# THE INFLUENCE OF SPECIFIC FUNCTIONAL-MOTOR ABILITIES ON FREESTYLE SWIMMING PERFORMANCE TIME

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**Abstract**

*The main goal of this research was to determine the relationship between the results in specific motor and functional abilities tests and the 100 m front crawl stroke performance time. The sample was comprised of 42 Top swimmers from the Republic of Croatia. It was found that the following tests correlate with the 100 m freestyle performance time: DYNCOO - dynamometric in water crawl coordination "Tethered swimming - coordination" (r=0,57), DYNHAND – dynamometric in water crawl hands "Tethered swimming - hand" (r=0,42), ERG1 – 1 butterfly strokes with resistance level 4 "Biokinetic swim bench" (r=0,36) and DYNLEG – dynamometric in water crawl legs "Tethered swimming - leg" (r=0,33). The results of the backward stepwise regression analysis indicate that in order to predict the 100 m front crawl stroke performance time, out of all the tests used in this investigation, it is sufficient to use dynamometric test as a predictor of swimming performance in that particular event. Performance time in 100 m front crawl stroke can only partially be explained by the results in the applied tests of specific motor abilities and functional abilities. In order to further explain the relationship between specific motor abilities as well as functional abilities and the 100m front crawl stroke performance time, further research needs to be conducted.*

**Key words:** *stroke force, Biokinetic swim bench, tethered swimming, dynamometric*

## Introduction

Any country that wants to dominate the swimming scene nowadays should strive to develop new, unseen training methods aimed at improving swimming technique. It should also strive to improve the periodization and recovery methods. One of the problems for when it comes to assessment of swimmers' characteristic is the available equipment. Since swimming pools "flume", they do not provide conditions are found during a competition, due to the inability of rotation around the longitudinal body axis, the body creates additional resistance. Because of this, the equipment for on-land assessment has been constructed, and it enables imitation of the stroke similar to a stroke as it occurs in the water. Apart from on-land testing, specific arm and leg strength is assessed in the water. In all sports there is a need for optimization of movements' efficiency in order to achieve maximal performance. This may be realized by continuous observation of different components responsible for efficient performance of an athlete. In swimming, one of the main problems regarding physiological testing procedures in real-world swimming conditions is that portable instruments are required, which to a certain extent limits swimmers in performing rotations around horizontal axis, makes breathing more difficult, and limits swimmers in performing correct turns. For these reasons, special equipment for on-land testing was designed, simulating in-water arms and legs dynamic to a maximum possible extent (Shionoya et al., 1999). Relationship among results in specific tests and their power of prediction of performance times is an issue often observed in swimming sport. Previous research on swimming ergometer, i.e. on *Biokinetic swim bench* (Tanaka et al., 1993) found, in general, positive effects of training on swimming-ergometer on development of – power; high correlation coefficient (0.90) between force observed on Biokinetic swim bench and swimming velocity in 25 yards time trial, high correlation coefficient (0.84) between average swimming velocity and maximal force extorted on *Biokinetic swim bench*, and improvement of swimming performance time in general. Maximal swimming velocity, especially in short distance events, depends on pulling force characteristics besides technical and energetic abilities of swimmers (Dopsaj et al., 2000). The test most widely used to measure pulling force in swimming is the tethered swimming test (Yeater et al., 1981; Dopsaj et al., 2000). Previous research on power of the stroke and the kick in the water, i.e. *tethered swimming* (Bollenes 1988; Hus & Hsu, 1997), generally determined that those were in high correlation with swimming performance times, and that there is a relevant significance of crawl kick as a factor of generating and preserving propulsion force, as well as high relationship of pull power and swimming performance times in all observed ages. Tethered swimming has long been in use in order to measure and evaluate swimmers propulsive force (Yeater et al., 1981) and it is considered a suitable mode to analyze anaerobic performance (Morouco, 2009). The tethered swimming can be used as an adaptation of Wintage test (Morouco,2009), being performed in the water as a more specific ergometer. Besides being a valid and reliable test (Dopsaj et al, 2003; Morouco, 2009) its relationship with performance in swimming is questioned (Smith et al., 2002), mainly because changes of arm and hand action seem to occur. The aim of this study was to determine the influence of certain specific motor and functional abilities on 100-m freestyle swimming performance time in a long course swimming pool.

