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LETTER TO THE EDITOR

About the use and conclusions extracted from a single tube snorkel used for respiratory data acquisition during swimming

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Abstract Pinna et al. (J Physiol Sci, 10.1007/s12576-012-0226-7, 2012) showed that a tethered swimming incremental protocol leads to higher maximal oxygen consumption values than during cycle ergometer and arm-crank tests, and evidenced that anaerobic threshold occurred at higher workloads during swimming comparing to other types of exercise. This is an interesting study in the field of exercise physiology applied to swimming that deserves merit once: (1) it employs direct gas exchange measurements during swimming, a rather hard task due to the characteristics of the water environment and the usual constraints imposed by the evaluation equipment, and (2) the physiologic comparison between swimming, running, cycling, and arm-cranking is complex, confirming that laboratory testing procedures are inadequate to estimate maximal oxygen consumption, maximal heart rate, and anaerobic threshold in swimming. However, in this Letter to the Editor, we would like to evidence some points that, in our opinion, are underdeveloped and not sufficiently clear, principally the incomplete description of the new breathing snorkel used, the non-reference to previous studies that used other snorkel models and obtained relevant data on oxygen uptake in swimming, and the assumption that swimmers uses less muscle mass when swimming than when running and cycling.

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In a previous paper, Pinna et al. [1] evidenced the use of a new breathing snorkel for respiratory data acquisition, but missed relevant information, particularly the values of dead space, and the diameter of tubes and valves. Authors refers the use of a similar snorkel as Roels et al. [2], but significant differences exists, specially the fact that it has only one breathing tube both for inspiration and expiration. This justifies its detailed and precise validation, once the possibility of mixing expired and inspired gases is not negligible. Moreover, the caliber of the tube allows one to suppose possible compromised ventilation that might impair exercise intensities closer to maximal oxygen consumption (VO_2max), or harder. Furthermore, Pinna et al. [1] validated their snorkel using a small number of subjects exercising in a cycle ergometer, conflicting with their main conclusion that no unspecific testing procedures should be used for swimming physiologic monitoring.

Likewise, authors have failed to report previous studies concerning specific snorkel and valve systems for swimming VO_2 assessment. Firstly, respiratory valves used for pulmonary function assessment on land were adapted for the Douglas bag method in swimming [3, 4], but, as they impose additional drag, a low-drag snorkel and valve system was developed [5]. Later, it was used for direct VO_2 assessment using mixing chamber's devices [6–9], and, afterwards, was upgraded [10] enabling real-time breath-by-breath data collection with a portable gas measurement system. Recently, a new AquaTrainer® snorkel was validated, presenting better air-flow, and ergonomic and comfort characteristics compared to previous models [11]. So, the use of commercially available respiratory snorkels is not recent, allowing researchers to collect data on the energy cost of exercise, time to exhaustion at the velocity corresponding to VO_2max, and VO_2 kinetics in swimming (cf [12–14]).

Another important question is that the protocols of Pinna et al. [1] had increments each minute, independently of the activity considered. VO_2max assessment protocols in swimming usually have steps of 4 min (or more), allowing muscle temperature to increase and pH to decrease, fostering an environment optimal for oxygen extraction. However, following a proper warm-up, 2–3 min of exercise has been shown to be sufficient for cardiovascular and biomechanical adaptations to occur promoting maximal oxygen extraction [15, 16]; furthermore, 200 m steps are frequently used for swimming incremental protocols [cf. 2, 7–9, 17]. Still, steps of 1 min duration [1] may not be sufficient to detect some of the cardiopulmonary parameters assessed in swimming monitoring (e.g. VO_2max and, particularly, anaerobic threshold-AnT).

Another hot topic is the quantification of the muscle mass involved in swimming, as some studies from the 1970s (e.g., [3]) suggested that, as reported by Pinna et al. [1], swimming requires less muscle mass than running and cycling; this explains why VO_2max has been considered lower in swimming than in the other two forms of exercise (despite being closer to cycling). However, Pinna et al. [1] observed that swimmers had a similar VO_2max during the swimming and running tests, being even higher during swimming compared to cycling. We agree that VO_2max is training-sensitive, but other explanations should appear, particularly that, at high velocities, swimmers use the lower limbs not only for balance but also for propulsion, significantly increasing the recruited muscle mass and energy expenditure comparing to previous beliefs. In recent EMG studies, a significant lower limb activity is observed [18], presenting an evident influence on the VO_2 uptake values [19]; also, di Prampero's group [20, 21] consider a muscle mass of 25 % of the total body mass for running, and 30 % for swimming. So, the statement that swimmers propel themselves using less muscle mass when swimming than when running and cycling should be treated with great caution.

Lastly, the fact that AnT was observed at a higher percentage of the maximum swimming workload (~82 %) compared to other exercise types is not a surprise, as it is accepted that it occurs at 80–85 % of maximum swimming intensity (e.g. [2]); in fact, when using the Vslope method, it was detected at 84.3 ± 8.7 % of the VO_2max [22], in agreement with running (82.3 ± 3.0 %, [23]) and cycling ergometers (84.6 ± 5.1 %, [24]) studies. So, as the subjects tested were swimmers, maybe data from running, cycling, and arm-cranking are underestimated. As the differences between exercise types were more evident in AnT than in VO_2max, Pinna et al. [1] argued that AnT appears to be more sensitive than VO_2max for detecting training specificity, and that it is a most useful indicator of aerobic endurance performance. We fully agree with the authors, once VO_2max is mostly used as an aerobic power indicator, more related with middle distance swimming efforts than with exercise around 30 min duration.

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