RELATIONSHIP AMONG ANTHROPOMETRIC CHARACTERISTICS, STROKE FREQUENCY AND STROKE LENGTH IN BRAZILIAN ELITE SWIMMERS

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INTRODUCTION: Several authors have been investigating the relationship among speed (V), stroke length (SL) and stroke frequency (SF) in competitive swimming for different distances with different swimming styles. Among these authors are: East (1970); Letzelter & Freitag (1983); Swaine & Reilly (1983); Craig et al. (1985) and Reischle (1991).
The close relationship between performance and the body's anthropometric characteristics has been known since the end of the last century, but it was not until the fifties that research in the area intensified. Since then, many anthropometric characteristics of the human body have been investigated and related to performance in sports, especially in swimming.
Lowenstein et al. (1994) studied the effects on swimming performance of artificially simulated increases in body fat levels of 2%. Fat levels were simulated with latex pads stuck to the bodies of swimmers. Swimmers with latex pads swam significantly slower than those who swam without them. There was also a significant correlation between, on the one hand, the difference in swimming times and, on the other hand, the percentage increase in simulated fat.
Keskinen et al. (1989) investigated the influence of height, span, mass, total height and body density on performance in short swimming events.
Smith (1978) investigated the relationship between performance and the following anthropometric characteristics: mass, height length of arms and legs. He found negative correlations between swimming time and weight and also between swimming time and leg and arm length.
Sprague (1976) measured 25 anthropometric variables and concluded that only the measures of foot, biceps and skinfold showed significant correlations with performance in freestyle swimming.
The relationship among performance in swimming, SF and SL is broadly documented in the literature, but the relationships among anthropometric characteristics, SF and SL are far less frequently mentioned.
The aim of this study is to identify which of the anthropometric measures are more related to stroke frequency (SF100) and stroke length (SL100) in the 100 meter freestyle events for Brazilian elite swimmers.

METHODS: Twenty Brazilian elite athletes swam 100 meters with maximum effort in a 25 m pool, starting in the water. A video camera VHS Sony model CCD-V700E, 50 Hz, was fixed to the side of the pool, perpendicular to the direction of swimming.
The analysis of the film was made with a program developed by Peak Performance Technologies, Inc. The hand (during its aerial phase) and the head were manually digitized. The data were analyzed by a 80386 PC interfaced to the video recorder (VCR). The initial and final 5.5 meters were not considered for the analysis.

Speed was assessed by determining the time it took for the swimmer to move between two specific points. These points were the final and the initial positions of the head in the water as it appeared digitized in the system. SF was assessed by determining the position of entry of the hand into the water, as digitized in the system. Speed, stroke frequency and stroke length were assessed for a 15-meter span in each 25 meter lap. The average value of each these parameters (V, SF and SL) was obtained by summing the values for the 4 laps and dividing the total by four.
The anthropometric measures were taken before the swimming test and consisted of 28 corporal measures. The measures were the following: mass and total height (obtained by conventional methods); height measures: breast bone (vertical distance from the ground to the Processus xyphoideus), seated (vertical distance from the base of the seat to the vertex), shoulders (vertical distance from the ground to the Ancromio), hips (vertical distance from the ground to the larger Trocanter), knees (vertical distance from the ground to the medial condyle); Malleolus (vertical distance from the ground to the internal Malleolus medialis); width measures: hips (horizontal distance among the Cristae iliacae), thorax (horizontal distance among the most distant points of the thorax taken at the height of the nipples); depth measures: waist (sagittal distance of the body at the height of the transversal minimum), buttocks (sagittal distance of the buttocks at the height of its largest curvature), thorax (sagittal distance between the Processus xyphoideus and the spine taken at the height of the nipples), total depth of the thorax (sagittal distance between the most distal part of the back and the nipples); length measures: arms (distance between the Ancromio and the Articulatio humeroradialis), forearm (distance between the Articulatio humeroradialis and the Processus styloideus), foot (horizontal distance between the heel and the most distant point reached by the toes); circumference measures: thorax (taken with a measuring tape around the thorax at the height of the nipples), arms (taken at the greatest girth of the upper arm), elbows (taken around this joint), wrist (taken on the Processus styloideus), fists (taken with closed hand and the thumb flexed over the middle finger), thighs (taken horizontally at the thigh's most proximal point), knees (measure taken horizontally in the middle of the patella), Malleolus (measure taken on the leg directly above the Malleolus); measure of the area of the right hand (obtained by tracing the outline of the hand onto a sheet of paper, Graphyk software AUTOCAD RELEASE 12 was employed for calculating the area and perimeter of the hand); span measure (measure of the distance between the middle finger of each hand with abduction of the arms). The assessment of the transverse area of the thorax was obtained by the formula for an ellipse added to the formula for two semi-circles. The ratio of the semi-circles was determined by means of the difference between the two measures of the depth of the thorax.

