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Original empirical article

CRITICAL VELOCITY WITH AND WITHOUT THE APPLICATION OF SWIMMING FINS AMONG YOUTH FIN COMPETITORS

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Abstract. *In this study we aimed to define critical velocity among male and female swimmers by means of the application of swimming fins. The sample in this study consisted of 10 Greek freestyle short distance swimmers. The participants swam distances of 25m, 50m, 100m and 200m freestyle with maximum intensity. The start of each test was from the water and always under the same conditions. Critical velocity was calculated according to the performance for each distance (Wakayoshi et al., 1993) and the time needed. For the statistical analysis, the MANOVA analysis was used. The results of this study showed that critical velocity calculation if significantly affected by the type of technical swimming, with a greater critical velocity in the case of swimming with fins between the genders. The type of technical swimming should be taken into consideration in the planning process of fin swim training especially in the case of pre-pubescent children. In addition, male swimmers were shown to have a higher cV when swimming with fins at a swimming distance ranging from 50 to 200 meters (Wilks' Lambda 0.0289, p = 0.015). This may indicate that young males use the fins in a more effective way than the female ones between the ages of 10 and 12.*

Key words: *Freestyle swimming, critical velocity, swimming fins.*

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INTRODUCTION

Critical velocity is a practical and reliable tool and has been utilized as an index for determining training speed and evaluating endurance capacity in the field of competitive swimming (Takashi et al., 2002). It has been proved to be a simple and non-invasive method for monitoring aerobic fitness and controlling training intensity in swimming (Wakayoshi et al., 1992). Critical speed is the fastest swimming speed that the swimmer can maintain without fatigue at a certain distance (Wakayoshi et al., 1992) and represents aerobic capacity in continuous exercise (Toussaint et al., 1997). Different tests have been found to be trustworthy for the determination of ideal velocity for aerobic training, without the use of blood indicators. They are used in swimming distances from 50 to 400m (Wakayoshi et al., 1999) and in some cases even longer distances (from 50 to 1500m, Fernandes &Vilas-Boas 1999). A strong correlation has been determined between swimming performance and swimming speed, corresponding to 4mmol/l of blood lactate concentration, which has been, on the basis of the correlation, used as a useful criterion of training intensity for the competitive swimmer (Wakayoshi et al., 1992; Madsen & Lohberg, 1987; Maglischo, 1982; Skinner, 1987). The coach must know the ideal swimming velocity in order to develop a swimmer's endurance during a training cycle and to estimate the training efficiency for the improvement of physical abilities.

Swimming training sessions may be performed under technical conditions as well as with or without fins. The technical conditions for swimming may be an important factor affecting the calculated value of critical speed. It is possible that the values of critical speed calculated for different types of technical swimming may not be transferable to the training process.

For the development of velocity, many means of training are widely used in swimming programs. One of the reasons for this is the increase of physical abilities such as velocity and type of technical swimming. One of the means used are swimming fins. In this study we aimed to define critical velocity in male and female swimmers at the beginning of the overall training process (a swimmer's sports career) by using swimming fins.

METHODS

Sample

Twelve swimmers participated in this study. The sample consisted of 6 male and 6 female swimmers. The age of the female subjects was 10.6± 0.5 years, the BH – 144.1±9.9 cm, the BM – 39.82±13.68 kg, and the BMI was – 18.56± 3.55 kg·m^2 and for the male subjects it was 11.6±0.5 years, the BH – 150.8±7.0 cm, the BM – 41.64±4.67 kg, and the BMI was – 18.31±1.74 kg·m^2.

Procedure

The swimmers trained systematically (5 days per week, at least 1.5 hours per day). They were informed about the aim of the research and the testing procedure and following their approval, we proceeded to carry out the test. For all swimmers (male and female), their respective height and weight were measured in the afternoon before a training session.

The swimmers were instructed to swim four distances at maximum intensity (25m, 50m, 100m & 200m). The order of the measurements was random with 1-3 days in between.

All of the measurements took place in open outdoor swimming pools of fifty (50) meters in length, with water temperatures of 26 ±1 C^0.

Before the measurements, the participants first warmed up during a 600m swim, under the instruction of their coach. For the purpose of this study, the swimmers swam 25m, 50m, 100m and 200m freestyle with maximum intensity according to swimming regulations, and performance time was recorded for each distance. All of the measurements were made with a start from the water and always under the same conditions. The performance for each distance was measured electronically (Seiko Water Resistant 10BAR, S140).

Critical velocity was calculated according to the performance that was measured (Wakayoshi et al., 1993) and the time needed to cover each distance.

Method of determining critical speed

The mathematical model calculates the value of the critical speed for the distances under consideration, which are 25m, 50m, 100m and 200m (Martin & White, 2000; Matković et al., 1999; Toussaint, 2000; Thanopoulos et al., 1994; Housh et al., 2001; Thanopoulos et al., 2008). Critical speed (cV) was calculated with reference to the following parameters: the time needed to swim the distances of 25m, 50m, 100m and 200m is placed in a linear correlation of time – distance by applying the simple equation of $\boldsymbol{y = a + bx}$ (MacLaren & Coulson, 1999; Martin & Whyte, 2000; Dopsaj et al., 2000; Thanopoulos et al., 2008). The standard $\boldsymbol{a}$ is the value of y for $x = 0$ and it is the y-intercept, whereas the standard $\boldsymbol{b}$ defines the slope of the line (Toussaint et al., 2000).

