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A mechanical speedo-meter to assess swimmer's horizontal intra-cyclic velocity: validation at front-crawl and backstroke

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SUMMARY

The aim of this paper was to validate the system for the assessment of horizontal intra-cyclic velocity while swimming front crawl and backstroke. 12 boys and 11 girls with at least 4-y of experience participating in regional and national level competitions undertook a set of maximal 2x25 m (Front-crawl and Backstroke). The speedo-meter (*f* = 50 Hz) cable was attached to the subject's hip and data was acquired on-line. At the same time, subjects were recorded in the sagital plane with an underwater video camera and thereafter the hip was digitized. It was analyzed the: (i) maximal velocity; (ii) minimal velocity; (iii) difference between maximal and minimal velocity; (iv) coefficient of variation. There were no significant differences for the mean values between apparatus for the variables selected, except for maximal velocity. Linear regression models where very high. More than 80% of the Bland-Altman plots were with the 1.96 standard-deviation criteria used on regular basis as rule thumb for techniques validation.

INTRODUCTION

Horizontal intra-cyclic velocity can be acquired with several techniques, e.g.: (i) computational digitizing of anatomical landmarks (i.e., videometry) [2]; (ii) Doppler effect procedures (i.e., radar gun) [4] or; (iii) mechanical apparatus (i.e., speedo-meter) [5]. The speedo-meter is easy, less expensive and less time-consuming than videometry. On the other hand, the radar gun has some major limitations to be used to measure swimming techniques.

There are commercially available several speedo-meter apparatus. One of them is the Swim speedo-meter (Swimsportec®, Hildesheim, Germany). In a previous paper it was reported the concept, development and validation of a software interface for that same hardware [3]. It was reported that the software developed using the LabVIEW® platform, was very robust, with a good performance and intuitive for the user. After calibration and developing the software interface, the integrated system (hardware plus software) presented a very high validation and accuracy. In this sense, the system developed is appropriate to assess the human's horizontal intra-cyclic velocity during land-based locomotion techniques [3]. However, there were some concerns about its use for aquatic-based movement.

The aim of this paper was to validate the system for the assessment of horizontal intra-cyclic velocity while swimming front-crawl and backstroke.

METHODS

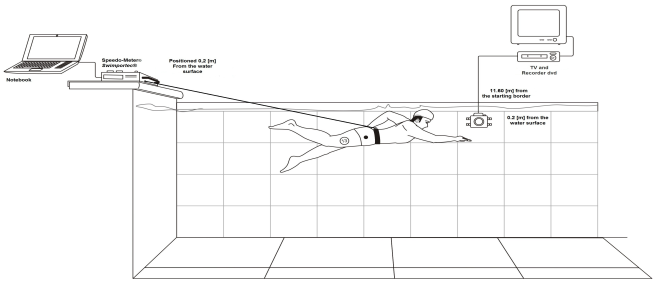
12 boys (14.42 ± 1.24 years-old, 166.29 ± 9.53 m of height, 56.45 ± 10.80 kg of body mass) and 11 girls (12.73 ± 0.79years-old, 160.40 ± 5.60 m of height, 47.54 ± 5.60 kg of body mass) with at least 4-y of experience in competitive swimming, participating on regular basis in regional and national level competitions at the moment of data collection volunteered as subjects.

Each swimmer undertook a set of maximal 2x25 m (Front-crawl and Backstroke) swim with an underwater start in a randomized order. Participants performed the bout alone with no other swimmer in the lane or nearby lanes to reduce drafting and pacing effects, or being affected by extra drag force due to exogenous factors.

Subject's velocity was acquired from both speedo-meter system and a videometric system in each bout (fig 1). The speedo-meter cable was attached to the subject hip and data was acquired on-line with the integrated system at a sampling rate of 50 Hz [2]. Data was exported to a signal processing software (AcqKnowledge v.3.5, Biopac Systems, Santa Barbara, USA) and filtered with a 5Hz cut-off low-pass 4th order Butterworth.

At the same time, subjects were recorded in the sagital plane with an underwater video camera (Samsung, Sdc-415, Japan) with a sampling rate of 50 Hz, fixed at 11.60m from the head wall, connected to mixing table (Samsung, SSC-1000N, Japan and a DVD recorder (DIGA DMR-EH55, Japan). The subjec's hip was manually digitized (Ariel Performance Analysis System, Ariel Dynamics Inc., USA) for one single stroke cycle in each bout. Thereafter data was transformed [1] and smoothed with a digital filter with a cut-off frequency of 5 Hz. It was analyzed the: (i) maximal velocity within the stroke cycle; (ii) minimal velocity within the stroke cycle; (iii) difference between maximal and minimal velocity within the stroke cycle; (iv) coefficient of variation of the subject’s velocity within the stroke cycle.