## Methods

*Sample of examinees*
Sample included 42 male swimmers of the Croatian National Swimming Team (*x=21.41; SD= 3.67 years*). The Ethics Committee of the hosting Faculty approved all the experimental procedures. All the swimmers with at least six years of competitive experience and trained seven to nine times per week (2 h per training session).

*Sample of variables*
Respecting the goals of this research, the total space of specific motor abilities and functional abilities was encompassed by a set of independent variables relevant for crawl swimming technique. A number of tests used in this research were applied as described in previous research of different authors (Cazorla 1993; Leko 2001). Variables in this research are: Independent variables – Biokinetic swim bench 1RM butterfly pull-ERG1, Biokinetic swim bench 10 RM butterfly pull-ERG10, Biokinetic swim bench 60 sec front crawl stroke-ERG60, Tethered swimming – kick – DYNLEG, Tethered swimming – hand – DYNHAND, Tethered swimming – coordination- DYNCOO, Maximum production lactate – MPL, Maximal heart rate – HRMAX, Minimal heart rate - HRMIN

*Dependent variable*
100-m front crawl stroke swimming test – C100
Subjects performed the test by starting on a starter's mark from a starting block and using front crawl stroke. They were instructed to give an all-out effort with obligatory flip turn after the first 50-m. Time was measured using an electronic stopwatch with a precision of 1/100 of a second *(Omega)*. The test was performed in a long course pool.

*Testing protocol*
In this study 6 specific motor and 3 functional abilities tests were analysed. Before the tests in the water, the swimmers warmed up according to their usual habits. After a 10–minute rest the measuring started tethered swimming (full technique) at medium intensity and after two three to strokes at the whistle of the time – keeper, they swam at maximal intensity for 10 seconds. The test was conducted in an indoor swimming within the sports complex SRC Mladost (Zagreb), a week before the competition in which all swimmers competed in a 100-m freestyle event. Before on-lend measurements, the swimmers warmed up for 20 minutes. The testing began with test conducted on a Biokinetic swim bench. The swimmers were given one practice trial before the data collection started. Two days after tethered testing the swimmers were performed a 200-m freestyle all-out effort. All swimmers performed C100 test approximately one week after the on-land and in-water testing. *DYNCOO, DYNHAND, DYNLEG* - a swimmer wears a belt around his waist which is connected to an elastic rope, which is further connected to a dynamometer. After starting from vertical position and maximally stretching the elastic while swimming, a swimmer tries to produce the highest possible peak value of dynamometric force during a 10 second period. The force is registered at the bottom of the screen mounted on the dynamometer. In this study, the maximal pulling dynamometric force was registered, which was achieved by swimmers in tethered swimming (hand - with pull buoys between legs, leg kick - with kick boards holding in hands) in front crawl stroke. Relative values of dynamometric force expressed in N/kg were used.

*Data analysis methods*
The results were processed using Statistic 7.1 software. (Stat Soft, Inc., 2008), and presented in Tables 3, 4 and 5. Descriptive parameters and coefficients of inter-correlations among all variables were calculated, and backward stepwise multiple regression analysis was conducted in order to determine the impact of the independent set of variables on the criterion variable.

## Results

Table 1. Descriptive parameters of motor and functional variables

| Variable | Mean | SD | Min | Max | Skew | Kurt |
|---|---|---|---|---|---|---|
| ERG1 | 372,22 | 92,30 | 230 | 732 | 1,64 | 4,81 |
| ERG10 | 3270,88 | 575,40 | 2169 | 4576 | -0,11 | -0,63 |
| ERG60 | 10532,30 | 2724,45 | 5039 | 18192 | 0,44 | 0,45 |
| DYNCOO | 339,64 | 42,63 | 237 | 403 | -0,59 | -0,44 |
| DYNHAND | 252,38 | 38,63 | 186 | 331 | 0,35 | -0,62 |
| DYNLEG | 156,49 | 25,19 | 92 | 209 | -0,26 | 0,12 |
| MPL200 | 18,30 | 2,81 | 10,8 | 21,7 | -1,09 | 0,72 |
| HRMAX | 199,26 | 8,44 | 183 | 218 | 0,09 | -0,55 |
| HRMIN | 57,76 | 6,87 | 42 | 71 | -0,46 | -0,31 |

