and advice of swimmers, coaches should follow the individualization principle, working individually with each swimmer, trying to match his/her proper training load by better combining swimming intensity (v) and technique (SR and SL).

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