A PHOTO-OPTICAL METHOD FOR THE ACQUISITION OF BIOMECHANICAL DATA IN SWIMMERS

J. PAULO VILAS-BOAS

Porto University, Faculty of Sport Sciences, Swimming Department, Porto, Portugal

INTRODUCTION

Swimming research faces a particular problem when compared with other fields of sport science knowledge: technical difficulties related with the water environment to (he data aquisition process. Hence, one of the first tasks that swimming sport scientists must overcome is the development of instruments, techniques and methods for performance evaluation.

In the last few years, swimming biomechanical research provided important contributions in this field. However, the development of simple and easy procedures is still needed, specially if designed to allow an important interactive potencial with the training process.

In this study. the application of a photo-optical method to the assessment of biomechanical data in breaststroke swimming is described. Basically, the method is identical to the one that was used by Reischle et al. (1981) for the assessment of speed fluctuations in butterfly, backstroke and crawlstroke.

METHODOLOGY

The method consists in a photographic registration, with prolonged exposure, of a trace produced by a pulse-light device attached to the waist of the swimmer, at a middle distance between the two hip joints.

This device uses 24 (3x8) yellow LEDs as light source, which flashes every 0.2 sec (5 Hz) and is powered by a 9 v battery. The actual protolype was accomplished in a 15,5x7x3cm plastic box weighing a total of 400g.

The photographic camera (*Canon T70*, 35mm) was fixed verlically to the swimmers movement direction, at a 5m height from the surface of the water. The optical axis of the camera was kept perpendicular to the swimmers movement direction. A *Kodacolor* 1000 ASA film was used. Photos were digitized using a *Calcamp* digitizing table, the Sigma Scan software and a PC computer. Calibration for distance was obtained using a calibration bar (3 x 20cm of alternated contrasting coliors), that was fixed to the lateral wall of the swimming-pool and was previously photographed in the longitudinal axis of the swimmers movement

Experiments look place in a indoor swimming-pool where the light was reduced as much as possible without compromising swimmers spacial orientation.

For this pilot study, two female breaststrokers were studied: the portuguese 100m record holder and a junior national level swimmer. The first one performed the breaststroke technique at race pace and the other at a freely choosen submaximal velocity. With the pulse-tight device, the total weight of the swimmers was, respectively, 58 and 49kg.

After digitizing, 8th degree polynomial regression curves for velocity 1 time were calculated. Using the extreme values of velocity per phase (leg kick, gliding and armstroke) and the duration of each one, a per phase acceleration curve was derived and then multiplied by the swimmers mass to calculate the resultante impulse per phase curve.

To assess the accuracy of the digitizing process, one photograph was digitized 10 consecutive times in different occasions and paired values were correlated.

RESULTS AND DISCUSSION

Correlation between the 10 velocity I time curves conseculively obtained from one photograph, provided r values that ranged from 0.991 and 0.999 ($p<0.001$), which suggests a low significance of human errors in the digitizing process.

Figure 1 presents velocity I time curves of the waist obtained for both of the portuguese swimmers tested, compared with the velocity 1 time curve of the center of mass (CM) of a ex-DDR elite swimmer (Mason et al., 1989). High r values revealed thal curves are well fited to the scattergram points, inclusively our curves, which were drawn with a reduced sampling frequency.

Curves that we obtained for the waist and the curve for CM (Mason el al., 1989) showed identical profiles, despite the late one revealed a higher peak in the armstroke when compared with the leg action, which was not observed in our curves. This difference may be justified by technical disadvantages in the armstroke of these portuguese swimmers. Costill et al. (1987) found the same low armstroke profile for a master swimmer. However, after a technical training program, the armstroke peak reached higher values than the leg kick velocity peak. Other observed differences seem fully compatible with sport level or pace differences, namely peak velocity values and stroke time.

