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## LONGITUDINAL ASSESSMENT OF SWIMMING PERFORMANCE IN THE 200-m FREESTYLE EVENT

### INTRODUCTION

Several studies have been carried out in order to identify the factors that can predict swimming performance. However, all these studies only analyzed determinant factors in a single moment. It was not taken into account the longitudinal stability and changes, as a result of individual development, new training methods and technological sophistication. Also was demonstrated that progression and variability of performance between competitions are useful for researchers and practitioners interested in factors that affect performance [8]. Indeed, the number of studies about swimming performance, adopting longitudinal approaches is reduced [e.g., 8, 9]. So far, appears not exist any research tracking the change and stability of swimmer's performance. The aim of this study was to track and analyze the stability of the 200-m freestyle performance throughout the swimmer's career, from children to adult age.

### METHODS

**SUBJECTS.** Twenty nine Portuguese male swimmers were analyzed for seven consecutive seasons between 12 and 18 years old.

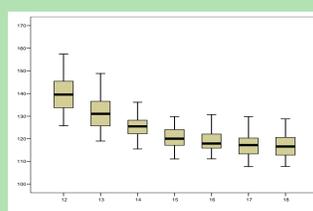
**DATA COLLECTION.** Swimming performance was collected using the best personal time in the 200-m Freestyle event in each season. Performances were collected from official competitions, on a short course pool (regional, national or international level). The official times were consulted on rankings tables provided by the Portuguese Swimming Federation and in an internet database (www.swimrankings.net, March 2009). At the age of 18, 7 were international level swimmers, 15 national level ones, and 7 regional level.

**STATISTICAL PROCEDURES.** An exploratory data analysis was performed to identify possible errors in data input, outliers and to assess data normality (Shapiro-Wilk test).

Longitudinal assessment was made based in two approaches: (i) mean stability; (ii) normative stability. For mean stability quartiles, means plus standard deviations were computed for each chronological age. Data variation was analyzed with ANOVA repeated measures followed by a post-hoc test (Bonferroni test). Normative stability was analyzed with self-correlation (Correlation of Pearson) between the performances throughout the seven seasons. It was defined that stability was: i) high if  $r \geq 0.60$ ; (ii) moderate if  $0.30 \leq r < 0.60$ ; (iii) low if  $r < 0.30$ , as suggested by Malina [6]. It was also calculated the Cohen's Kappa (K), with a confidence interval of 95%. The qualitative interpretation of Kappa values was: (i) excellent if  $K \geq 0.75$ ; (ii) moderate if  $0.40 \leq K < 0.75$ ; (iii) low if  $K < 0.40$  [4]. All statistical procedures were computed with SPSS software's (v. 13.0, Apache Software Foundation, Chicago, IL, USA). However, K value was computed with the Longitudinal Data Analysis software (v. 3.2, Dallas, USA). Significant level was set at  $p < 0.05$ .

### RESULTS AND DISCUSSION

There was a trend for a performance improvement throughout the swimmer's career from children to adult age presented by figure 1. Significant variations in the mean swim performance were verified [ $F(1,28) = 11815.908$ ;  $p < 0.01$ ]. Post-hoc test verified significant variations between all chronological ages analyzed ( $p < 0.01$ ) except for the pairwise comparison between 16-17 years old and 17-18 years old that were not-significant. This can be explained by changes that occurred during swimmers development, in different maturational stages. As swimming performance is determined by different parameters, the swimmers development will affect the energy cost of swimming [3]. Changes in anthropometric characteristics, like body length and body mass, are identified as causes to increase energy cost [1]. Along with these morphological changes, development shows an increase in swimmers muscular strength. It appears that hormonal development that occurs during maturation has a determinant role in increasing muscle size [7]. Constant training also contributes to improve swimming technique to obtain gains in performance [10].



**Figure 1.** Diagram of performance extremes and quartiles.

The self-correlation values (table 1) ranged between moderate and high throughout the swimmer's career. Stability becomes high ( $r = 0.644$ ) from 14 years old until 18 years old. However this increase reveals a "braking effect" in the improvement of swimmers performance starting at 16 years old. This may be associated with: (i) a maximal level of external training reached by the swimmers, which is more difficult to overcome;

(ii) a decrease in physiological functional capacity with age [2] or; (iii) a slowdown or stagnation in the development of anthropometric characteristics [5].

**Table 1.** Self-correlation values throughout swimmer's career.

Chronological age	12	13	14	15	16	17	18
12	1						
13	0.902	1					
14	0.751	0.882	1				
15	0.672	0.748	0.841	1			
16	0.593	0.699	0.779	0.929	1		
17	0.536	0.589	0.686	0.850	0.884	1	
18	0.536	0.561	0.644	0.813	0.862	0.955	1

\*  $p < 0.05$

The K value, expressing the stability throughout the overall swimmer's career, was moderate ( $K = 0.455 \pm 0.057$ ) with  $0.398 \leq K \leq 0.512$  for a 95 % of confidence interval. Based on a so long career, it is clearly that swimmers performance stability is difficult to maintain always on a high level. However, the change from 14 to 15 years old appears to show a sharp increase in stability. This can be explained by: i) maturational process, that provides greater availability for training process, in order to obtain more ambitious performances, ii) consolidation of values and culture of swimming performance acquired throughout swimmer's career.

### CONCLUSION

As a conclusion, the prediction of adult swimmer's performance level, based on children performance is moderate. However, it seems that the change from 13 to 14 years old can be a milestone. At moment the ability to predict the swimmer's

### REFERENCES

- Chatard JC, Padilla S, Carzorra G, Lacour JR. Influence of body height, weight, hydrostatic lift and training on the energy cost of the front crawl. *N Z L Sports Med.* 1985; 13:82-84
- Donato A, Tench K, Glueck D, Seals D, Eskurza I, Tanaka H. Declines in physiological functional capacity with age: a longitudinal study in peak swimming performance. *J Appl Physiol.* 2003; 94: 764-769
- Kjendlie PL, Ingjer F, Madsen O, Stallman RK, Stray-Gundersen J. Differences in the energy cost between children and adults during front crawl swimming. *Eur J Appl Physiol.* 2003; 91: 473-480
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; 37:439-446.
- Malina RM, Bouchard C. Growth, maturation, and physical activity. In: *Risk Factors and Children's Health.* Champaign, Illinois: Human Kinetics Books (1991).
- Malina RM. Adherence to physical activity from childhood to adulthood: a perspective from tracking studies. *Quest* 2001; 53:346-355.
- Matos N, Winsley RL. Trainability of young athletes and overtraining. *J Sport Science.* 2007; 6: 353-367
- Pyne D, Trewin C, Hopkins W. Progression and variability of competitive performance of Olympic swimmers. *J Sports Sci* 2004; 22 (7):613-20.
- Stewart A, Hopkins W. Consistency of swimming performance within and between competitions. *Med Sci Sports Exerc.* 2000; 32(5):997-1001.
- Zamparo P. Effects of age and gender on the propelling efficiency of the arm stroke. *Eur J Appl Physiol.* 2006; 97:52-58

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