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THE RELATIONSHIP BETWEEN FRONT CRAWL PERFORMANCE AND HYDRODYNAMICS IN YOUNG FEMALE SWIMMERS

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The aim of this study was to analyse the relationship between front crawl performance and hydrodynamic variables during leg kicking. Sixteen female swimmers (9.2±0.6 years) participated in this study. The 200m front crawl performance, the 200m front crawl kicking performance and the active drag during leg kicking were measured. The velocity perturbation method was used to determine active drag. The 200m front crawl performance was significantly correlated with performance in 200m kicking (0.89), with hydrodynamic drag force during leg kicking (-0.70), and power output in kicking (-0.64). Drag coefficient was not related to the performance in 200 m front crawl. These findings underline the importance of leg kicking to performance in front crawl swimming in these ages and suggests the important role of kicking tasks during training in young swimmers.

KEY WORDS: swimming, children, kicking tasks.

INTRODUCTION: Swimming performance is affected by several factors including swimming technique. The swimmer's technical proficiency comprises hydrodynamic variables such as hydrodynamic drag force and propelling force components. Previous investigations reported that forward propulsion in front crawl swimming is mainly achieved through the arm stroke with minimal contribution from the leg kick (e.g., Hollander et al., 1986; Toussaint & Beek, 1992). Additionally, other authors stated that the leg kick is the most inefficient action of front crawl swimming and its main function is to stabilize the trunk and keep the body in a streamlined position during swimming to reduce hydrodynamic drag (e.g., Bucher, 1974; Laurence, 1969). However, Deschodt et al. (1999) showed that the legs actually improve the propulsive action of the arms, thus improving the generated propulsive force of the whole body. In addition to the controversy around this topic, the investigation under the importance of leg kicking to overall performance in age-group swimmers and in females seems scarce. Therefore, the purpose of this study was to analyse in female age-group swimmers the relationship between front crawl performance and hydrodynamic variables during leg kicking.

METHODS: Sixteen young female swimmers volunteered to participate in this study. Their mean ± 1 standard deviation age, body mass, height and best swimming performance in 200 m front crawl was 9.2±0.6 years-old, 42.4±8.5kg, 1.5±0.1m and, 214.2±48.0s, respectively. All swimmers belonged to the same swimming club and were trained by the same coach for the last two years.

The performances in 200m short course front crawl, in the 200m short course front crawl kicking and the active drag during leg kicking were measured in three consecutive days. The velocity perturbation method was used to determine active drag in front crawl kicking (Kolmogorov & Duplishcheva, 1992; Kolmogorov et al., 1997). Active drag was calculated from the difference between the swimming velocities with and without towing the perturbation buoy. To ensure similar maximal power output for the two sprints, the swimmers were instructed to perform maximally at both trials. Both trials were conducted in a 25m indoor swimming pool and in-water starts were used (Marinho et al., 2010). Swimming velocity was assessed during 13m (between 11m and 24m from the starting wall). The time spent to cover

this distance was measured with a chronometer (Golfinho Sports MC 815, Aveiro, Portugal) by two expert evaluators and the mean value was considered for further analysis.
The normality of the distributions was assessed with the Shapiro-Wilk test. The performance in 200m short course front crawl was related to active drag data (drag force, drag coefficient and power output values) and to the performance in the 200m leg kicking using *Pearson* correlation coefficient. The level of statistical significance was set at α=0.05.

RESULTS: Table 1 presents the descriptive (mean ± 1 standard deviation) values of the performance in 200m front crawl, the performance in 200 m front crawl kicking and the active drag parameters during leg kicking.

Table 1
Descriptive (mean ± 1 standard deviation) values of the analyzed variables.