Colman et al. (1989), Mason et al. (1989) and Persyn et al. (1990) found that breaststroke CM and hip velocity I time curves for the same subject are assynchronous, and that, in the hip curve, the extreme values are more distanced from the mean velocity than in the CM curve. They concluded thal hip curves can not be used to illustrate CM kinematics. In opposite. Costill et ah (1987) found only slite differences between the two curves, and stated that hip curves are important tools to technique evaluation and advice. Maglischo et al. (1987) found almost identical and synchronous curves, and observed that differences between hip and CM velocity / time curves for breaststroke are reduced when a point at a middle distance from both hip joints is used, instead of one of the hips. This was the reason why we placed the pulse light device in the swimmers waist 'instead of the hip, as Rischle et al. (1981)

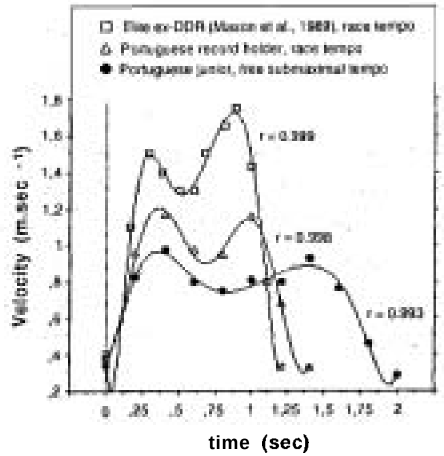

Figure 1. Waist velocity variation curves obtained for the portuguese breaststroke swimmers, compared with the center of mass curve of a world elite swimmer. *r* values for the 8th degree polynomial regression are shown.

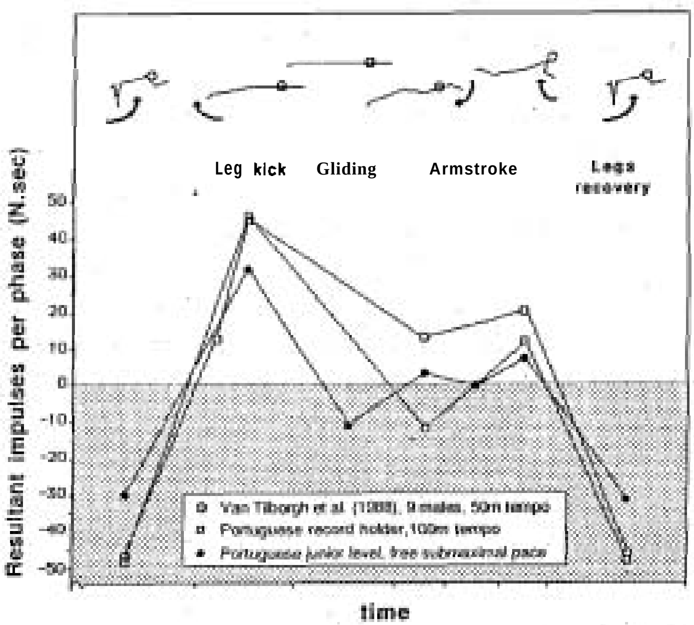

Figure 2. Per phase resultant impulse curves oblained for the portuguese breaststroke swimmers, compared with the curve published by Van Tilborgh et al. (1988). calculated from cenler of mass velocity variation curves. Dwalion of the stroke cycle was equalized for different swimmers.

prefered, and may account for the profile similarity of ow cwves when compared with CM ones.

Comparison between ow, and Mason's results also suggest that waist curves may satisfactorly reproduce the profile of the CM ones. Hence, we calculated resultant impulses per stroke phase and compared values with results of Van Tilborgh et al. (1988). obtained for 9 male german swimmers performing breaststroke at a 50m tempo (Fig. 2).

In figure 2, duration of the stroke cycle was equalized for different swimmers in order to simplify comparisons. This figure shows that all 3 cwves follow the same pattern. Differences between ow 2 curves might be easily explained by differences in sporl level and m performance tempo, respectively the higher peak impulse during the leg kick and the lower negative impulse during the recovery of the legs. Differences to the curve of Van Tilborgh et al. (1988) may result from differences in the synchronization pattern, namely the possible superposition of arm and leg actions due to the 50m tempo used by the German swimmers.

CONCLUSIONS

The photo-optical method used seems to be an useful tool to assess biomechanical data in breaststroke swimming, namely the velocity / time curve. Data from this curve can be derived in impulses per phase with a reasonable coherence, despite errors associaled with anatomical changes of the CM dwing a breaststroke cycle. Results can be used to compare mdividual technique in different moments, or to compare one subject technique with the profile of an elite swimmer. This method can contribute to bridge the theory / practice gap, allowing a satisfactory evaluation and training advice of breaststroke swimmers in a less time consuming way than the traditional motion analysis systems.

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