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Changes in mean swimming speed and efficiency in the front crawl at 2x25m track

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ABSTRACT

Šťastný, J., & Motyčka, J. (2015). Changes in mean swimming speed and efficiency in the front crawl at 2x25m track. *J. Hum. Sport Exerc.*, 9(Proc1), pp.S286-S292. Between the years 2009 and 2014 our team have collected data from more than 2000 measurements of four different swimming techniques. The swimmers that have participated in the research study include members of the Czech national swimming team and, competitive swimmers at national level. This article focuses on the measurements conducted during 50m front crawl swimming at a 25m pool, using data of 96 swimmers (52 men, 44 women). The aim of the study was to compare swimming efficiency and mean speed during two consecutive 25m segments. The average swimming efficiency and standard deviation during two successive 25m segments of the 50m distance were:

1) All measurements 0,979; $s = 0,013396$; 0,972 $s = 0,017616$

2) Males 0,974; $s = 0,018071$; 0,962 $s = 0,024814$

3) Females 0,983; $s = 0,008431$; 0,979 $s = 0,004562$

The mean speed and standard deviation during two successive 25m segments of the 50m distance were:

1) All measurements 1,639; $s = 0,129161$; 1,556; $s = 0,121743$

2) Males 1,504; $s = 0,042109$; 1,443; $s = 0,056049$

3) Females 1,734; $s = 0,060302$; 1,637; $s = 0,082359$

Results show that swimming efficiency and mean speed decrease during the second 25m segment of the 50 m distance in both groups - men and women. The decrease in medium speed and efficiency between the first and the second section was higher in the male category **Key words:** TACHOGRAPH, CAMERA, SWIMMING TECHNIQUE, NATIONAL TEAM, VELOCITY.



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INTRODUCTION

Our team has been involved in monitoring the performances of Czech swimmers and the development of a measuring device and software since 2009.

The swimmers that have participated in the research study include members of the Czech national swimming team, members of the Czech junior swimming team, competitive swimmers at national level, and students of sport secondary schools.

As it is known, speed of a swimmer fluctuates during a single stroke cycle as well as in each segment of swimming. Our measuring device records such changes in speed and synchronizes them with the image of three cameras placed underwater. From these data, the software is able to compare the speed achieved in the measurement with the personal maximum of the swimmer. It can also calculate mean speed, efficiency, and other variables. The measurement results enable us to give constructive feedback to the swimmers for their subsequent training and race preparation.

In the past, we mainly dealt with data of individual swimmers which means that there has been a lack of a general overview of the values monitored by us. But in fact their statistical evaluation helps swimmers to get more complex information based on comparison with the other competitors.

We would like to present the evaluation of mean speed and efficiency obtained from our measurements conducted during 50m front crawl swimming at a 25m pool. Our focus is on the change of these values during two consecutive 25m swimming segments.

MATERIAL AND METHODS

Participants

In this study we have used data of 96 competitive swimmers coming from the Czech Republic, of which 52 were males (14-33 yr., Median 17) and 44 were females (age 14-26 yr. Median 16). All the swimmers volunteered as subjects thanks to our cooperation with sports schools, swimming clubs, and the national team of the Czech Republic.

The measurements were taken between the years 2009 and 2014.

Measures

We obtain our data from the measurement system Tachograph (Motycka, 1974). Storing the data, synchronization and follow-up evaluation are done in the software SwimData. The software saves and synchronizes data from two sources - three underwater cameras (20 to 25 frames per sec.) and speed sensors - tachographs (1000 samples per second)

Procedure

The vast majority of measurements are conducted in a short course swimming pool (25m long) in Brno, some take place in the equally long swimming pool in Nymburk. Conditions are similar in both locations. The measurements are carried out by a permanent team of 6 people. Two people are in charge of the speed sensors, one person operates the mobile camera recording swimmers from the side, another member of the team works at a computer where he or she enters the input data. At the same time all data

from the measurement devices are stored in the computer. Other two people are responsible for the team management, organization of measurements, etc.

