MAXIMUM PROPULSIVE FORCE AND MAXIMUM PROPULSIVE IMPULSE IN BREASTSTROKE SWIMMING TECHNIQUE

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INTRODUCTION

Recently, a intermittent light trace photographic method was used to assess breaststroke swimming speed fluctuations (Vilas-Boas, 1994). With swimming speed profiles, is possible to estimate horizontal resultant impulses per stroke phase. Nevertheless, this method doesn't take into account the center of gravity (CG) kinematics, but only a fix anatomic spot. Meanwhile, the assessment of CG kinematics in swimming is rather difficult (McIntyre and Hay, 1975; Colman et al., 1989). and naturally face even more problems than usual one-media film procedures (Stijnen et al., 1981).

The aim of this study was to evaluate the relationship between breaststroke maximum propulsive impulse per stroke phase, estimated from light trace photographic method, and maximum propulsive tethered force. As a secondary purpose, we evaluated gender differences in maximum breaststroke tethered propulsive force and maximum propulsive resultant impulse during the stroke cycle.

MATERIAL AND METHODS

Subjects were 12 Portuguese top level breaststroke swimmers (7 females and 5 males). Mean age was 17.6 (SD = 1.67) years for males and 14.6 (SD = 1.72) years for females. Weight and height mean values were, respectively for males and females: 66.0 (SD = 9.33) Kg; 54.0 (SD = 6.79) Kg; 173.8 (SD = 7.60) cm and 163.1 (SD = 4.78) cm.

Maximum tethered swimming force was registered trough a Lafayete-Jackson force transducer, model 32528, mounted in specially designed support and previously calibrated. This support allowed the measurement of the horizontal component of the force exerted by the swimmer. The swimmers, wearing a special waist belt, were connected to the force transducer trough a steel cable with reduced elastic properties. After a 30 min slow pace free warm-up period, subjects performed a three times 6 sec of maximum breaststroke tethered swimming, with a 5 min rest period. Immediately before each 6 sec bout, swimmers performed a 5 to 10 sec of submaximal tethered swim, in order to keep the steel cable fully extended.

Maximum propulsive resultant impulses per stroke phase were calculated trough speed fluctuation profiles, that were assessed using a photo-optical method (Vilas-Boas, 1992). This was based on extended exposure photographic (Canon T70, 1000 ASA film) light traces of a pulse light device placed in the waist of the swimmer, at a middle distance between the two hip joints. After digitizing (CalComp table and Sigma Scan software), pairs of values for time (t) and speed (v) were modeled using special polynomial regression procedures (Vilas-Boas, 1994). Using the model, time t values for maximum and minimum speed values during the stroke cycle were determined trough derivation (PC-Matlab, 3.13). and acceleration values per phase were determined. These values were then multiplied by the swimmers body mass, and again by the time duration of each stroke cycle phase, in order to allow the assessment of resultant impulses per phase.

For horizontal resultant impulses per stroke phase estimation, each swimmer performed 3 times a 25 m distance at 200 m race pace, paced through a Pacer Products light pacer. Between each trial a 20 min rest was observed.

Maximum propulsive impulses per phase were correlated with individual maximum propulsive tethered forces. Mean differences between genders were tested using one way ANOVA for a = **0.05,** using the Fisher PLSD test.

RESULTS

Results on.horizontal resultant impulses per breaststroke phase are presented in Figure **1.**

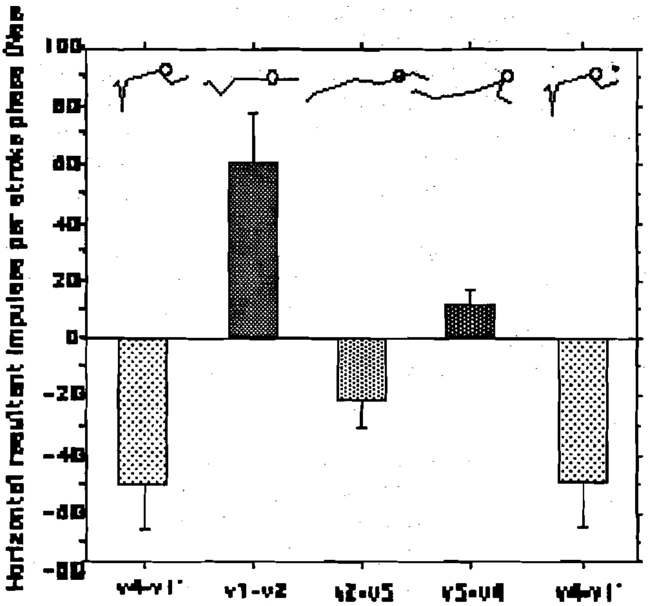

Figure 1. Means and standard deviations for horizontal resultant impulses per breaststroke stroke phase. vl **...** **v4** are minimal and maximal values of the speed fluctuation equation.

