THE INFLUENCE OF SEX AND ANTHROPOMETRIC PARAMETERS ON THE PARTIAL AND TOTAL VELOCITIES OF PORTUGUESE TOP SWIMMERS.

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INTRODUCTION.

The relative contribution of the arms and the legs to the swimmer's speed has been. since ever, a matter of interest for coaches and researchers, especially in the crawl stroke. From all the studies produced, some consensuality arose: legs are, obviously, less propulsive than arms, they also are more demanding from an energetical point of view and. beyond propulsion, they can play an important role on the support and allignement of the body and in the reduction of drag resistence.

However, between each stroke and from swimmer to swimmer, it exists a wide field of variation on what concerns to the use of the legs. The role that legs are playing is a function of factors such as sex, physical and stroking characteristiques of the swimmer. the stroke and the swimming distance, being important to the coach to determine what kind of work legs are doing on that particular swimmer, in order to act according to it.

Between all the available studies, just a few are worried about the determination of the direct influence of all those factors. on the way in which legs are used and how they link themeselves with the arms in order to achieve maximum speed.

For instance. Persyn et al. (1983) founded significant differences between some anthropometric parameters of front crawl swimmers using distinct rythms of leg kickings, while Grimston Hay (1986) correlated indicatars such as speed, stroke distance and stroke cycle with selected anthropometric variables, namely lengths. frontal areas and cross-sectional areas of body segments. Before that. Clarys et al (1974) had already show that dimensions and body forms have a strong influence on the tatal resistance of the water.

Other authors have suggested that men and women use legs in different forms. For instance Smith (1978) observed that, sometimes, female swimmers are faster than male when using only the legs. It is also the case of Watkins & Gordon (1983) ; these authors demonstrated that it is harder for men to swimm only with the arms, when the legs are not supported, which permitted them to conclud that. while in female swimmers legs contribute more to propulsion, in male swimmers they are more important in supporting and alligning the body.

So, the objectives of this investigation were to study, in portuguese swimmers and in the four strokes, the variation of same performance indicators, namely, the relative contribution of the partial an the total velocities, the increase of speed induced by the legs action and the degree of coordination of the action of both arms and legs, in order to achieve maximum speed, in function of the sex of the swimmers and of selected anthropometric parameters, such as lengths, frontal areas and croos-sectional areas of body segments.

METHODOLOGY

The methodology consisted in the following basic steps:

A) constitution of two groups of swimmers Imale .and female group) each of them with 14 individuals all recruted in one of the portuguese best competitive teams.

B) definition of the variables. The independent ones were tho sex, in one case, and the following anthropometric parameters, in the other: the highest values of the lengths, frontal areas and cross-sectional areas of the trunk, arm, forearm, hand, thy, leg and foot. On the foot, the f rontal area o f the plantar zone was also considered

because of the breasstroke. The length of the trunk was excluded. The dependent variables were, in both cases and for each stroke, the following performance indicators: partial velocities (arms only, legs only) total velocity, relative participation of the partial velocities on **total** velocity, increment of speed induced by the legs action and the coordination coefficient, which is equal to the ratio between the squared total velocity and the sum of the squared partial velocities, multiplied by **100.**

C) determination of a series of swimming times using the standard test situation proposed by Bucher **(** 1975 ,) and ilustrated on figure 1. Each swimmer had to **swimm** twelve laps of 15 meters, three in each stroke, only with the arms (leg's supported) only with the legs (no arms support) and with both.

D) determination of the selected anthropometric parameters, using an adaptation of the photographic procedure developed by **Grimston** & Hay (1986). The relevant points were marked on the swimmers and they were photographed just after they assumed the postures shown in figure 2. In order to compute a conversion factor between projected and real measures, a graduated scale was also photographed in the same plane. By means of digitizing techniques, the lengths, widths, depths and the frontal areas for the segments were obtained. The frontal areas of the plantar region of the feet were obtained by direct digitization of the footprint drawned on sheets of paper. The cross-sectional areas on the limbs and **trunk** were estimated using the formula for the area of an ellipse, with the smaller and the larger axes equal to the width and to the depth of the body segment, respectively.

E) Statistical analysis involving. In the comparison between the two groups, were used the T Student test and the variance analysis. Within each group, the **Bravais Pearson** correlation coefficient was used to search for relations between the performance indicators and the anthropometric variables.

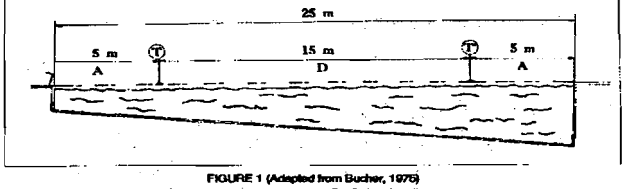

FIGURE 1 (Adapted from Bucher, 1975)
A - Starting and ending zones; D - Swimming distances
T - Start of time counting; T'- End of time counting

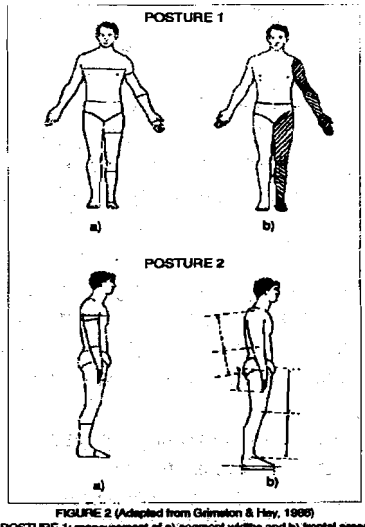

FIGURE 2 (Adapted from Grimston & Hay, 1986)
POSTURE 1; measurement of a) segment widths and b) frontal areas
POSTURE 2: measurement of a) segment depths and b) segment lengths

RESULTS AND DISCUSSION

About the comparison between the two groups, table 1 makes a first qualitative approach, in which it is possible to verify that, apparently, male swimmers are more dependent on the arms to swimm at maximum speed. Consequently, on female swimmers the INC variables tend to be higher, just like the efficiency of the coordination between arms and legs, as expressed by the respective coefficient. In fact, both INC and CC are always higher in the female group, in opposition with PA, always bigger in the male group. PL is bigger in backstroke and in breaststroke in the female group, while in butterfly and f ront crawl is higher in the male group where, even though, induces smaller speed increments.

