PREDICTION MODELS FOR FREESTYLE PERFORMANCE TIMES IN MASTER SWIMMERS

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This study was designed to define the most important factors to predict freestyle performance times in 135 elite master swimmers by prediction models which include age, anthropometric and strength variables. To cross validate these equations found for Elite swimmers, we used a group composed by 126 lower technical level age - and experience - matched master swimmers. Results demonstrated that age, height and hand grip strength were the best predictors in short events, whereas age and height predict middle and long events. The corresponding coefficients of determination (R^2) of performance times were 0.84 in 50m, 0.73 in 100m, 0.75 in 200m, 0.66 in 400m and 0.63 in the 800m events. A good correlation have been found when these models have been applied in 126 non-elite master swimmers demonstrating to be useful in all Master swimmers.

KEY WORDS: aging, height and hand grip strength**.**

INTRODUCTION:

Many studies in the literature have been conducted to identify models based on anthropometric and strength measures capable to predict swimming performance times (Geladas, N. D. et al. 2005). None of these studies it was dedicated of Master Swimmers although they are an invaluable model for a good stability of the anthropometric parameters and to evaluate effects due to prolonged training, both on the age-related decline in general functional capacity and on the specific performance (Donato, A. J. et al. 2003, Tanaka, H. et al. 1997, Zampagni, M. L .et al. 2008). We focalized our study on anthropometric and strength measures of upper extremity for their noted contribute in the total thrust in the crawl stroke (Geladas, N. D. et al. 2005). We hypothesized that stature, body mass, arm and forearm length, volume of the forearm, including age, might play a relevant role in predicting performance times in master swimmers. In agreement with the literature height was chosen for its noted contribute in developing propulsive forces in water (Grimston, S. K. et al. 1986), hand grip measure was tested being notoriously measured to evaluate the general decline of upper extremity strength with aging (Doherty T. 2003) and having an implication in 100 m freestyle performances (Geladas, N. D. et al. 2005). Finally age was included in order to see how it could affect performance time according to the distance covered. Aims of the present study were: a) to determine in elite master swimmers of both genders whether, using anthropometric variables, hand grip strength and age, it was possible to predict 50m, 100m, 200m, 400m, 800m freestyle performance times, b) to investigate if the considered predictors were related similarly to different freestyle events, from short (50m, 100m) to middle (200m, 400m) and long distances (800m). In order to cross validate these equations we used a group composed by 126 lower technical level age - and experience - matched master swimmers.

METHODS:

Data Collection: The study included 135 freestyle Elite Master swimmers of both genders, aged 40-80, competitors in international level, for the 50m (n=30), 100m (n=32), 200m (n=23), 400m (n=26) and 800m (n=24) freestyle events. A control group (CG) of 126 aged-matched and experience-matched, freestyle swimmers of both genders was chosen among master swimmers of similar anthropometric characteristics but lower levels, who had competed in the 50m (n=30), 100m (n= 30), 200m (n= 22), 400m (n=23) and 800m (n=21) freestyle events during a regional level competition. A field laboratory was organized beside the swimming pool both during 10th World Masters Championships and Italian Regional competition held in November 2005. Written informed consent was obtained from all the subjects. Performance time expressed in seconds was adopted as a measure of the performance. Time data were recorded with the Automatic Equipment (Sony Electronics) belonging to the Italian Timekeeping Federation (F.I.CR.) in all races and the time of each event was measured during competition, as it represents the peak of performance of the master athletes established under rigorous conditions (Donato, A. J. 2003, Tanaka, H. et al. 1997). Anthropometric measures. *Height* (cm) was measured with a precision of 0.1 cm with a stadiometer. *Body mass* (kg) was recorded with a scale to the nearest 100g. Arm and forearm length were measured on the right arm. *Arm length* (Lbu)(cm) was calculated as the distance between the acromion and olecranon. *Forearm length* (Lau) (cm) was calculated as the distance between the olecranon and the radial styloid process. Forearm volume (Vct) (cm^3) was estimated by adopting a geometrical model, which assumes the that the forearm is formed by two truncated cones (Zampagni, M. L et al. 2008). Hand grip Strength (Hgm) was measured in the dominant side according to Teixeira LA et al. using a Jamar Dynamometer (Asimov Engineering Co., Los Angeles, USA).The reliability of this device was previously reported (American Society of Hand Therapists, 1992, as 0.95 (ICC). A strong verbal encouragement was provided during test. The best value of the two attempts was used for statistical comparisons.

