Tiago M Barbosa[1,4], Mário J Costa[1,4], Mário C Marques[2,4], Marc Moreira[3,4], António J Silva[3,4], Daniel A Marinho[2,4]

[1] Polytechnic Institute of Bragança, Bragança, Portugal
[2] University of Beira Interior, Covilhã, Portugal
[3] University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[4] Research Centre in Sports, Health and Human Development, Vila Real, Portugal

A path-flow analysis model for active drag force determinant variables in age-group swimmers

INTRODUCTION

The goal of competitive swimming is to travel the event distance as fast as possible. The identification of the parameters that predict swimming performances is one of the main aims of the swimming "science" community. Indeed, it is consensual that biomechanical and energetic variables are determinant for enhance performance (Barbosa et al, 2010). Added to this, there are also anthropometrical and hydrodynamic variables that are often reported as being related to swimming performance. Indeed, several research groups dedicate their attention to the relationships establish between all these domain and performance but, with special emphasis on elite adult swimmers. However, several parameters often assessed in adult swimmers are not able to be used in age-groups due to several reasons. Even so, on regular basis, age-group coaches also do biomechanics, anthropometric and hydrodynamic assessments but with less expensive, evasive or complex procedures. The role of drag force in competitive swimming is one of the main topics for researchers and field practitioners as it allows enhancing performance. The development of "flow chart" models confirming the relationships between drag force and other determinant variables was never attempted in competitive swimming. Moreover, main research groups dedicate little attention to age-group swimming.

The aim was to develop a structural equation modeling (i.e., path-flow analysis model) for active drag force (Da) based on anthropometric, hydrodynamic and biomechanical determinants in young swimmers. The theoretical model was developed according to main review papers about these relationships (e.g. Lavoie and Montpetit, 1986; Barbosa et al., 2010) and the age-group coach's assessments. The theoretical model designed is presented in figure 1.

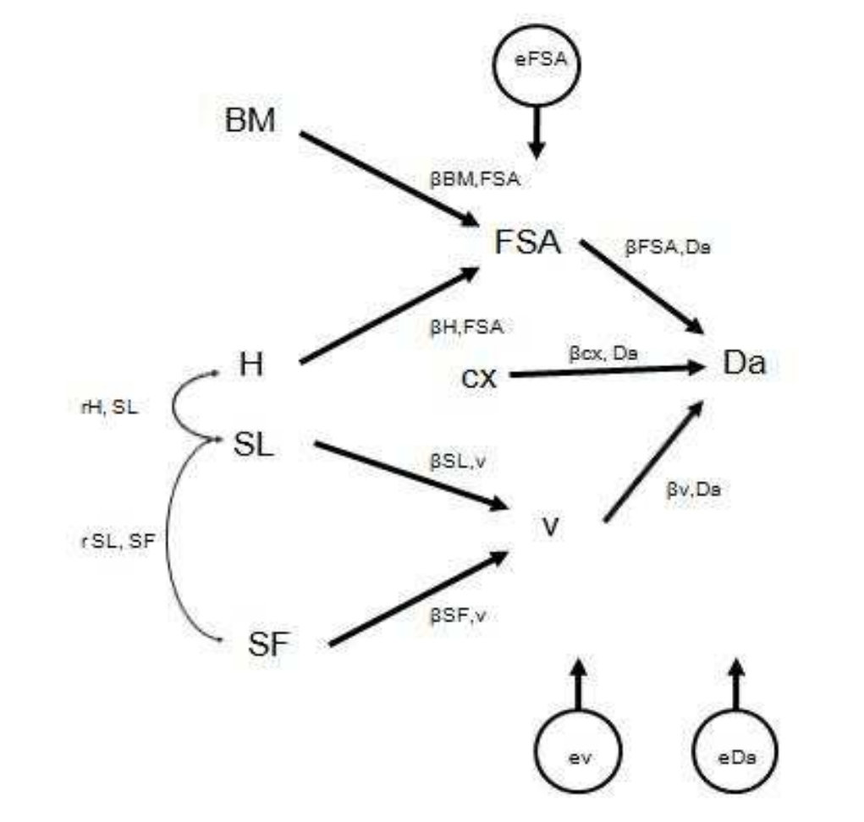


Figure 1. Theoretical path-flow model.

METHODS

Subjects. Sixteen male swimmers (12.50±0.51 years-old; Tanner stages' 1-2) with several competitive levels were evaluated. Parents and coaches gave their consent for the swimmers participation in this study. All procedures were in accordance to the Declaration of Helsinki in respect to Human research.

Data collection. For anthropometrical assessment it was recorded the body mass (SECA, 884, Hamburg, Germany), height (SECA, 242, Hamburg, Germany), and frontal surface area, this last one as (Clarys, 1979):

$$FSA = \frac{6.93BM + 3.50H - 377.2}{10000} \quad (1)$$

Where *BM* is the body mass in [kg] and *H* is the height in [cm].
The hydrodynamic variables assessed were drag coefficient and Da with the velocity perturbation method (Kolmogorov and Duplisheva, 1992):

$$D = \frac{D_b v_b v^2}{v^3 - v_b^3} \quad (2)$$

Where D is the swimmer's active drag at maximal velocity, D_b is the resistance of the perturbation buoy and, v_b and v are the swimming velocities with and without the perturbation device, respectively.