Table 1. Qualitative comparison of the results of both groups, in all the strokes and in all the variables.

Variables	PL	PL	PA	PA	INC	INC	CC	CC
	%	%	%	%	%	%	%	%
Groups	M	F	M	F	M	F	M	F
Fly	+	-	+			+		+
Back	-	+	+			+		+
Breast	-	+	+			+		+
Free	+	-	+			+		+

(+) higher average value in the group; (-) lower average value in the group. M - male group; F - Female group; PL - participation of the legs; PA - participation of the arms; INC - increment of speed induced by the legs; CC - coefficient of coordination.

Table 2. Significant differences between both groupes, in the four strokes and for all the considered variables.

Butterflv	Backstroke		Breaststroke		Freestvle
PL	T=2.102 c)	PL	T=1.713 b)	PA	T=1.839 b)
	F=4.421 b)		F= 2.935 a)		F=3.383 a)
PA	T= 3.678 e)	PA	T=1.763 b)	INC	T=1.839 b)
	F=13.525 d)		F=3.107 a)		F=3.383 a)
INC	T= 3.678 d)	INC	T=1.597 a)	CC	T=1.875 b)
	F=13.525 d)				F=3.516 a)

T - One tailled Student's T test; F - Analysis of variance F ratio.
a) - Significant for P< .10; b) - Significant for P< .05; c) - Significant for P< ,025; d) - Significant for P< .0l; e) - Significant for P< .005; Pl - Participation of legs; PA - Participation of arms; INC - Increment of speed induced by the legs; CC - Coefficient of coordination.

Although existing, not all these differences are significant from a statistical point of view. Those who are, are included on table 2. Only in butterfly significant differences were not found. On the other strokes, PA and INC are always significantly different, while PL denotes significant differences in backstroke and in breaststroke and CC only in the front crawl stroke.

For each group, table 3 shows the most important correlations eiitablished between the considered variables, while the values of R express the percentage of explained variance in the dependent variables, by the independent variables. Although other significant correlations have been found, only those higher than 0.75 for men and 0.65 for women are presented. The male group presented a lot more significant values of R

than the female group. The correlations for the male group involved mainly partial and total velocities. For the female group, the correlated performance variables were the PA, the INC (twice) and the CC.

Table 3. Correlation between the performance indicators and the anthropometric parameters. Most signficant values of R and R2 in both groups. For the male groups, only r values higher than .75 are includede. For the female group, onlz R values are higher than .65 are included.

Stroke	Correlated variables	R^2 value (explained variance)
	Male group	
Fly	FA FOOTdr/VLA	69%
	CSA AXILA/VAA	59%
	CSA ARM/VAA	62%
	FA ARM/VAA	67%
	CSA ARM/VTS	59%
	CSA THY/ VTS	64%
	FA ARM/VTS	62%
	FA FOOTdr/CC (-)	67%
Back		
Breast	CSA AXILA/VTS	61%
Free	FA FOREARM/VAA	71%
	FA ARM/VTS	61%
	Female group	
Fly	LGTH THY/INC	46%
	LGTH THY/PA (-)	46%
	FA THY/INC	49%
	CSA LEG/CC	45%
Back		
Breast		
Free		

FA - Frontal area; CSA - Cross sectional area; LGTH - Length; FOOTdr - Dorsal portion of the foot; VLA - Velocity with legs alone; VAA - Velocity with arms alone; VTS - Velocity with total stroke; PA - Participation of arms; INCincrement of speed induced by the legs; CC - Coefficient of coordination.

Except for backstroke, all the other strokes presented significant values of R in the male group. However, the larger amount of significant values of R was found in butterfly. This stroke was the only one for which significant values of R were found in the female group.

For both groups the high values of Rü show the importance of these anthropometric parameters on factors that may determine successfulness on competitive swimming, especially the frontal and cross-sectional areü.s, just as Grimston & Hay (1986) pointed. The obtained values of R varied between 59% and 71% in the male group and between 46% and 49% in the female group. Those values were higher than those found by Grimston & Hay (1986). However, these authors have used performance indicators that were different from those used in this work.

CONCLUSION

For the portuguese swimmers, the sex and the anthropometric parameters considered influence the way in which the propulsive forces of the arms and legs me coordinated to obtain the maximum swimming speed. While all the strokes are influenced by the sex of the swimmer, his (her) physical characteristics are important mainly in butteffly and in the male group. This results suggests that the portuguese female swimmers are not yet differenciated from a non-swimmers population. The results also suggest that the portuguese male swimmers me more dependent than the female on the action of the arms, to achieve the maximum speed. Female swimmers use more the legs to increase propulsion and are more effective in the coordination of the action of the arms and legs for the developmentof the maximum speed.

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