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ARM SYMMETRY IN 11-13 YEARS OLD FRONT CRAWL SWIMMERS

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The purpose of this study was to analyse the arm symmetry in age-group swimmers performing front crawl at very high intensity. Eighty trained swimmers of 11-13 years of age performed 25-m front crawl at 50-m pace. Two underwater cameras were used to assess the Index of Coordination (identifying each stroke phase) and the Symmetry Index. It was observed an asymmetry, which is in accordance with the results obtained for adult swimmers. It was also observed that only catch up mode was adopted by these young swimmers to achieve the swimming intensities corresponding to 50-m front crawl pace. Complementarily, the observed lower relative duration of the propulsive phases seems to be explained by the higher time spent during the entry/catch phase.

KEY WORDS: swimming, front crawl, arm symmetry, age group, kinematics.

INTRODUCTION: The front crawl technique, which is the fastest form of human aquatic locomotion, is often used in training and competition (Tourny-Chollet et al., 2009). This swimming technique is described as alternated, once when one arm is propelling, the other is recovering. However, this alternated action of the arms seems not to guarantee propulsion symmetry (Tourny-Chollet et al., 2009). In fact, as Seifert et al (2005) noticed, most of the front crawl swimmers adopt asymmetric arm coordination, which is characterized by a propulsive discontinuity of one arm action and propulsive superposition of the other arm.
To assess the arm symmetry in swimming, it was recently proposed the Symmetry Index (cf. Tourny-Chollet et al., 2009) that was adapted from Robinson's Symmetry Index (1987) applied to walking. However, to assess the Symmetry Index (SId) it has to be previously calculated the Index of Coordination (IdC). This last index, proposed by Chollet et al (2000), is based on the measurement of the lag time between the propulsive phases of the two arms. In addition, nevertheless it has been recently shown that it might not exist a common optimal movement pattern in high performance sports, common coordination patterns have been reported (Seifert et al, 2003), enabling, for instance, the distinction between skilled and less skilled performers.
The aim of this study was to characterize the SId (and the IdC) in 11-13 years old swimmers performing front crawl at very high intensity. For a more detailed, subjects were also studied by gender and maturation.

METHODS: Eighty swimmers (forty boys and forty girls) from the infant competitive swimming age group competitive category (girls of 11-12 and boys of 12-13 years of age) volunteered for this study. According to Tanner [27], images relating to the development of secondary sex characteristics were presented to the swimmers, and a self-evaluation rating (based in five stages) was carried on. Afterwards, the same images were presented to swimmer's parents and coaches separately. The final result was expressed as the mean value of these three evaluations.
All swimmers performed 25-m front crawl at 50-m race pace (controlled by their respective coach). In-water starts were used, and each subject swam alone. Two underwater video cameras (Sony® DCR-HC42E) recording the sagital and the transverse planes, and placed inside a sealed housing (SPK - HCB) recorded two complete underwater arm stroke cycles. To transform the virtual in real coordinates it was used a bidimensional structure (6.30-m^2, and thirteen calibration points). Biomechanical analysis was performed with the software APASystem (Ariel Dynamics, Inc., USA), being digitized frame by frame (at 50 Hz), two