Prior to measurements, swimmers have time to complete a warm-up in the water. Then, after having measurement devices attached to their bodies, they can start swimming. Swimmers swim three 50m segments. The first segment is swum by kicking legs without using arms, the second one is swum by moving arms while the legs rest. During the last segment swimmers use both, their arms and legs. Swimmers take a rest between the laps.

Analysis

We have evaluated the mean speed and efficiency in two consecutive 25 meter sections, for each of these sections separately. Pushing off and touching the wall are not included in the evaluation as they can distort the results.

The beginning of the analyzed interval is adjusted manually in the programme Swim Data Viewer (Figure 1) from the second stroke of the swimmer after reaching the water surface. The analyzed interval ends 2 meters before touching the wall upon completion of each length. Then the software can calculate efficiency and mean velocity [$\text{m} \cdot \text{s}^{-1}$] for that particular section (Motycka et al., 2009).

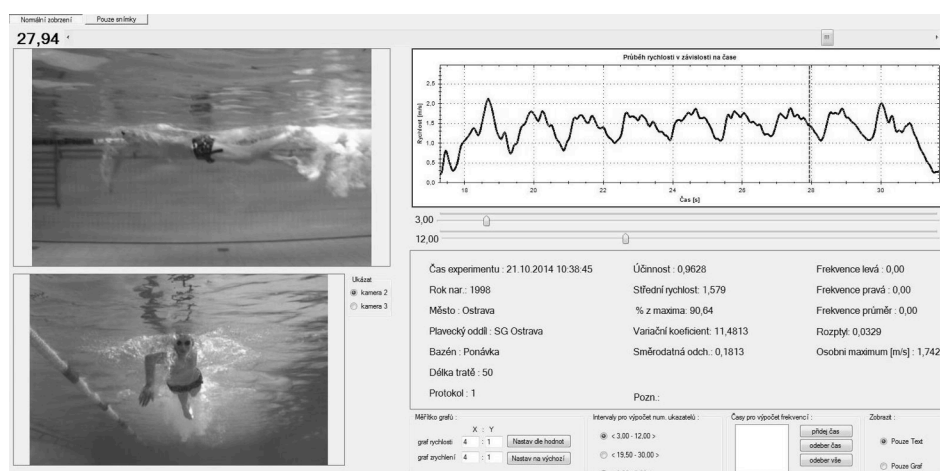


Figure 1. SwimDataViewer

The results are written into MS Excel and processed with the help of the software Statistica.

RESULTS

After having all the data processed, normality tests for the efficiency and medium speed in the first and second 25m sections are performed. They are done for three categories – men, women, and men + women. The credibility level is $\alpha = 0.05$.

Swimming efficiency [%]

The results indicate that the distribution of efficiency is not normal. We used non-parametric Wilcoxon rank test for the calculation of statistical significance.

From Table 1 it can be read as follows: swimming efficiency is higher in men in comparison to women. The decrease in swimming efficiency during the second 25meter section is lower in the category of women. For clarity, the changes in speed during particular sections are displayed in Figure 2 with the aid of a box plot.

Table 1. Efficiency

Variable	gender	N	average [%]	eff.1 - eff.2	decrease eff. [%]	median [%]	s. deviation	p (Wilcoxon)
efficiency 1	men +	96	0,972561	0,006573	0,675844497	0,9778	0,0174	0,0000
efficiency 2	women		0,965988			0,9698	0,0193	
efficiency 1	men	52	0,974483	0,007558	0,775590749	0,9801	0,0178	0,00002
efficiency 2	women		0,966925			0,9737	0,02	
efficiency 1	men	44	0,970291	0,005411	0,557667751	0,9755	0,0168	0,0043
efficiency 2	women		0,96488			0,9677	0,0186	