Data Analysis: At the beginning a Kolmorogov-Smirnov test was adopted to verify the normal distribution of all considered parameters. A simple matrix of correlation was applied among all independent variables and performance times (at each event) in whole group, to find the most important factors to compute multiple regression models. Thus subjects have been divided in according to each competition, mean and SD values of age, anthropometric variables, hand grip strength and time of performance were calculated. ANOVA was used to verify the homogeneity of all considered variables of both groups of competitors. Time prediction equations. Assuming time (at each distance) as the dependent variable, five multivariate linear regressions were performed for each freestyle event (50m, 100m, 200m, 400m, and 800m) as a linear combination of all the other variables. To optimize the model, a backward multiple regression method was adopted. This method eliminates the least influent at every step variable in the regression equation and the backward elimination procedure is terminated when all included variables (if any) are significant. Following that, the normal distribution of the residuals was again checked. For each equation, significance of the model, R^2 and standard error of estimate (SEE) were calculated. Therefore, the regression equations established for the elite group were cross-validated in the control group of lower technical level master swimmers. Pearson's correlation coefficients were calculated between the observed and the predicted performance times in the control group. All analyses were performed at the alpha level of 0.05 and the statistical power of the applied analysis ranged between 0.90-0.99 in all cases. All data were analyzed using SPSS version 13.

RESULTS:

Variables were all normally distributed. Whole group demonstrated that the most important factors correlated with all freestyle events, were age, height and Hgm. As expected, age was directly correlated vs. all performance times, while height and Hgm inversely. ANOVA performed for each swimming event demonstrated that there were not significant differences between Elite and control group for age, and all considered physical traits ($p > 0.05$ in all cases) however, elite master swimmers were generally taller and showed larger forearm volume than controls. As expected, the elite swimmers swam significantly faster than controls in all events ($p < 0.01$). In the short events (50m and 100m) they were significantly ($p < 0.01$) stronger, for Hgm, than controls. Time prediction Equations in Elite Master Swimmers are reported in Table 1.

Mean difference between observed and predicted times were not significant ($p > 0.05$ in all cases) and very low for each event: 0.14 sec in 50m, 0.17 sec in 100m event, 0.80 sec in 200m, 0.67 sec in 400m, 0.10 sec in 800m (in absolute value), regression equations at each distance are represented graphically in Figure 1.

Table 1. Prediction equations for freestyle performance times in 135 elite master swimmers at each freestyle event.

Performance time prediction equation at each freestyle event	R^2	SEE	Sign.
t_{50}(s)= 56.157+0.297 Age(y)-0.186 H(cm)-0.015 HGM(N)	0.84	2.43	p < 0.01
t_{100}(s)= 159.785+0.488 Age(y)-0.625 H(cm)-0.021 HGM(N)	0.73	5.01	p < 0.01
t_{200}(s)= 339.472+1.507 Age(y)-1.520 H(cm)	0.75	14.77	p < 0.01
t_{400}(s)= 1049.652+2.820 Age(y)-5.048 H(cm)	0.66	54.08	p < 0.01
t_{800}(s)= 951.550+7.919 Age(y)-4.017 H(cm)	0.63	69.11	p < 0.01

Time (t) is expressed in seconds, height (H) in cm and hand grip strength (HGM) in Newton. Accuracy (R^2), Standard error of estimate (*SEE*) and significance of the model are indicated.