RESULTS: The SF100 variable correlated positively and significantly with the following anthropometric measures: depth of the waist (r = .48), depth of the buttocks (r = .46) and transverse area of the body (r = .45). There was no significant correlation with the other measures. Several measures correlate negatively with SF100, among them the various height measures, width of the thorax, the various length measures, except the length of the feet. Other negative correlations are: the measures of the circumference of the knees and elbows and the perimeter of the right hand. 71% of the circumference measures had a positive correlation with SF.

The variable SL100 correlated significantly and negatively with the variables width of the pelvis (r = -.54), depth of the waist (r = -.46) and buttocks (r = -.47) and the transversal area of the body (r = -.52). Also, there were other correlations which were negative but not statistically significant in relation to the measures of the depth of the thorax, length of the feet, circumference of the arms, wrists, closed fists, thighs and thorax. Positive correlations were observed in all the height measures and in the majority of the length measures.

The stepwise regression analysis showed that the length measures contributed 34.98% to the determination of the variable SF100. This was followed by the variables depth of waist with 22.79%, the circumference measures with 17.18%, the height measures with 12.52% and the width measures with 12.51%.

The main anthropometric factor which influenced the variable SL100 was the width measures (35.06%). Other factors were: length measures (29.98%), circumference (19.01%) and, finally, height (15.93%).

DISCUSSION: Athletes who use high SF, compared to the athletes who use high SL, have a tendency to be wider in the sagittal and frontal planes of the middle part of the body, and less robust in the thorax.

The regression analysis among SF100 and the anthropometric measures showed a 71.9% negative correlation, and there was also an approximately 47% negative correlation of anthropometric measures with SL100. There is a tendency to a prevalence of negative correlations with SF and positive correlations with SL. Such a tendency can also be found for the swimmers in the studies by Grimston & Hay (1986).

Positive and significant correlations between SL and the variables span, height and corporal mass were found in the study by Keskinen, Tilli & Komi (1989). No significant and positive correlations were found between SR and height and corporal mass, and a negative but not significant relationship was found between SF and span. These results could not be confirmed in this study, probably due to the gender differences between the investigated groups.

A broader comparison of these results with the results of the current literature cannot be made, mainly in virtue of the differences of the protocols employed in the anthropometric measures. Other important differences which prevent us from making further comparisons include: gender and level of performance of the groups, and the statistical procedures employed in the data analyses.

CONCLUSIONS: The following conclusions have been drawn from the results of this investigation:

1. A negative correlation prevailed for the variable SF.
2. A positive correlation prevailed for the variable SL.
3. The athletes who use a greater stroke frequency in the 100 meter freestyle tend to be shorter, with shorter arms and legs, narrower thorax and deeper abdomen, thicker arms and legs and larger feet.
4. The athletes who use a larger stroke length in the 100 meter freestyle tend to be taller, with longer arms, narrower pelvis and wider thorax, thinner arms and legs and smaller feet.

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