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 consensus that biomechanical and energetic variables are determinant for enhance performance (Barbosa et al., 2020). 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 of stressed 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, easier or simple 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. Linawe and Marnpint, 1984; Barbosa et al., 2020) and the age-group coaches’ assessments. The theoretical model designed is presented in figure 1.

METHODS

Subjects. Sixteen male swimmers (12.50±3.5 years-old; Inner stage: 1-2) with several competitive levels were evaluated. Parents and coaches gave their consent for the swimmers participation in the study. All procedures were in accordance to the Declaration of Helsinki in respect to human research.

Data collection. For anthropometric assessment it was recorded the body mass (SECA, 884, Hamburg, Germany), height (SECA, 240, Hamburg, Germany), and frontal surface area, this last one as (Clarys, 1979):

\[
\text{FSA} = \frac{0.69 \times \text{BMI} + 3.54 \times \text{H}}{10000} \quad (1)
\]

Where BMI is the body mass in [kg] and H is the height in [cm].

The hydrodynamic variables assessed were drag coefficient (C_D) and Da with the velocity perturbation method (Kolmogorov and Dupliševa, 2021):

\[
D = \frac{\rho v^2}{C_D FSA} \quad (2)
\]

Where D is the swimmer’s active drag at maximal velocity, Ds is the resistance of the perturbation flow and, v and C_D are the swimming velocities with and without the perturbation device, respectively.

Drag coefficient (C_D) was calculated:

\[
C_D = \frac{2D}{\rho \text{FSA} v} \quad (3)
\]

Where \( \rho \) 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 paddling during the start. Swimming velocity was measured in the middle 15-m:

\[
v = \frac{d}{t} \quad (4)
\]

Where \( d \) is the mean swimming velocity in [m/s], \( t \) the distance covered by the swimmer in [m] and \( t \) 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 cross-frequency meter from 3 consecutive stroke cycles, in the middle of the 15-m by an expert evaluator as well. Stroke length in [m] was estimated as (Craig and Pendergast, 1979):

\[
\text{SL} = \frac{1}{2} v \quad (5)
\]

RESULTS AND DISCUSSION

Statistical procedures. The normality of the distributions were evaluated with the Kolmogorov-Smirnoff test. Path-flow analysis was performed with the estimation of linear regression standardised 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. Standardised regression coefficients (\( \beta \)) were considered. Significance of each \( \beta \) 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_SME. The Da presented significant association with all exogenous variables, except for SF and SL. Confirmatory model excluded the FSA (R_SME = 0.1). Even so, 95% of Da was explained by remaining variables in the 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.

REFERENCES


Kolmogorov SV, Dupliševa A. Active drag, useful mechanical power output and hydrodynamic force coefficient in different swimming strokes at maximal velocity. Journal of Biomechanics 1962; 25-318.