Drag coefficient (C_D) was calculated :

$$C_x = \frac{2D}{\rho FSA v^2} \quad (3)$$

Where ρ is the density of the water and *FSA* is the projected frontal surface area of the swimmers.

For biomechanical assessment it was measured the swimming velocity, stroke frequency and stroke length. Each swimmer made a maximal 25-m swim with an underwater start. The swimmers were advised to reduce gliding during the start. Swimming velocity was measured in the middle 15-m as:

$$\bar{v} = \frac{d}{t} \quad (4)$$

Where v is the mean swimming velocity in [m.s^{-1}], d the distance covered by the swimmer in [m], t the time spent to cover such distance in [s] measured with a chronometer by an expert evaluator. The stroke frequency (SF) was measured with a cronofrequency meter from 3 consecutive stroke cycles, in the middle of the 15-m distance by an expert evaluator as well. Stroke length in [m] was estimated as (Craig and Pendergast, 1979):

$$SL = \frac{\bar{v}}{SF} \quad (5)$$

METHODS

Statistical procedures. The normality of the distributions were evaluated with the Shapiro-Wilk test.

Path-flow analysis was performed with the estimation of linear regression standardized coefficients between the exogenous and endogenous variables. All assumptions to perform the path-flow analysis were taken into account. When appropriate, according to the theoretical model, simple or multiple linear regression models were computed. Standardized regression coefficients (β) were considered. Significance of each β was assessed with the t-Student test ($p < 0.05$). The effect size of the disturbance term, reflecting unmeasured variables, for a given endogenous variable, was 1-R^2.

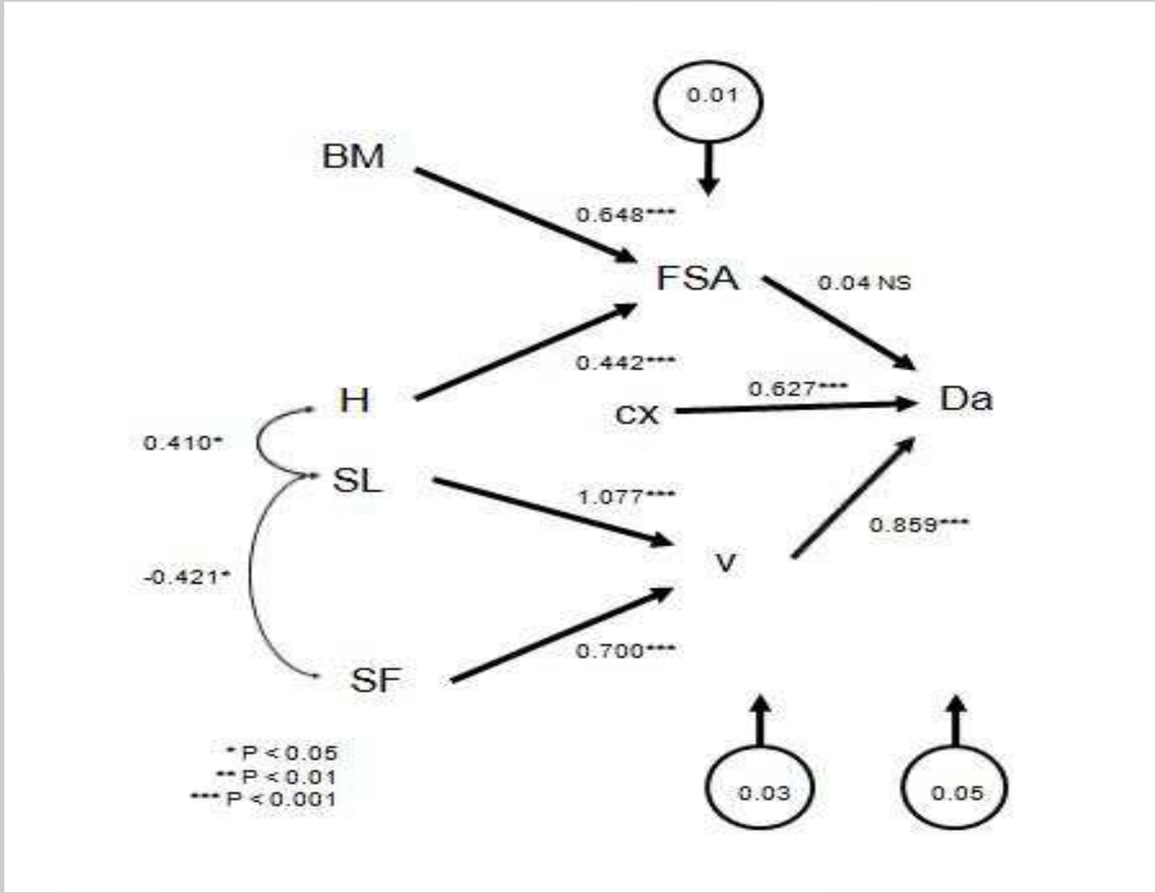
To verify the quality of the model, root mean square residuals (RMSR) was computed:

$$RMSR = \sqrt{\frac{\sum_{i=1}^{p} \sum_{i=1}^{q} (rij - pij)^2}{p+q}} \quad (6)$$

