

The efficiency of a racing dive in swimming

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Abstract:

The goal of this study was to show the influence of the lower limb dynamics on the efficiency of a racing dive and its impact on the swimmers' end results. We tested a group of 7 swimmers (5 men and 2 women, age = 19.6 ± 2.1 years, height = 184.3 ± 7.4 cm, weight = 73.3 ± 11.7 kg). The test consisted of 3 vertical jumps on a diagnostic device FiTROJumper (VJ) (FiTRONiC, Bratislava, Slovak Republic), reaction time (RT) on a FiTRO agility check device (FiTRONiC, Bratislava, Slovak Republic), reaction on start block (RSB), vertical speed after the racing dive until reaching 9 metres (VS) and flight phase from the push off until the moment when the head enters the water (FP). To determine the importance of differences between the observed parameters (R - RSB; VJ - VS; VJ - FP), we used Kendall's tau coefficient (r , $\alpha = 0.05$). The statistical analysis was realized by means of IBM® SPSS® Statistics V19 software. The average level was: VJ = 45.2 cm, RT = 514.9 ms, RSB (T) = 960 ms, RSB (G) = 830 ms and FP (T) = 316 cm, FP (G) = 330.9 cm. The statistical analysis proved a linear dependence between RT – RSB (T) ($r = 0.81$, $p < 0.05$), between RT – RSB (G) ($r = 0.39$, $p < 0.05$), between VJ - VS ($r = 0.59 - 0.81$, $p < 0.05$), between VJ – FP (T) ($r = 0.10$, $p < 0.05$) and between VJ – FP (G) ($r = 0.78$, $p < 0.05$).

Key words: competitive swimming, lower limb dynamics, explosive strength, reaction, testing.

Introduction

By the start in swimming, we mean the first 15 metres after the dive. It is characterized by the highest acceleration of the entire swimming performance. The difference between the average speed and the highest speed can reach 21 - 43%. The start is a crucial part of the swimming performance and is determined by the track length the swimmer has to overcome. Its efficiency is to a large degree influenced by the swimmer's reaction time to a starting signal, the push off intensity, the length and height of the flight, the angle and depth of the body in the water, maintaining optimal body shape, the efficiency of the lower limb strokes, the right estimation of surfacing and start of the first stroke cycle without a rapid change or loss of the speed gained by the racing dive. Several authors (Blanksby, Nicholson & Elliott, 2002; Vilas-Boas et al., 2000 et al.) associate the dynamic strength with the reaction time and use a single expression - dynamics. These authors conducted their research in the field of a swimming start as well. They believe the lower limb dynamic strength and the reaction on the start block to be the limiting factors. The research helped Bishop et al. (2009) to confirm a significant dependence between the lower limb dynamic strength and the swimmer's speed after he/she dives in the water. The efficiency of a racing dive is highly influenced by a strength gradient, meaning the maximum strength reached in a unit of time. This indicator to a great extent influences the strength impulse as well. Allerano et al. (2000) pointed out the significant relationship between the reaction time, lower limb dynamics and the end result of a swimming performance. They analysed the speed for the first 9 metres and came to the conclusion that the speed vector value before the arms reached the water (4.63 m.s^{-1}) correlated with the time for 5 metres ($r = 0.56$). Davies et al. (2001) pointed out the importance of the racing dive efficiency, when they increased the lower limb dynamic strength with the help of plyometric training. This resulted in a performance improvement for 5 metres by 0.069s. This improvement was possible due to an elevation of a vertical jump by 4.5 cm. Authors Blanksby, Nicholson & Elliott (2002) observed the speed for 9 metres after the swimming start according to the type of the racing dive. After the set period of time, the authors found out that the training resulted in a statistically significant improvement. Guimaraes & Hay (1985) consider the vertical jump value to be an important indicator of a racing dive. Galbrait et al. (2008) proved that the racing dive quality significantly influences the swimming performance for the first 10 meters. However, we cannot forget that individualization is needed in elite swimming. This means that as far as the efficiency research of the training load and its means are concerned, we have to make use of the intraindividual approach from the point of view of time parameters, which is characterized by a dominance of asynchronous arrangement of the dependent and independent variable data (Broďáni, 2011).

The goal of the study was to determine and analyse the influence of the lower limb dynamics on the efficiency of a racing dive in swimming by means of the vertical speed for selected distances from the point, when the head enters the water after the racing dive until reaching 9 metres.

Methods

Subject characteristics

The research was conducted on 5 male and 2 female swimmers. They were chosen intentionally ($n = 7$, age = 19.6 ± 2.1 years, height = 184.3 ± 7.4 cm, weight = 73.3 ± 11.7 kg) from the Slovak swimming clubs - VŠC Dukla Banská Bystrica, ŠKP Košice, Swimming club V. Krtíš and Delta Komárno.