Table 2. Inter-correlation among predictors and between predictors and criterion

| | ERG 1 | ERG 10 | ERG 60 | DYN COO | DYN HAN | DYN LEG | MPL 200 | HR MAX | HR MIN |
|---|---|---|---|---|---|---|---|---|---|
| ERG 10 | 0,60* | | | | | | | | |
| ERG 60 | 0,27 | 0,32* | | | | | | | |
| DYN COO | 0,31* | 0,42* | 0,40* | | | | | | |
| DYN HAND | 0,19 | 0,35* | 0,23 | 0,60* | | | | | |
| DYN LEG | 0,23 | 0,35* | 0,13 | 0,54* | 0,39* | | | | |
| MPL 200 | -0,14 | -0,17 | 0,36 | 0,37 | 0,35 | 0,35 | | | |
| HR MAX | 0,09 | 0,15 | 0,17 | 0,14 | -0,05 | 0,33* | -0,92* | | |
| HR MIN | 0,06 | 0,06 | 0,25 | -0,22 | -0,17 | 0,17 | -0,60* | 0,52* | |
| IPS | 0,36* | 0,28 | 0,26 | 0,57* | 0,42* | 0,33* | -0,22 | 0,27 | -0,04 |

Table 3. Results of backward stepwise regression analyses

| Model summary | R | R Square | Adjusted R Square | Std. Error of the Estimate | | |
|---|---|---|---|---|---|---|
| | 0,57 | 0,33 | 0,312 | 50,44 | | |
| Coefficients | Unstandardized Coefficients | Standardized Coefficients | | | | |
| | B | Beta | t | sig. | 0-order | Partial |
| (Constant) | 562,75 | | 8,90 | 0,000 | Correlation | |
| DYNCOO | 0,82 | 0,57 | 4,43 | 0,000 | 0,57 | 0,57 |

## Discussion and conclusion

There is a high correlation (r=0.60) between variables ERG1 and ERG10 (Table 2), which is expected given the similar movement structures in mentioned test. Previous findings may be corroborated by a relatively small difference in average pulling forces between ERG1 (372.22) and ERG10 (327.09). Lower correlation coefficients between these variables and ERG60 were obtained because of different movement structures and considerably longer duration of ERG60 test compared to ERG1 and ERG10.

Correlation coefficients of results in tests performed on Biokinetic (ERG1, ERG10, and ERG60) with results in variables DYNCOO and DYNHAND are moderate, and with results in variables DYNLEG are low. Test DYNLEG was used for testing the forces generated by leg muscles, and forces extorted during stroke pull were tested on Biokinetic swim bench, and this could be considered to be the main reason for low correlation coefficients. After the inspection of correlation coefficients of tests performed on Biokinetic swim bench with DYNCOO and DYNHAND, certain regularity was noticed. Namely, contrary to our expectations, variable ERG1 is in smallest correlation with DYNCOO and DYNHAND, compared to ERG60 with greater, and ERG10 the greatest correlation. The highest correlation of ERG10 with dynamometry tests was acquired because of approximately same duration, i.e. number of pulls, and higher correlation with ERG60 compared to ERG1 because of similarity of movement structures in ERG60, DYNCOO and DYNHAND. High correlation coefficients between variables DYNHAND and DYNLEG with DYNCOO were observed, and this finding was expected due to the fact that movements are constituent parts of coordination in front crawl stroke.

Morouco et al., (2008) have observed high correlations between force during the 30 sec maximal tethered swimming and performance time in short and middle distance events, while D' Acquisto & Costill (1998) have observed high correlation coefficient between power and performance time in 100-m and 400-yd events. High correlation coefficient between MPL200 and $HR_{MAX}$ was absolutely expected due to similarities of the test and high-intensity swimming. Moderate correlation between $HR_{MIN}$ and $HR_{MAX}$ also meets expectations. In fact, greater heart volume and strength, which are indicated by lower values for variable $HR_{MIN}$, ensure equal blood flow even at the lower heart rates, i.e. values for the variable $HR_{MAX}$.