Critical velocity (cV for Fin and cV for Swim) was estimated from the slope of the linear regression line between swimming distance and time for three different distances ranging from 25m and 50m (cV50), 25, 50 and 100m (cV100), 25, 50 100 and 200m (cV200). The y-intercept (y-INT) was assumed to represent anaerobic swimming capacity and was calculated for the same distance ranges.

Coefficient $\boldsymbol{b}$ represents the critical distance of swimming (b for Fin and b for Swim). The critical distance is equal to the duration of the initial anaerobic ATP swimming capacity which means the distance that can be swum with the consumption of the initial net ATP energetic capacity in specific velocity (Toussaint et al., 1998, MacLaren & Coulson, 1999).

The collected data went through a descriptive statistical analysis so the basic statistical parameters (M=mean, SD=Standard deviation) could be calculated. Differences between the parameters of the time needed to cover a distance, of critical velocity and of the y-intercept were evaluated, while the MANOVA was used to determine differences between the genders. The level of significance was set as $p<0.05$.

RESULTS

Table 1 shows the basic descriptive statistic indexes of the measured variables.

Table 1 Critical velocity (cV) and critical distance (b coefficient) at a distance of 50, 100 and 200 m with and without swimming fins for male (n=6) and female (n=6) swimmers. The values are expressed in Mean, Standard Deviation and 95% of confidence interval (m/s for cV, and m for b coefficient).

		N	Mean	Std. Deviation	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
cV50_Fin	Males	6	1.4618	.09594	1.3611	1.5625
	Females	6	1.3228	.10045	1.2174	1.4282
cV100_Fin	Males	6	1.3868	.06770	1.3158	1.4579
	Females	6	1.2206	.07531	1.1416	1.2996
cV200_Fin	Males	6	1.2978	.06156	1.2332	1.3624
	Females	6	1.1717	.06625	1.1021	1.2412
b50_Fin	Males	6	4.1805	1.02193	3.1080	5.2530
	Females	6	4.3890	1.03748	3.3002	5.4778
b100_Fin	Males	6	5.7564	.51068	5.2204	6.2923
	Females	6	6.7439	1.08636	5.6038	7.8840
b200_Fin	Males	6	8.7222	.55121	8.1437	9.3007
	Females	6	8.5427	.90886	7.5889	9.4964
cV50_Swim	Males	6	1.2264	.12453	1.0957	1.3571
	Females	6	1.1686	.10854	1.0547	1.2825
cV100_Swim	Males	6	1.1893	.06695	1.1191	1.2596
	Females	6	1.0958	.07665	1.0154	1.1762
cV200_Swim	Males	6	1.1551	.06031	1.0918	1.2184
	Females	6	1.0961	.05400	1.0394	1.1527
b50_Swim	Males	6	5.6941	1.90081	3.6993	7.6889
	Females	6	5.9137	1.45609	4.3856	7.4417
b100_Swim	Males	6	6.5441	1.02734	5.4660	7.6223
	Females	6	7.7044	1.19434	6.4510	8.9578
b200_Swim	Males	6	7.8311	1.21282	6.5583	9.1039
	Females	6	7.6648	.46315	7.1787	8.1509

Table 2 shows the results from MANOVA analysis in relation to the variables of cV for Fins, b for Fins, cV for Swim and b for Swim. According to the results, it is can be seen that, generally speaking, a statistically significant difference can be found between the male and female swimmers for the variable 'swimming with fins': cV for Fins Wilks' Lambda 0.289, F = 6.553. For the variable critical distance with fins (b for Fin) and in all variables for swimming (cv for Swim and b for Swim) no statistical significant difference was observed.

Table 3 shows the results of the calculated variables for each individual case according to gender. The results showed that in relation to cV in swimming with fins, there is a statistically significant difference in all the calculated distances (50,100 and 200m) at the level from: cV50_Fin p = 0.034, cV100_Fin p = 0.002 and cV200_Fin p = 0.007. One more individual difference was observed in cV100_Swim, at the level p = 0.048.

Table 2 Critical velocity (cV) and critical distance (b coefficient) at 50, 100 and 200 m general statistical differences between genders.