Variable	Mean±1SD
200m front crawl performance [s]	214.21±48.09
200m front crawl kicking performance [s]	313.56±59.71
Drag force during kicking [N]	9.48±4.42
Drag coefficient during kicking	0.25±0.11
Power output during kicking [W]	7.79±4.32

Table 2 presents the correlation between the 200m front crawl performance and the hydrodynamic variables during kicking (200m performance, drag force, drag coefficient, power output). One can notice that the 200m front crawl was significantly correlated with the performance in 200 m kicking (r=0.89; p<0.01), the hydrodynamic drag force during leg kicking (r=-0.70; p<0.01) and with power output during kicking (r=-0.65; p<0.01). Drag coefficient values were not related to the performance in 200 m front crawl.

Table 2
Pearson correlation coefficient between 200m front crawl performance and the hydrodynamic variables during kicking.

	200m front crawl performance
200m kicking performance	r = 0.89, p<0.01
Drag force during kicking	r = -0.70, p<0.01
Drag coefficient during kicking	r = -0.42, p=0.12
Power output during kicking	r = -0.65, p<0.01

DISCUSSION: The purpose of this study was to analyse in age-group swimmers the relationship between front crawl performance and hydrodynamic variables during leg kicking. The main data suggests that in female age-group swimmers the 200m front crawl performance seems to be dependent on leg kicking actions.
The velocity perturbation method was used to determine active drag in front crawl kicking. This method has been previously used in other investigations (e.g., Garrido et al., 2010; Kolmogorov et al., 1997), representing a simple and reliable approach to determine active drag in young swimmers. Indeed, one of the great advantages of this methodology is to allow its use in large groups of swimmers. In contrast to other methodologies, that required heavy and costly experimental procedures, the velocity perturbation method just required the use of the hydrodynamic body device and a chronometer to assess active drag, an important criterion to be considered during young swimmers evaluations (Barbosa et al., 2009).
To the best of our knowledge, there is no study in the literature analyzing the active drag during front crawl leg kicking in young female swimmers. Therefore, the comparisons are somewhat difficult to be carried-out. Hydrodynamic drag values of the current study were much lower than data found in other experiments conducted with children for whole body front crawl swimming, assessed with this same procedure (e.g., Kjendlie and Stallman, 2008; Marinho et al., 2010). This difference was expected, since the velocity achieved during leg

kicking is much lower than the one during whole body front crawl stroke. Moreover, the body position during leg kicking tends to be more stable, thus reducing hydrodynamic drag.
Regarding the relationship between front crawl performance and kicking variables, it is important to stress out the significant association between the 200m front crawl performance and the 200m kicking performance, drag and power output during leg kicking. The swimmers who achieved better performances in 200m front crawl presented higher values of hydrodynamic drag and power output and better performances in the leg-kicking test. McCullough et al. (2009) found similar trend (r=0.79) in short distance tests (correlation between 50m swim time and 22.86m kick time), in adult women (i.e., 20.6±1.6 years-old). Although the assumption that the contribution of leg kicking to overall performance in front crawl is reduced, when compared to arm stroke (e.g., Hollander et al., 1986; Toussaint & Beek, 1992), the results of the current study can be supported by the data of Deschodt et al. (1999), stating the role of leg kicking in front crawl stroke in young swimmers.
This paper reports only to front crawl, being the swim stroke with more competitive events and that some coaches present more training routines and drills on regular basis. However, since it is possible to apply the velocity perturbation method to all competitive strokes, it seems interesting to enlarge this study to remaining ones and to verify the role of leg kicking to overall performance at butterfly, backstroke and breaststroke.
Main limitations of this study can be related to the inference of these results to other aged swimmers (e.g., adult/elite ones) and remaining swim strokes.

CONCLUSION: In young female swimmers the performance in 200m front crawl seems to be dependent on leg kicking actions. Therefore, the swimmers who presented higher values of hydrodynamic drag force and power output during leg kicking also achieved better performances in 200m front crawl. Moreover, the correlation between leg kicking performance and 200m front crawl performance confirm the role of leg kicking action to overall performance in front crawl swimming at these ages. These findings can suggest the important role of kicking actions tasks during training in young swimmers.

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