Measurement organisation

We conducted the research in a 25 m swimming pool in Banská Bystrica and Trenčín, and also in the laboratories of the Department of Physical Education and Sports, Faculty of Arts at Matej Bel University. The research took place in the morning hours, from 9:00 - 11:00. The time interval is stated by the authors in their studies (Jančoková, 2000; Pivovarniček, 2013, 2014; Pivovarniček & Lacena, 2014) as the first performance peak of the day. It is also important to mention that men and women in the observed group did not go through any special training focused on the given subject before the research itself took place.

Measurement of motor abilities

We conducted two tests in the laboratories:

1. vertical jumps (VJ) on the FiTROJumper device (FiTRONiC, Bratislava, Slovak Republic). We measured the vertical jump height with an accuracy of 0.1 cm. The FiTROJumper device uses the relation $h = (g \times Tf^2) / 8$ to calculate the jump height. The producer FITRONIC s. r. o. guarantees the accuracy and reliability of the device by means of verified simultaneous measurements with a push off platform by the KISTLER company. The best maximum performance was the deciding parameter for vertical jumps (VJ).

2. the reaction time (RT) test FiTRO agility check (FiTRONiC, Bratislava, Slovak Republic). The maximum reaction time for stimuli generated for 10s was the deciding parameter for reaction (R).

During the swimming pool testing, we performed two starts. One of them was the athletic grab start, the other was track start. We observed:

1. the reaction time to the starting signal from the first visible movement until leaving the starting block (RSB)
2. individual vertical speeds while overcoming distances up to 9 metres (VS)
3. the flight phase of a racing dive (FP)

The test results in the swimming pool were realized by means of a video analysis and video recording on a HD - 96camcorder. The research was approved by the Ethical Committee of Matej Bel University in Banská Bystrica.

Data Analyses

Within the characteristics of descriptive statistics in the presented study, we used the arithmetic mean ($\bar{x}$) from the position units, standard deviation (SD) from the variability units, and minimum and maximum value of the measured data. To statistically determine the importance of linear dependence between the observed parameters (RT - RSB; VJ - VS; VJ - FP) we used the Kendall's tau coefficient (τ), which was interpreted in the following way: below 0.1 - trivial correlation, 0.1 - 0.3 - low correlation, 0.3 - 0.5 - medium correlation, above 0.5 - high correlation (Cohen, 1988). The probability of type I error (α) was set at 0.05 in all statistical analyses. The statistical analysis was realized by means of the IBM® SPSS® Statistics V19 software (Statistical Package for the Social Sciences).

Results and discussion

The research results show the values reached by the observed group in individual parts of the test. We also interrelated the measured values from the FiTROJumper towards the FP length after the racing dive and the VS up to 9 metres, and also the Fitro agility check towards the RSB. In the VJ height test, swimmer 2 reached the minimum value of 39.8 cm. The male swimmer M. K. reached the maximum value (56.9 cm). The standard deviation of the vertical jump height was 6.86. All the results measured in the vertical jump height test are stated in Table 1. Issurin & Verbitsky (2002) emphasize the importance of the vertical jump. Through research and observation, they discovered that the vertical impulse is more important, particularly for the grab start. This also proved to be true for anterior-posterior impulse. We reached a similar conclusion, when we compared the FiTROJumper results with the flight distance length from the push off spot on the starting block to the moment, when the head enters the water.

Table 1 . Measurement results

	VJ (cm)	RT (ms)	RSB (ms)		FP (cm)	
			“track”	“grab”	“track”	“grab”
x	45.2	514.9	0.96	0.83	316.0	330.9
SD	6.9	47.8	0.07	0.04	10.9	18.5
Min	39.8	451.0	0.87	0.77	304.0	316.0
max	56.9	600.0	1.07	0.90	340.0	374.0

*Legend: VJ - vertical jump, RT - reaction time, RSB - reaction on start block, FP - flight phase

To determine the influence of the lower limb dynamics on the efficiency of a racing dive more accurately, we tested the reaction time of the observed group as well, because several foreign authors associate the dynamic strength with reaction (Blanksby, Nicholson & Elliott, 2002; Vilas-Boas et al., 2000 and others).

Maximum value of the best attempts, which means the worst reaction time was measured on M. M. with the reaction of 600 ms. Swimmer 7 reached the best reaction time of 451 ms. SD showed the value of 47.79.