Figure **2** shows the results of maximum propulsive impulse and maximum tethered force. Individual and gender means are presented. A wide variation within subjects can be observed, as well as a statistical significant difference between means obtained for males and females in both parameters.

The **Pearson** correlation coefficient calculated between maximal tethered force and maximal positive horizontal resultant impulse was r = **0.851** **($p<0.05$).** The correspondent value of the determination coefficient was r^2 = **0.723,** which means that **72.3%** of the variance of each parameters are associated with the variance of the other.

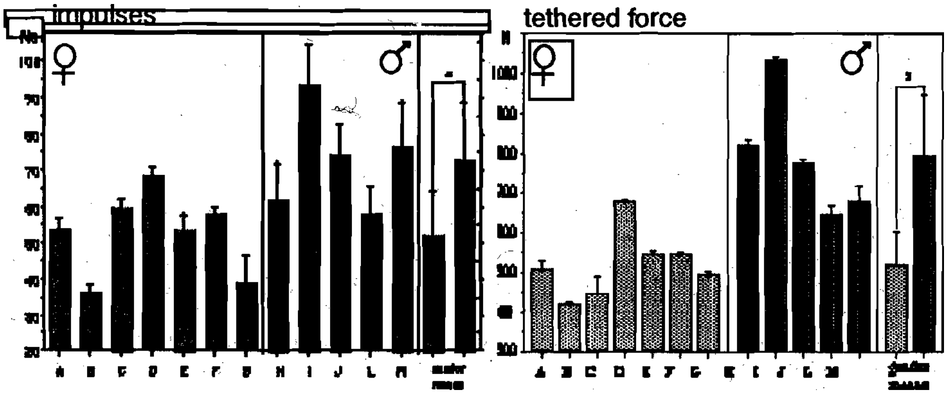

Figure 2. Means and standard deviations for individual and gender maximum resultant propulsive impulses and maximum propulsive tethered force results. A to M are subjects (* = p<0.05).

DISCUSSION

Figure 1 shows that, in accordance with literature (van Tilborgh et al., 1988). breaststroke technique is characterized by a succession of resistive and propulsive phases, and that is during the acceleration phase associated to the leg kick that is observed the higher positive, or propulsive, horizontal resultant impulse. The second higher positive impulse may be associate to the armstroke. These results, however. can't be directly compared with those previously reported by van Tilborgh et al. (1988), since these authors considered other phases than those established in this study. Nevertheless, results seem to be fairly consistent, mainly if it is taken in account differences in swimming mean velocity.

The comparison of our tethered force values with others reported in literature is difficult, since authors usually use submaximal tethered situations or extended test durations (Minxing, 1984).

Gender differences in both maximum tethered force and maximum propulsive horizontal resultant impulse per phase can be explained through well documented differences in strength between males and females (Wells, 1985).

Despite maximum tethered force and maximum propulsive resultant impulse per stroke phase are different biomechanical parameters, the correlation found between both was previously expected, once muscle strength and the individual hydrodynamic propulsive capacity seems to be the most important biomechanical factors that affects both parameters. Meanwhile, the correlation obtained was probably affected by: (1) the impairing influence of active drag during the most propulsive phases of the breaststroke technique; and (2) by the specific hydrodynamic conditions probably faced by the swimmer in a on spot swim (Mosterd and Jongbloed. 1964). despite Bollens et al. (1988) couldn't conclude on non-similar electromyographic patterns for full tethered and free front crawl swims.

CONCLUSIONS

In summary, the results of this study showed that: (i) there was a positive and significant correlation between maximum propulsive tethered force and maximum propulsive horizontal resultant impulse per breaststroke phase, estimated through a intermittent light trace method; (ii) maximum propulsive tethered force and maximum propulsive horizontal resultant impulse per breaststroke phase, were significantly higher in male than in female swimmers and (iii) maximum breaststroke propulsive impulses were associated with the leg kick phase.

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