Where r is the Pearson correlation coefficients and p the correlation predicted by the model (based on total effect, i.e., the addiction of the direct and indirect effects plus spurious effects). Qualitatively, it is considered that if: (i) RMSR < 0.1 the model adjust to the theory; (ii) RMSR < 0.05 the model adjusts very well to the theory and; (iii) RMSR ~ 0 the model is perfect.

RESULTS AND DISCUSSION

The Da presented significant association with all exogenous variables, except for SL and SF. Confirmatory model excluded the FSA (RMSR > 0.1). Even so, 95% of Da was explained by remaining variables in the model.



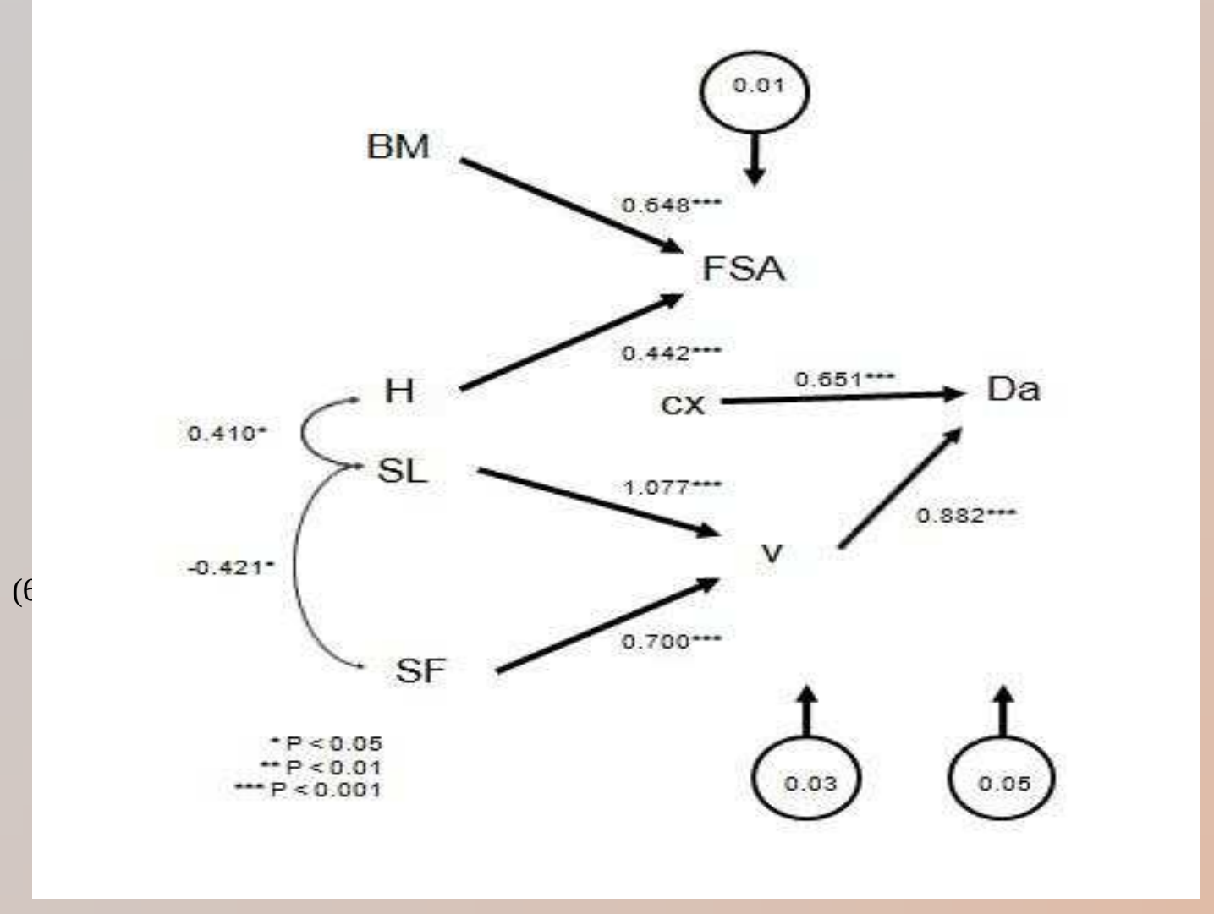


Figure 2. Confirmatory path-flow model.

CONCLUSION

Confirmatory path-flow model can be considered as not suitable of the theory. For a near future it is advice to develop new FSA estimation equations specific for young swimmers rather than using models developed with adult/elite swimmers.

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