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KINEMATICAL AND NEUROMUSCULAR ASPECTS RELATED TO PERFORMANCE DURING THE SWIMMING START

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The aim of this study was to relate kinematical and neuromuscular aspects with performance in the swimming start. Ten swimmers took part in this study. Kinematical analysis (flight distance, flight time, start and entry angle and maximum height) and the muscle power were evaluated. Pearson's correlate with significance set at 5% was used. Significant correlation of the start angle with flight distance ($r= -0.59$; $p< 0.05$) and with flight time ($r=0.88$; $p< 0.01$) were found; between maximum height and flight time ($r= 0.59$; $p< 0.05$) were found too. We can conclude that performance in the swimming start was determined by the start angle and maximum height. Muscle power did not affect performance in swimmers in this study.

KEYWORDS: swimming, muscle power, biomechanics

INTRODUCTION: Swimming is a sport whose time is the great adversary, where the details of technique execution are very important to obtain good results. The motion technique in swimming is divided in three phases: start, turn and swim (Hay, 1981). According Blanksby et al. (1998), a good starting block provides a significant advantage for the swimmer and can represent approximately 10% of the total time in short race. An efficient swimming start, in all of the swimming events, depends on the great combination of the actions on the block and the swimmer's projection to the water in order to positively influence the subsequent phase (Ruschel et al., 2007). Besides the biomechanical aspects of performance technique, lower limbs muscle power training is extremely important when seeking improved performance in the swimming start (Breed & Young, 2003; Bocalini et al., 2007). Despite the importance of muscle power to swimming performance, there were found few studies to correlate this variable with performance. Thus, more studies are needed to fill the gap in the literature and assess the level of importance of this variable in the swimmers performance. Furthermore, a perfect swimming start technique is a fundamental part of good performance, because a simple technical error may be responsible for increasing the race time. In the present investigation we used the flight distance and flight time as the main variables in performance. Thus, the aim of this study was to relate kinematical and neuromuscular aspects with performance in the swimming start.

METHODS: Ten swimmers (26.4 ± 6.6 years; 76.4 ± 6.6 kg of body weight; 181 ± 7.1 cm of height) took part of this study. All procedures received local ethics committee approval. A video camera (Sony®, DSC-P32, 30 Hz) was positioned 3 m of distance in the start block and 1.20 m of height. Landmarkers were placed in the specific anatomic points: acromiale, radiale, stylion, trochanterion, lateral tibiale, lateral malleoulus and second metatarsal. Data collection was carried out in the 50 m indoor swimming pool (Florianópolis, SC, Brazil). The swimmers realized one starting block with the grab starting. After the calibration, the date was digitalized in the Skill Spector® software (version 1.2.5) to obtain the spatiotemporal variables. To the angle analysis, the images files were exported and analyzed by Corel Draw X3® software (version 13). The kinematical variables analyzed were: a) flight time (time elapsed from the last contact with the block to the contact of the swimmer's hand with the water); b) flight distance (distance measured from the moment of last contact to the moment the swimmer's hand touched the water); c) maximum height (greatest height reached by the hip joint); d) start angle (the angle formed by the swimmer's body and the horizontal plane at starting block); e) entry angle (angle between the trunk of swimmer and horizontal plane

when the swimmer's hand touched the water). The muscle power was assessment by the squat jump (SJ) on the force plate (Kistler®, Quattro Jump, 9290AD, Winterthur, Switzerland). Three SJ was realized and the mean of jump height, power and peak of velocity were used by level of muscle power. Descriptive statistics (mean and standard deviations), Shapiro-Wilk test and Pearson's correlate were used with significance set at 5%.

RESULTS: The descriptive values of kinematical and neuromuscular variables are shown in table 1.

Table 1
Descriptive values of kinematical and neuromuscular variables.

	Mean	Standard deviation
Flight distance (m)	3.3	0.16
Flight time (s)	0.40	0.05
Start angle (º)	20.0	6.3
Entry angle (º)	39.1	10.3
Maximum height (m)	1.40	0.12
Power ($W \cdot kg^{-1}$)	21.6	3.0
Height (cm)	43.4	4.8
Peak of velocity ($m \cdot s^{-1}$)	2.63	0.2

Significant correlate of the start angle with flight distance and flight time were found. In addition, significant correlate between maximum height and flight time was found. No significant correlate between entry angle and performance (flight distance and flight time) and neuromuscular variables and performance were found (table 2).

Table 2
Correlations of kinematical and neuromuscular variables with performance in the starting block.

		Flight distance (m)	Flight time (s)
Neuromuscular variables	Power ($W \cdot kg^{-1}$)	-0.49	0.39
	Height (cm)	-0.47	0.30
	Peak of velocity ($m \cdot s^{-1}$)	-0.45	0.30
Kinematical variables	Start angle (º)	-0.59*	0.88**
	Entry angle (º)	-0.52	0.26
	Maximum height (m)	-0.41	0.59*

* $p < 0.05$; ** $p < 0.01$

DISCUSSION: The main finding of this study was the significant correlation of the start angle with the flight distance and the flight time. Accordingly, it is possible to indicate that when the athlete performed the swimming start with smaller angles, your body will promote a better trajectory (projectile) and thus obtain higher flight distance and lesser flight time before reach the water. According Maglischo (1999), an optimal angle between the swimmer's body and the horizontal plane at swimming start allows the athlete to achieve an arc trajectory, thereby promoting a correct underwater. Furthermore, the start angle is several determinant of other variables such as entry angle, flight time, flight distance and swim velocity (Vaghetti et al., 2010), interfering directly in the race performance. Another significant correlation between hip maximum height and flight time was found, i.e., higher values of maximum height correspond to higher values of flight time achieved by the swimmers. Thus, the swimmer shouldn't perform the swimming start with high hip height because this increases the flight time and consequently decrease the swimming start performance. The moment that the swimmer is in the maximum height of flight phase, he must prepare to underwater. According Vaghetti et al. (2010), during this moment the hips should be flexed, knees and elbows

extended, head between arms, so that the swimmer can reach the water with a good angle to the horizontal plane and your body dive by the hole made by hands. In addition, the angle of entrance may influence the depth of glide (Miller et al., 2003), according to Ruschel et al. (2007) who found significant correlation between entry angle and total start time in 15 m (r = 0.51). In other hand, in this study no significant correlation between entry angle and performance was found. The lack of significant correlations between the muscle power and performance variables in the swimming start (flight distance and flight time) can be explained by specificity jump. Despite the vertical jumps are reliable markers of muscle power assessment in athletes of different sports (Markovic et al., 2004), the vertical jump may be not sensitive for assessment the swimming performance, which may have affected the results. Although no significant relationship found between these variables, should be considered that the lower limbs muscle power is an important physical fitness to the starting block, according researches (Breed & Young, 2003; Bocalini et al., 2007) that found an improvement in the swimming start after power training.

CONCLUSION: We can conclude that performance in the swimming start was determined by the start angle and maximum height. Muscle power did not affect performance in swimmers in this study. Thus, the start angle and maximum height are mean important factors to be observed by athletes and coaches, in order to improve the execution of swimming start.

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