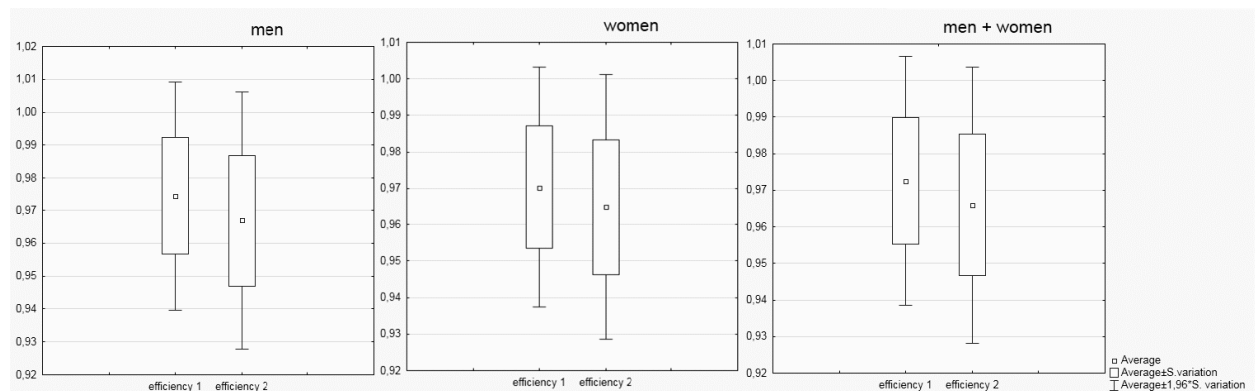


Figure 2. Efficiency, box plot - men; women; men + women

Mean swimming speed [$m \cdot s^{-1}$]

Mean speed distribution is normal => the parametric t-test (dependent samples) has been used for the calculation of statistical significance.

In Chart 2, we evaluated the values of the average mean speed for each category.

The values are higher in men, lower in women. The drop of speed between the first and second sections (MS1 - MS2) is higher in men. The reduction of speed is about 4.5%. The statistical null hypothesis is rejected (speed in the first and second section is different). Figure 3 illustrates the frequency distribution of mean speed.

Table 2. Mean speed

men + women N = 96	median	average [m*s ⁻¹]	s. deviation	m.s.1 – m.s.2	decrease m.s. [%]	p (t-test)
mean speed 1	1,559	1,56828	0,139206	0,07076	4,511949397	0,00000
mean speed 2	1,495	1,49752	0,137339			
men N = 52						
mean speed 1	1,676	1,66242	0,102167	0,07838	4,714813344	0,00000
mean speed 2	1,583	1,58404	0,108853			
women N = 44						
mean speed 1	1,456	1,45702	0,08396	0,06175	4,238102428	0,00000
mean speed 2	1,385	1,39527	0,088707			