consecutive non-inspiratory cycles, particularly the hip (femoral condyle), and, on both sides of the body, the distal end of the middle finger, the wrist, the elbow, the shoulder, the knee and the ankle.
Following Chollet et al. (2000), the IdC corresponds to the time from the beginning of the propulsive phase of one arm to the end of the propulsive phase of the other arm. IdC was calculated based on the division of the arm's actions in four phases: (i) entry/catch, corresponding to the time since the entry of the hand in the water until it starts to make the backward movement; (ii) pull, since the end of the previous action until achieve the vertical alignment of the shoulder (first propulsive phase); (iii) push, since the end of the previous action to the exit the hand of the water (second propulsive phase) and (iv) recovery, covering the time from the exit of the hand until its new emersion. The duration of a complete arm stroke was the sum of the propulsive and non propulsive phases.
The IdC was calculated for both arms, being defined as the time gap between the beginning of pull in the first right arm stroke and the end of the push in the first left arm stroke (IdC_{left}), and as the time gap between the beginning of pull in the second left arm stroke and the end of the push in the first right arm stroke (IdC_{rigth}) (Chollet et al., 2000). Following these authors, the IdC, and each stroke phases, were expressed as the percentage of the duration of a total arm stroke. The sum of the pull and the push phases, and of the catch and the recovery phases, gave the duration of the propulsive and non propulsive phases, respectively. With these two IdC values (IdC_{left} and IdC_{rigth}) it was possible to determine the arm coordination symmetry, which was calculated as following (cf. Tourny-Chollet et al., 2009):

$$[IdC_{left} – IdC_{right}/ 0,5(IdC_{left} + IdC_{right})] \times 100$$

Accordingly with the above referred authors, it is observed symmetry between left and right IdC when -10% < SId < 10%, and it is observed asymmetry when SId is above 10% (asymmetry to the right side) or below -10% (asymmetry to the left side) (Herzog et al., 1989).
Normal distribution of data and the interaction between gender and maturation were verified before statistical analysis. Comparisons of means between maturational groups were performed through an ANOVA test for independent groups, followed by a Bonferroni post-hoc test. Gender comparisons were performed using a t-test for independent groups. Significance level was 5%.

RESULTS: It was observed mean ± SD values for IdC of -7.94 ± 4.42 (%), evidencing that only the catch up coordination mode was adopted by these young swimmers when performing front crawl at very high intensity; this data and the IdC values by maturation and gender groups are shown in Figure 1 (not existing any statically differences between groups). The sum of the propulsive and of the non propulsive phases for all the sample (independently of swimming maturation or gender) was of, approximately, 42 and 57% (respectively).

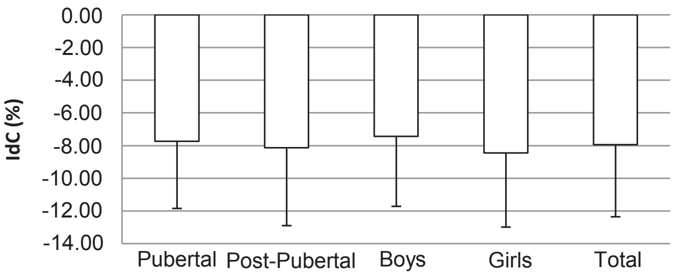

Figure 1: Mean and standard deviation IdC values (%) for maturation and gender groups, and for the total sample.

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Regarding the main aim of this study, it seems that swimmers, as a group, presented a symmetric arm action, with a tendency to an asymmetry to the right side (SId = 4.24 ± 115.47, being -300 the minimum and 370 de maximum registed). Likewise, when comparing maturation groups, it was registered symmetric values for pubertal (the mean was 0.92 ± 127.58, the minimum registed was – 300 and the maximum was 333) and post-pubertal (7.55 ± 103.49 ranging between the values of -169 and 370) swimmers, with no differences observed between groups. However, analyzing the SD values, this symmetry was not so clear, showing that the sample is very heterogeneous. Conversely, when a comparison by gender was made, it were observed asymmetric values to the right side for boys (28.19 ± 117.23) and to the left side for girls (-19.71 ± 109.96) (but without differences between groups). However, IdC_{left} (-7.46 ± 5.78 and -7.94 ± 5.93 for boys and girls, respectively) and IdC_{right} (-7.28 ± 5.85 for boys and -9.28 ± 5.36 for girls) were observed and, when compared, did not show any statistical differences between them. Relatively to the arm phases for the left and right arm, only the push phase to the left side showed statistical differences, which is longer for boys (25.90 ± 3.51 for boys and 24.30 ± 2.84 for girls). The entry/catch phase was the longer phase (~33%). The pull phase was the smallest phase (~18%) and the recovery phase showed values of ~24%.

