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Comparison Between Swimming VO_2peak and VO_2max at Different Time Intervals

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Abstract: Accepting that the evaluation of the aerobic energy system contribution is very important for swimming training diagnostics purposes and that oxygen uptake kinetics (VO_2) is one of the most used parameters in that task, we purposed to assess the variability of the peak VO_2 and VO_2max values obtained in a 200 m front crawl effort, using five different presentation intervals: breath-by-breath and average of 5, 10, 15, and 20 s. Ten male high-level swimmers performed a 200 m front crawl effort at maximal velocity being attached to a respiratory valve that allowed to directly measure the breath-by-breath VO_2 kinetics. VO_2 peak was accepted as the highest single value on breath-by-breath sampling and VO_2max was considered as the average values of the 5, 10, 15 and 20 s sampling obtained during the test. The obtained VO_2peak and VO_2max mean values in breath-by-breath and averaged 5 s sampling were similar to those described in the literature for experienced male competitive swimmers. Higher VO_2 values were observed for breath-by-breath sampling, being observed differences between that data acquisition method and all the other time intervals (5, 10, 15 and 20 s). Differences were also visible between the 5 s averaging and the other less frequent data acquisitions considered (10, 15 and 20 s), evidencing that less frequent sampling frequencies underestimate the VO_2max values. More future research about this topic, also conducted in real competition conditions, i.e., in swimming-pool (not in running or cycle ergometers) is needed.

Keywords: Front crawl, oxygen kinetics, swimming, VO_2peak, VO_2max.

INTRODUCTION

Success in competitive swimming is determined by several influencing factors, namely the bioenergetic and biomechanical ones, as it is possible to infer from the swimming performance equation: v = E * (ept / D), were v is swimming velocity, E represents the energy expenditure, ept is the propulsive mechanic efficiency and D represents the hydrodynamic drag [1].

Considering the disparity of the competitive swimming distances (ranging from 50 to 1500 m, which corresponds to 20 s to 15 min of duration), the 200 m freestyle may be one of the most interesting events. Being a very attractive race, it is bioenergetically situated between the 100 m freestyle event (with a clear predominance of the anaerobic metabolism [2]) and the 400 m freestyle distance (in which the aerobic metabolism evidences it full potential [3]). Thus, the 200 m event seems to depend both in anaerobic and aerobic energy pathways [2].

In this sense, accepting that the evaluation of the aerobic energy system contribution is very important for swimming training diagnostics purposes, we find important to study the specific oxygen uptake kinetics (VO_2) of the 200 m front crawl distance. However, when studying the VO_2 response to a specific effort it is essential to analyze the variability on the VO_2 data imposed by the used sampling interval [4]. Myers *et al.* [5] reported 20% of variability on the VO_2 values due to different chosen data sampling intervals. In this perspective, understanding that the swimming related community has not studied the best sampling interval to use when assessing maximal oxygen uptake, we aimed to study the variability of the peak VO_2 and VO_2max values obtained in a 200 m front crawl effort, using five different presentation intervals: breath-by-breath and average of 5, 10, 15, and 20 s, respectively.

METHODS

Ten male high-level swimmers volunteered to participate in the present study. Subject's characteristics (mean ± SD) were as follows: age = 20.5 ± 2.3 years, height = 185.2 ± 2.3 cm, body mass = 77.4 ± 5.3 kg and fat mass = 10.1 ± 1.8%. All subjects were informed of the protocol before the beginning the measurement procedures.

In a 25 m indoor swimming pool, 2 m deep, with water temperature of 27.5ºC, each swimmer performed a 200 m front crawl effort at maximal velocity. As swimmers were

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attached to a respiratory valve (cf. Fig. **1**) that allowed to directly measure the VO_2 kinetics [6], open turns without underwater gliding as well as in-water starts were used. This respiratory snorkel and valve system was previously considered to produce low hydrodynamic resistance [6]. VO_2 kinetics was measured breath-by-breath by a portable metabolic cart (K4b[2], Cosmed, Italy) that was fixed over the water (at a 2 m height) in a steel cable, allowing to follow the swimmer along the pool and minimizing disturbances of the "natural" swimming movements during the test. VO_2 peak was accepted as the highest single value on breath-by-breath sampling and VO_2max was considered as the average values of the 5, 10, 15 and 20 s sampling obtained during the test.

Fig. (1). Specific snorkel and valve system for breath-by-breath VO_2 kinetics assessment in swimming.

Mean ± SD computations for descriptive analysis were obtained for the studied variable using SPSS package (version 14.0 for Windows). Additionally, ANOVA of repeated measures was used to test the differences between the five different sampling intervals considered. A significance level of 5% was accepted.

RESULTS

Mean and SD values of VO_2peak VO_2max regarding the five time intervals studied are described in Table **1**.

Table1. Mean and SD VO_2peak and VO_2max Values (Expressed in $ml.kg^{-1}.min^{-1}$) Considering the Breath-by-Breath and the 5, 10, 15 and 20 s Time Intervals Studied in the 200 m front Crawl Test

Sampling Interval	VO_2peak/VO_2max ($ml.kg^{-1}.min^{-1}$)
Breath by breath	77.7 ± 5.5
5 s	68.1 ± 6.1 [(a)]
10 s	64.1 ± 5.2 [(a,b)]
15 s	62.1 ± 4.1 [(a,b)]
20 s	61.1 ± 3.0 [(a,b)]

Legend: [a] ≠ breath-by-breath, [b] ≠ 5 s (both for $p < 0.05$).

Higher VO_2 values were observed for breath-by-breath sampling, being observed differences between that data acquisition method and all the other time intervals (5, 10, 15 and 20 s). Differences were also visible between the 5 s averaging and the other less frequent data acquisitions considered (10, 15 and 20 s).

DISCUSSION

It is well accepted that for modern diagnostics of swimming performance, and after the Douglas bags procedures, new and more precise and accurate analytical techniques for VO_2 kinetics assessment are needed.

The obtained VO_2peak and VO_2max mean values in breath-by-breath and averaged 5 s sampling (respectively) were similar to those described in the literature for experienced male competitive swimmers [7, 8]. Regarding the primary aim of this study, our results seem to corroborate the specialized literature, conducted in other cyclic sport activities (namely treadmill running and cycle ergometer), which state that less frequent sampling frequencies underestimate the VO_2max values [5, 9, 10]. This fact seems to be explained by the greater temporal resolution that breath-by-breath sampling offers, allowing a better examination of small changes in high VO_2 values. However, the breath-by-breath gas acquisition could induce a significant variability of the VO_2 values acquired, being unanswered which of the models tested is the most appropriate sampling interval to be used.

More future research about this topic, also conducted in real competition conditions, i.e., in swimming-pool (not in running or cycle ergometers) is needed. Indeed, the selection of optimal sampling strategies is fundamental to the validity of the research findings, as well as to the correct training diagnosis and training intensities prescription. Literature results should be taken with caution when comparing VO_2peak and VO_2max values assessed with different sampling intervals. Additionally, a standardized criterion should be found to accurate set the VO_2peak that removes the possibility of selecting an artifact.

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