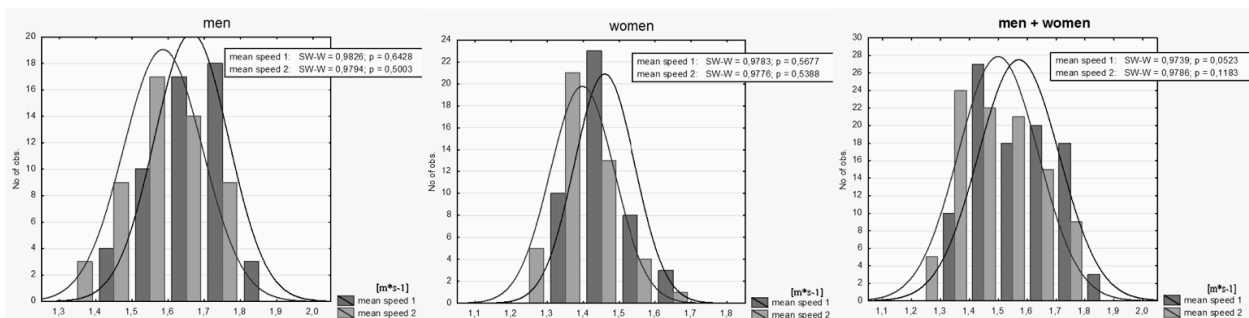


Figure 3. Mean speed distribution graph - men; women; men + women

DISCUSSION

Mean speed is the value that is considered to be the most important indicator for a swimmer when it comes for the results. For swimmers, it is crucial to maintain their maximum swimming speed for the longest part of the race as possible. The efficiency of swimming technique can tell us how effectively a person uses his or her energy.

The more fluent the movement of a swimmer in the water is from the point of speed, the less energy the swimmer needs for that particular swimming section. The reduction in speed of the swimmer in each pace (cycle) is caused by a swimming stroke and its specifics, but from our point of view it is the quality of mastering the swimming style - swimming technique, that matters. The longer the track is, the more the low efficiency of swimming will be visible.

Factors affecting decrease in front crawl speed include:

A) Fitness components

1. Endurance.
2. Power (insufficient strength of the stroke of arms or legs).

B) Technical components

1. Wrong stroke timing and coordination - in some moments the swimmer is not driven forward by any body part.

2. Wrong body position which leads to decrease in the propulsive force (e.g. wrong position of head, arms, back, pelvis, back, arms, ankles that are not relaxed, etc).

C) Other factors - physical, mental, tactical, external influences

Changes in speed and efficiency at two consecutive segments will be mainly affected by physical fitness. Points B and C mentioned above will remain almost unchanged during swimming at a selected (measured) track.

The fact that women had lower average efficiency (0.970, 0965) in comparison with men (0.974; 0.967) surprised us. It could be so due to their slightly lower average age. Based on our previous empirical findings, we assumed that better swimming technique and higher efficiency would play an important part in the results of women, whereas men would put more emphasis on power. However, the male swimmers had a significant decrease in the efficiency in the second 25m segment (0.78%) in comparison with women (0.58%). Next time we will conduct a more detailed analysis of this fact with regards to age groups.

We will also focus on the evaluation of results from a longer track (100 m), which should indicate efficiency and speed development in the third and fourth swimming segments.

The higher mean speed of men (1.662; 1.584 [$\text{m} \cdot \text{s}^{-1}$]) in comparison to women (1.457; 1.395 [$\text{m} \cdot \text{s}^{-1}$]) corresponds with our expectations. As in the case of efficiency, mean speed decreased more in men (4.7%) than in women (4.2%). We assume that it may be caused by greater water resistance at a higher speed during swimming.

By comparing our results with some other gained in the future we may be able to make training recommendations not only from the perspective of swimming technique, but also in terms of the evaluation of fitness of a swimmer.

In a few individual cases there was an improvement in the efficiency in the second 25m section. Does it mean that exhaustion can function as a stimulus for the improvement of swimming technique and thus further saving of energy?

CONCLUSIONS

We evaluated and defined the changes in mean speed and efficiency between the first and second segments of a 50-meter track. The reduction of both values is statistically significant. Our results show that exhaustion causes decline in swimming efficiency and mean speed during the second 25m segment of a 50 m track. It happens in both groups, men and women.

The assumption that men would have higher average mean speed in comparison with women was right. However, our assumption that women would have higher efficiency of swimming cannot be confirmed.

The decrease in mean speed and efficiency between the first and the second 25m sections was higher in the male category.

The results enable us to make training recommendations for swimmers measured in the future. The amount of decline in speed and efficiency is determined by physical fitness of a swimmer.

In the future we want to analyse a longer track (100m). Will their decline be steady equable, or will it be affected by other influences?

Furthermore, we are interested in the possible influence of age categories over results and also in the evaluation of the results gained from the segments where swimmers were allowed to move either their arms or legs while swimming.

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