Effect			Value	F	Hypothesis df	Error df	Sig.
Gender	cV for Fins	Wilks' Lambda	.289	6.553[a]	3.00	8.00	.015
	b for Fins	Wilks' Lambda	.385	4.256[a]	3.00	8.00	.051
	cV for Swim	Wilks' Lambda	.465	3.066[a]	3.00	8.00	.091
	b for Swim	Wilks' Lambda	.443	3.348[a]	3.00	8.00	.076

a. Exact statistic
b. Design: Intercept + Gender

Table 3 Between – subject effects differences according to Fin and Swim variables.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Gender	cV50_Fin	.058	1	.058	6.011	.034
	cV100_Fin	.083	1	.083	16.161	.002
	cV200_Fin	.048	1	.048	11.678	.007
Gender	b50_Fin	.130	1	.130	.123	.733
	b100_Fin	2.926	1	2.926	4.061	.072
	b200_Fin	.097	1	.097	.171	.688
Gender	cV50_Swim	.010	1	.010	.733	.412
	cV100_Swim	.026	1	.026	5.066	.048
	cV200_Swim	.010	1	.010	3.187	.105
Gender	b50_Swim	.145	1	.145	.050	.827
	b100_Swim	4.039	1	4.039	3.255	.101
	b200_Swim	.083	1	.083	.098	.760

DISCUSSION

The results show that in the distances of 50m, 100m and 200m in children at a pre-pubescent age that train with swimming fins in relation to gender differ only in the cV value with fins. Physiologically, cV indirectly represents the intensity with which comes the accumulation of fatigue. These results can show that the measured male and female swimmers cover freestyle distances from 50 to 200m with similar efficiency, but when they swim with fins, the male swimmers swim faster, in a statistically significant manner (critical velocity in relation to intensity).

Even though the measured sample belongs to the category of small samples, the results of this research cannot be generalized for the population of these specific athletes. Only with strong interpretations of the results could we claim that the distances of 50 to 200m belong to the distances that, due to high intensity, use mainly the mechanism of glycolysis for energy production, that is, the anaerobic lactic acid (Madsen & Lohberg 1987; Martin & Whyte 2000). So, even if the participants are at a pre-pubescent age (from 10 to 12 yrs), the male swimmers were chronologically 1 year older, 6.7 cm taller and 1.82 kg heavier than the female ones. With the use of fins, a bigger surface for action in water is guaranteed, which the feet use to affect the water, a fact that guarantees greater strength of the feet as well as better propulsive capacity of the body in swimming and so higher swimming speed. In reality, male swimmers, as the biologically stronger gender, swim with fins with more efficiency in comparison to female swimmers and can use their stronger feet according to the better propulsive ability and the increase of energetic swimming efficiency, a fact that leads to a statistically significant higher critical velocity in swimming.

Generally speaking, critical velocity did not show a statistical significant difference between the two genders. Nevertheless, we can conclude that the male swimmers who use fins are more efficient in relation to female swimmers, in a statistically significant manner.

This is also obvious from the following mathematical calculations where there is a difference between the variables cV50_Swim, cV100_Swim and cV200_Swim - 0.0554, 0.0947 and 0.0584 m/s, while in cV50_Fin, cV100_Fin and cV200_Fin - 0.1398, 0.1674 and 0.1268 m/s in relation to gender (male and female respectively). In other words, this means that when they swim with fins, the male swimmers have higher critical velocity in swimming with 60.37%, 43.43% and 53.94% at these distances in relation to the female swimmers and to the condition of swimming without fins.

CONCLUSION

The results of this study showed that critical velocity calculation if significantly affected by the type of technical swimming, with faster critical velocity for swimming with fins between genders. The type of technical swimming should be taken into consideration in the planning process of fin swim training especially for pre-pubescent children. Also, male swimmers were shown to have a higher cV for swimming with fins at swimming distances between 50 to 200 meters. This may indicate that young male swimmers use fins in a more effective way than female swimmers between the ages of 10 to 12 yrs.

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KRITIČNA BRZINA SA I BEZ UPOTREBE PLIVAČKIH LOPATICA KOD MLADIH PLIVAČA TAKMIČARA

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U ovom radu smo pokušali da definišemo kritičnu brzinu kod muških i ženskih plivača na osnovu upotrebe plivačkih lopatica. Uzorak u ovom istraživanju činilo je 10 grčkih plivača na kratke staze. Učesnici su plivali na razdaljinama od 25m, 50m, 100m i 200m slobodnim stilom uz maksimalni intenzitet. Svaki put su plivanje započinjali iz vode i pod istim uslovima. Kritična brzina je sračunata na osnovu uspeha postignutom na svim razdaljinama (Wakayoshi et al., 1993) i vremena koje je plivačima bilo potrebno. Za statističku obradu podataka upotrebili smo MANOVA analizu. Rezultati ovog istraživanja su pokazali da je na određivanje kritične brzine značajno uticala vrsta plivačke tehnike, i da je veća kritična brizna utvrđena u slučaju upotrebe plivačkih lopatica među polovima. Vrstu tehnike plivanja bi trebalo uzeti u obzir prilikom planiranja procesa treniranja uz pomoć lopatica, naročito u slučaju plivača koji ulaze u pubertet. Pored toga, plivači su imali veće vrednosti cV kada su plivali sa lopaticama na razdaljinama od 50 do 200m (Wilks' Lambda 0.0289, p = 0.015). Ovo bi moglo da bude naznaka toga da plivači uzrasta 10 do 12 godina na efikasniji način koriste lopatice od plivačica.

Ključne reči: *slobodni stil, kritična brizina, plivačke lopatice.*