A CASE STUDY TO INVESTIGATE THE SWIMMING PROPULSIVE EFFICIENCY

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ABSTRACT: *In competitive swimming, the most important factor is to possess the ability to produce propelling force in an efficient way. Till now the biomechanists could not serve the direct method to estimate the swimmers ability from this point of view. The possibilities of the trainer is limited, thus they can give advice based only on their subjective observation. How could a swimmer move the extremities to generate propelling force utilizing the potential of the fluid environment, is still unknown. Even to estimate the magnitude of the force production is a near inpossible task, since the applicability of the Schleihauf method was criticized and later was confirmed in several ways, that this is an incorret approach. Flow visualisation, pressure measurement and tuft methods provided evidences from the role of the unsteady effects, but these methods are so far not good enough to describe the real way of the mechanism. To avoid injurys and to give advice regarding the force production it is very important to find a method to approach this problem acurrately. Using the tethered swimming measurement to record the force production and to record the motion of the extremities with underwater cameras can provide a possible explanation of the occurences around the the swimmers hand arm complex action in the water. According to our measurement the ratio between the synchronised kinematic data and the data based on computation method differentiate well across the used ferquencies and can be determined by plonomyal function: c:-75,551, b1:5,555 and b2-0,054; R Square= 0.951. We can describe the frequency: 39,167 cycle/minute which fits the requirements to perform in a highest efficiency to be typical of the individual swimmer.*

1 INTRODUCTION

Propulsion is one of the most important factors in swimming competitions. Physically and mentally the best trained swimmer can not produce sufficient results in the lack of exploiting the maximal potential of the fluid environment. The occurrences in the fluid depend on the swimmers anatomical nature and the sensomotoric function of the Central Nervous System, in which way the extremities are moved in the water. Many researchers tried to identify and universalize the function and the motion of the swimmer's extremities in the water, but the uncertainty is growing due to newly explored influential conditions (Sanders, 1999; Arellano, 1999; Toussaint, 2000; Toussaint et al., 2002; Rouboa et al., 2006). Beside many other factors, according to our expectation, the performance of the swimmer can differ in respect of utilization of the environmental potential. During competition and training the swimmer uses different stroking frequencies to vary the swimming speed and also if a swimmer swims with a constant frequency the certain level of intercyclic movement difference is present. The effectiveness of the alternatively performed cycles can differ between used frequencies by one swimmer and between individuals. In this study, our aim was to determine the most effective stroking frequency for a highly trained international level swimmer. Based on our preliminary studies (Karsai et al. 2008), the difference between the tethered force, the force computed kinematical, and anatomical parameters can indicate the magnitude of the utilization of the fluid potential. Performing the mentioned measurement on different stroking frequencies can reveal the function of the determined value across different movement patterns.

2 METHOD

An international level adult female swimmer was asked to perform the tethered crawl swimming test in different frequencies. The method to determine the swimmer's force production was used a simple three segment model based on her anatomical and kinematical parameters recorded during the experiment. For the force calculation based on kinematical and antropometrical parameters the hydro dynamical drag equation (without the "C" component) was applied and its projection to the swimming direction was compared with the measured force production (push mode) measured by the TENZI TMF 16 type water ergometer. The kinematical parameters were defined by the APAS based on 4 underwater camera's records. The target frequency (TF) for the Crawl arm stroke was set from 25 to 55 cycles/minute (C/M) with 5 C/M increments. The kinematic and kinetic data were synchronized with a control light. The test duration of each frequency step lasted 20 sec. The experiment steps were performed without breathing, and the legs were tied and supported. Three whole arm cycles were used for the analysis. To determine the most efficient stroking frequency we used the nonlinear regression analysis.

3 RESULTS

The obtained results for force data (Table 1.) were in accordance with the literature. Between the achieved and the target frequencies we experienced only slight differences. The lowest mean value at TF 25 C/M was 32.64 N and the maximal was 112.81 N. Under increasing the TF, the mean and the maximal achieved force increases till the TF 50 C/M where the mean force rises up to 71.48 N and the maximal force 195.21 N. At the highest TF 55 C/M step the mean force dropped considerably to 63.03 N and one peak showed 203.21 N at a right hand stroke.

Table 1. Summary of the performed frequencies and force production in different frequencies and the ratio between measured and the computed data

	[illegible]						
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Autocorrelation showed that the data was consistent during the experiments, highest r=0,923 value was observed at TF 40 C/M step. Regression analysis showed, that the performance can be described with a second order polynomial function: c:-75,551, b1:5,555 and b2-0,054; R Square= 0.951 considering the mean values. The ratio between measured and the computed values (Fig. 1.) are at TF 25 C/M: 2,20 and riches at C/M 35 c/m the maximum 20,72 at TF 40 C/M: 16,59 and at the last two steps drops to 3,49 at both cases. The shape of the function shows an inverted U form, the parameters of the second order function; c:-84,166 b1: 5,082 and b2 -0,065, R Square: 0,714. The computed optimal frequency for the swimmer: 39,167 C/M.

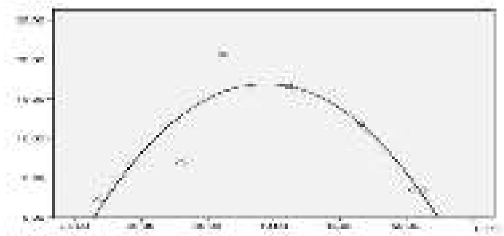

Figure 1. The inverted U shape function of the determined ratios and the performed frequencies

Discussion and Conclusion

By the results pointed out we can conclude that this method fits the requirements to determine the swimmer's most efficient stroking frequency. The combination of the kinematical and kinetical parameters can give meaningful information from the structure of the performance. Despite that the observed a highest ratio at a lower frequency (36,17 C/M) was present, which seems controversial to our result (39,167 C/M) based on the function, the high R square value of the function indicates that there is a possible measurement error at the TF 35 C/M step which influences the computation. The repeated measurements could provide information from the alteration of the propulsive efficiency during the preparation phase, and the data are also comparable with other swimmer's values to discern the swimmers on this basis.

Further investigation is needed to reveal the background of this function based on the gathered data and extend the experiment to higher number of participants.

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