DISCUSSION: As it was highlight above, independently of their gender and maturation, young swimmers adopted the catch-up coordination mode to perform the front crawl at high intensity, i.e., at velocities corresponding to their 50-m race pace. Although the post-pubertal and girls groups showed a tendency to exhibit lower values than pubertal and boys groups, respectively, there were no statistical differences between them. This fact is not coincident with the specialized literature conducted in older swimmers which evidenced that, at very high velocities, elite male (Millet et al, 2002; Schnitzler et al, 2007; Seifert et al, 2006) and elite swimmers from both genders (Chollet et al, 2000; Seifert et al, 2003b) always exhibited superposition coordination (expressing IdC values higher than zero).
As referred above, no statistical differences were noticed in IdC independently of swimmers maturation and gender. These results could be explained by the maturational perspective of motor development (Tourny-Chollet et al, 2009) since, nevertheless the organismic constraints (e.g. anthropometrical characteristics and maturation state) might imply some differences between swimmers, the task in which they were involved was similar. In fact, despite of the age differences, these swimmers belong to the same competitive age-group, and to swimming clubs with the presumably similar planning and periodization strategies since the respective coaches had also similar academic education. In addition, their competition is organized in groups where girls are younger than boys. According to Vorontsov (2010), girls begin their maturation earlier than boys, which can justify why the entire sample shows similar values. In fact, towards the age of 11-12 years, the adult kinematics and dynamic structure of swimming technique establishes both in girls and boys (Vorontsov, 2010), suggesting that the differentiation between genders only occurs when maturation is completed.
Complementarily, our age group swimmers spent lower relative duration in the overall propulsive phases rather than elite swimmers performing at very high intensity (>50%) (Chollet et al, 2000; Millet et al, 2002; Schnitzler et al, 2007; Seifert et al, 2003; Seifert et al, 2003b). Conversely, the values of non propulsive phases obtained by our swimmers is, to the best of our knowledge, the highest value of the literature, being the result of a longer entry/catch phase; the present age group swimmers spent more time in entry/catch phase than adults (~20%) (Chollet et al, 2000; Schnitzler et al, 2007; Seifert et al, 2003; Seifert et al, 2003b).
The mean values – indicating symmetry – obtained for the entire sample seems to be justified because after dividing the sample it was observed that boys adopted asymmetry to the right side and girls to the left side, which leads the mean to be closer to zero. This fact also leads the pubertal and post-pubertal groups to exhibited symmetrical mean values. When comparing genders (despite maturation groups), although girls showed a smaller values both genders exhibited asymmetry, but boys had asymmetry to the right side and girls

to the left side. These results related to asymmetry are in accordance to Seifert et al (2005), whom noticed that the most of the front crawl adult swimmers adopted asymmetric arm coordination suggested that asymmetry may thus be a true coordination mode and not just a functional error (Tourny-Chollet et al, 2009). According to these authors (Seifert et al, 2005; Tourny-Chollet et al, 2009) this asymmetry could be as a result of the unilateral breathing usually reinforced by learning and training.

Regarding to the arm left and right phases, the difference between genders in left push phase could explain this asymmetry. This longer phase showed by boys lead them to exhibited slightly high values (although not statistical significant) of IdC_{right} compared with girls. In this sense, boys try to maximize the strength of the right arm, which could be their dominant arm, to increase propulsion.

CONCLUSION: Only catch up mode was resisted in young swimmers when swimming front crawl at very high intensity. The observed lower relative duration of the propulsive phases was due to the higher time spent during the entry/catch phase. An asymmetry to the right side for boys and to the left side for girls were registered, which could be the result of the unilateral breathing usually reinforced by learning and training (as noticed before by Nikodelis et al., 2005 and Tourny-Chollet et al., 2009), but also due to the fact that young swimmers are in the middle of their maturational development.

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