Validation of the integrated system *versus* videometric system was computed with: (i) paired Student's t-test (validation criterion: $p \geq 0.05$); (ii) linear regression models (validation criterion: $R^2 \geq 0.49$) and; (iii) Bland-Altman plots (validation criterion: at least 80 % of the plots within the ± 1.96 standard deviation).



	Paired differences									
	M ± Std		95% Confidence Interval of the Difference							
	Speedo-Meter®	APAS®	M	Std	Std. Error Mean	Lower	Upper	t	df	p
Maximal velocity	1.470 ± .211	1.479 ± .213	-.009	.023	.003	-.016	-.002	-2.652	45	.011
Minimal velocity	1.206 ± .169	1.209 ± .176	-.003	.030	.004	-.012	.006	-.696	45	.490*
Difference between maximal and minimal	.263 ± .118	.269 ± .129	-.006	.036	.005	-.017	.004	-1.152	45	.256*
Coefficient of variation	.065 ± .033	.063 ± .034	.002	.012	.001	-.001	.005	1.087	45	.283*

M = Mean; Std = Standard Deviation; t – t value; df = degree of freedom; *p* – *p* value t test paired. **p* > 0.05.

Figure 1: Apparatus set-up.

RESULTS AND DISCUSSION

There were not statistically significant differences for pair wise data between speedo-meter system and videometric system in the minimal velocity ($p > 0.05$), difference between maximal and minimal velocity ($p > 0.05$), coefficient of variation ($p > 0.05$), but there was for the maximal velocity ($p < 0.05$). (table 1).

Table 1: Comparison mean values between speedo-meter system and videometric system [m/s].

Linear regression models between speedo-meter system and videometric where very high for the maximal velocity ($R^2 = 0.987$; $p < 0.001$), minimal velocity ($R^2 = 0.970$; $p < 0.001$), difference between maximal and minimal velocity ($R^2 = 0.922$; $p < 0.001$) and coefficient of variation ($R^2 = 0.863$; $p < 0.001$) (figure 2). Moreover the 95 % interval confidence agreement limits were very close together. More than 80 % of the Bland-Altman plots were with the 1.96 standard-deviation criteria (i.e., 95 % interval confidence) used on regular basis as rule thumb for techniques validation (figure 3). In this sense, the speedo-meter system accomplished all the validation criteria adopted, except for a significant difference between for the mean values between both apparatus in the maximal velocity ($p > 0,05$). However, this variable is less sensitivity and informative than remain ones about the speed fluctuation phenomena while swimming [5]. Plus, data accuracy was very high for all variables of velocity.

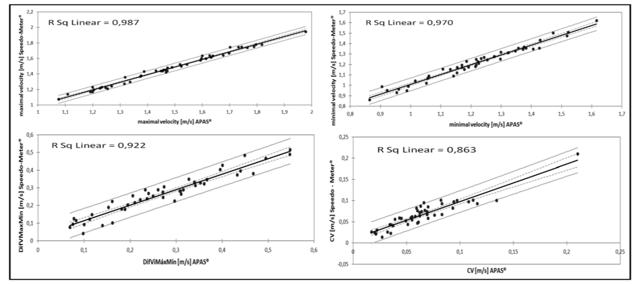


Figure 2: Linear regression models between speedo-meter system and videometric system.

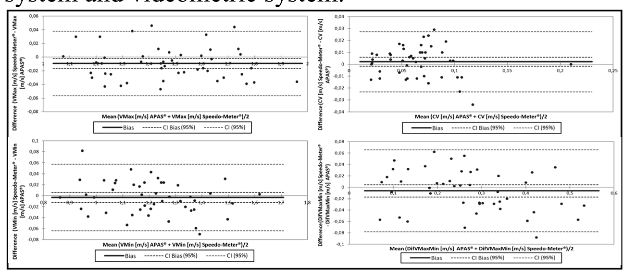


Figure 3: Bland-Altman plot between speedo-meter system and videometric system.

CONCLUSIONS

The integrated system (hardware plus software) presented a very high validation and accuracy. So, the system seems to be an appropriate apparatus to assess the human’s horizontal intra-cyclic velocity swimming Front-crawl and backstroke.

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