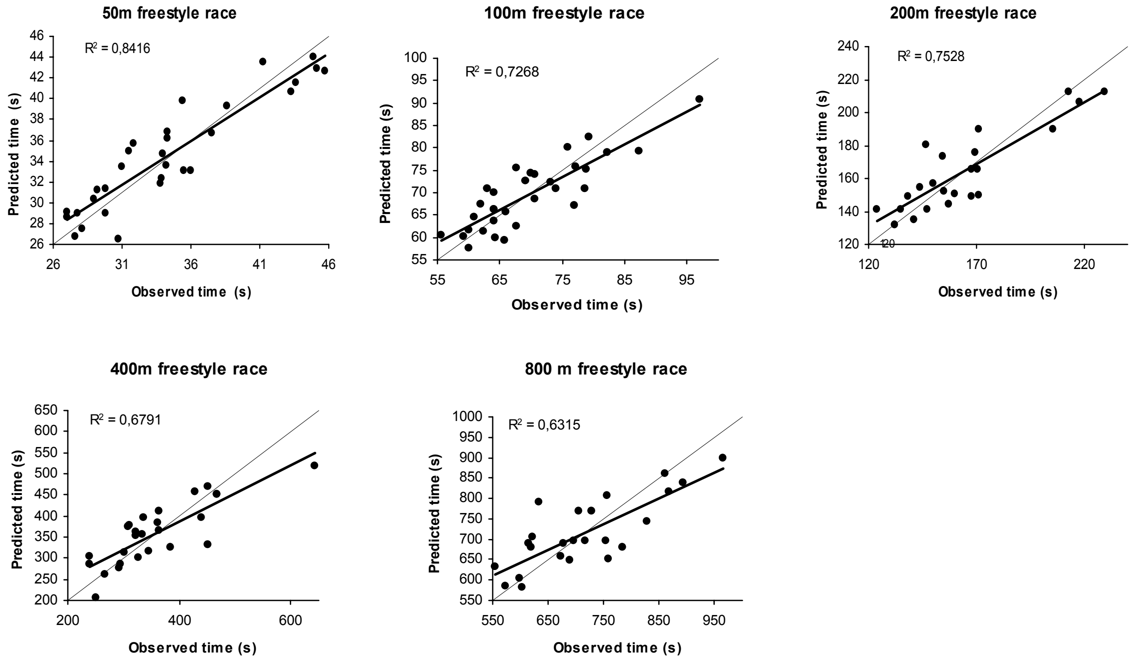

Figure 1 – Predicted time vs. observed time of performance in 135 elite master swimmers for each distance event.

When these equations were applied to the same predictor variables in the sample of lower technical level age - and experience - matched master swimmers a good agreement was found between measured performance time and predicted performance time (r = 0.73 in 50m, r = 0.67 in 100m, r = 0.79 in 200m, r = 0.75 in 400m, r = 0.83 in 800m, with p < 0.01 in all cases).

DISCUSSION:

The first important finding of this work was that all calculated prediction equations for performance time in elite master swimmers, of both genders, provided high R^2, ranging from 0.63 to 0.84. The second important finding was that relative importance of these predictors varied with swimming events, by showing that age, height and hand grip strength were the best important predictors in short events (50 and 100m) and only age and height in middle (200 and 400m) and long events (800m). A good agreement was found between predicted and observed performance times in the cross-validation sample, which validates selected anthropometric and strength variables for master swimmer population. Considering elite master swimmers, hand grip strength, age and height were the best predictors in short events describing about 84% of variance of performance time in the 50m event, and 73% in the 100m event. Age and height were the best predictors in middle (200m and 400m) and long (800m) distance events, explaining 75% of variance of performance time in 200m, 66% in 400m and 63% in 800m events. These results indicate that 200m, 400m and 800m events are better described by anthropometric characteristics rather than strength capability, suggesting that other physiological and biomechanics parameters linked with swimming performance should be included to obtain a better prediction models. In Elite Master swimmers hand grip strength influenced performance time more in short events (50m, 100m) than in middle and long events. Similar and significant correlations have been found in other investigations in young swimmers (Geladas, N. D. et al. 2005). These results corroborate our hypothesis that hand grip strength can be considered a relevant parameter to predict performance times in older athletes being in line with previous findings (Geladas, N. D. et al. 2005, Zampagni, M. L .et al. 2008). Hand grip strength was significantly greater in the elite swimmers than controls for 50m and 100m freestyle events, thereby suggesting it is an important parameter to determine a better ability to perform short races (Geladas, N. D. et al. 2005). Age positively correlated to all performance times, yet performance decline was more evident for short distances than for long ones. This observation is in line with other investigations (Donato, A. J. et al. 2003 Tanaka, H. et al. 1997, Zampagni, M. L .et al. 2008) which attribute older persons are better able to perform short, rather than long distance races, suggesting that events of varying duration necessitate very different levels of involvement of the various energy-producing pathways in skeletal muscle. Performance times were significantly and negatively correlated with height; the result for Elite Master Swimmers did not depend on event distance either by adopting simple or multiple correlation analyses. The beneficial effect of height in swimmers is in agreement with the literature (Geladas, N. D. et al. 2005), and, as described by Grimston and Hay (Grimston, S. K. et al. 1986), longer body segments would appear to influence the development of propulsive force to a greater extent than that of resistance forces. As resistance in water is related to the square of the swimming velocity, the greater the resistance developed during the swimming motion, the greater the velocity. Furthermore, height is inversely correlated with a Froude number (Fr) $Fr=v/\sqrt{(gh)}$, where v is the swimming velocity, h is the height and g the acceleration due to gravity, thus implying that a decrease in Fr will lower the wave making resistance.

CONCLUSION:

The present study describes a simple method to predict performance time in elite master swimmers based on both anthropometric and strength variables which can be easily computed by coaches during the swimming training program. Such models might determine individual performance time, thus contributing both to improve ability to adjust individual training programs and elite master swimmer selection. Coaches might be able to better determine whether an athlete needs a training program that includes strength development in order to optimize performance times.

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