The highest correlation coefficients among predictor variables with a criterion variable C100 are correlation coefficients with variables DYNCOO (0.57), DYNHAND (0.42), ERG1 (0.36), and DYNLEG (0.33). Observed correlations lead to a conclusion that the greatest impact on a performance time in 100-m freestyle event is defined by the force generated in coordinated action of arms and legs.

In the same time, it can be registered higher impact of force produced by the arms compared to the force produced by the legs.

The results of the backward stepwise regression analysis (Table 3) indicate that the prediction of 100-m freestyle performance time is possible only using the predictor test DYNCOO. $R^2$ (0.33) indicates that there is 33% of common variability between 100-m events and results in test DYNCOO. It was found that the following tests correlate with the 100 m freestyle performance time: DYNCOO - dynamometric in water front crawl coordination (r=0.57)- *Tethered swimming*, DYNHANDS– dynamometric in water front crawl hands "Tethered swimming- pull" (r=0.42), ERG1 – 1 butterfly strokes with resistance level 4 (r=0.36) and DYNLEGS – dynamometric in water crawl kick "Tethered swimming- kick"(r=0.33).

The results of the backward stepwise regression analysis indicate that in order to predict the 100-m freestyle performance time, out of all the tests used in this investigation, it is sufficient to use dynamometric test as a predictor of swimming performance in that particular event. Remaining variability in 100-m freestyle should be observed in forthcoming studies. Finally, significant correlation between 100-m freestyle performance and performance in tests DYNCOO (0.57), DYNHAND (0.42), ERG1 (0.36) and DYNLEG (0.33) was observed.

Leko (2001) observed that "from the set of predictor variables, tests [1] "Tethered swimming of front crawl stroke in a coordination" (DYNCOO), [2] "Tethered swimming-kick" (DYNLEG), and [3] 30m running (S30) had significant 67% power of prediction of results in 100m freestyle swimming." The results of backward stepwise regression analyses reveal the fact that for optimal prognosis of results in 100-m front crawl stroke, it is enough to use "Tethered swimming" test front crawl coordination (DYNCOO) which is significantly correlated with a criterion C100. Performance time in 100 m freestyle can only partially be explained by the results in the applied tests of specific motor abilities and functional abilities. Further research dealing with the relationship between specific motor and functional abilities and the 100m freestyle performance time is warranted.

The test "Tethered swimming" should have its practical application in continuous supervision of utilization of swimmer's strength of the pull and kick in the water in different periods of training and competition, and for short-term prediction of front crawl swimming performance. Tethered forms of sprint-resisted training aimed at improving power and the rate of anaerobic metabolism are no more stressful then free swimming repeats of these types. Therefore, swimmers can perform them several times each week (Maglischo, 2003).

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## UTJECAJ SPECIFIČNIH FUNKCIONALNO MOTORIČKIH SPOSOBNOSTI NA REZULTAT U KRAUL TEHNICI


**Sažetak**

*Osnovni cilj istraživanja je utvrditi povezanost rezultata u testovima specifične motorike i funkcionalnih sposobnosti na rezultate u discipline 100 metara slobodno. Mjerenje je izvršeno na uzorku od 42 plivača reprezentacije Republike Hrvatske. Utvrđeno je da su sa uspjehom u discipline 100 metara slobodno statistički značajno povezani testovi DYNCOO – dinamometrija koordinacije u vodi (r=0,57), DYNHAND – dinamometrija ruku u vodi (r=0,42), ERG1 – 1 dupin provlak na opterećenju 4 (r=0,36) i DYNLEG – dinamometrija nogu u vodi (r=0,33). Rezultati backward stepwise regresijske analize ukazuju da je za optimalnu prognozu rezultata na 100 metara slobodno, iz skupa testova provedenih u ovom istraživanju, kao prediktor dovoljno koristiti samo test dinamometrija. Uspješnost u discipline 100 m slobodno moguće je tek djelomično objasniti korištenim skupom testova specifične motorike i funkcionalnih sposobnosti. Za iscrpnije objašnjenje utjecaja specifične motorike i funkcionalnih sposobnosti na uspjeh u discipline 100 metara slobodno potrebno je provesti daljnja istraživanja.*



***Ključne riječi***: *sila zaveslaja, biokinetik, privezano plivanje, dinamometar*

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