We also measured the RSB to a sound signal. Swimmer 7 reached the best RT of 0.87 s after the track start. The difference between the best RSB = 0.87 and the worst RSB = 1.07 s was 0.20 s. SD = 0.07. The comparison of the observed group with Olympic swimmers in Sydney, conducted by Krueger et al. (2003) brought significant results. He found out that the average RSB for women ranged from 0.69 s to 0.99 s. The measurements of the RSB to a sound signal after the grab start brought more information on the given subject. Swimmer 7 reached the best RSB = 0.77 s. He also reached the best RT on the FiTRO agility check. Swimmer 5 was the second best with RSB = 0.78 s. Swimmer 4 was third with RSB = 0.82 s. Swimmer 6 reached RSB after the grab start = 0.82 s, female swimmer 1 reached RSB = 0.84 s, female swimmer 2 = 0.85 s. Swimmer 4 was the slowest with RSB = 0.90 s. SD = 0.04.

An interesting fact was that the RT reached by the observed group on the FiTRO agility check was in the same order from the best swimmer to the worst. The same thing happened during the reaction time test to a sound signal after the grab start. Krueger et al. (2003) also made an interesting comparison of the observed group with the Olympic swimmers in Sydney. He found out that the average time for a grab start for women ranged from 0.69 s to 1.02 s.

Swimmer 5 reached the longest FP distance after the track start = 340 cm. Swimmer 7 achieved surprising results. He reached the FP = 308 cm. SD was on the level of 10.9. We determined the part of the body that touched the water, due to the lower variability of the head movement compared to the arm movement. We followed the recommendations of foreign authors (e.g. Vilas-Boas, 2000; Guimaraes & Hay, 1985; Blanksby, Nicholson & Elliott, 2002; Galbrait et al., 2008 and others). The average results achieved by our group ($\bar{x}$ FP = 315.4 cm) were similar to the results by Vilas-Boas (2000), who states the average distance for the track start = 317 cm.

We observed the FP realized by the grab start as well. Swimmer 5 achieved the best result with the FP length = 374 cm. Swimmer 7 was the second best with a result of 332 cm. Female swimmer 1 reached the FP length = 328 cm, swimmer 3 = 320 cm, female swimmer 2 = 318 cm. Swimmer 6 reached the worst result with FP = 316 cm. Except for one man (swimmer 6), the observed group achieved better results in the grab start testing. The difference for best swimmer 5 was 34 cm, 24 cm for swimmer 7, 8 cm for swimmer 3 and 14 cm for swimmer 4. For female swimmer 1, the difference was 18 cm in favour of the grab start and the difference for swimmer 2 was 14 cm. Swimmer 6 achieved a better result in the track start by 2 cm. SD = 18.45. It is necessary to mention that the observed group may have reached better results in this racing dive due to a higher preference at competitions. The average results (330.6 cm) achieved by our group were similar to the results by Vilas-Boas (2000), who states the average distance for the grab start = 331 cm.

Table 2. Vertical speed after the track start ($\text{m}\cdot\text{s}^{-1}$)

Object	1.	2.	3.	4.	5.	6.	7.
Diving speed	4.24	3.98	4.07	4.18	6.67	4.22	6.62
5 metres	2.93	2.72	2.75	2.85	3.46	2.71	3.15
6 metres	1.68	1.61	1.58	1.67	2.39	1.67	2.15
7 metres	1.43	1.33	1.31	1.32	1.72	1.43	1.73
8 metres	1.14	1.10	1.12	1.17	1.36	1.13	1.29
9 metres	1.03	1.01	1.04	1.09	1.15	1.01	1.21
Average diving speed	4.85						
Average speed for 9 metres	1.08						

Table 2 shows the results of the vertical speed reached at entering the water until 9 metres after the track start. The swimmers' goal was to reduce any kind of movement after they entered the water, which means they were not allowed to perform lower limb kicks or waves. They were only supposed to assume a floating position.

Naturally, the highest speed was measured when the swimmers entered the water. Swimmer 5 reached the highest speed with $VS = 6.67 \text{ m.s}^{-1}$. Female swimmer 1 reached the lowest diving speed of 3.98 m.s^{-1} . The average diving speed was 4.85 m.s^{-1} . The vertical speed of the swimmers gradually declined. The highest speed for 9 metres was 1.2 m.s^{-1} and the lowest speed was 1.01 m.s^{-1} . The average speed for 9 metres was 1.08 m.s^{-1} .

Table 3. Vertical speed after the grab start (m.s^{-1})

Object	1.	2.	3.	4.	5.	6.	7.
Diving speed	4.83	4.27	4.48	4.72	7.52	4.42	7.46
5 metres	3.12	2.82	2.92	3.09	4.00	2.89	3.75
6 metres	1.95	1.81	1.92	1.98	2.60	1.78	2.52
7 metres	1.64	1.54	1.59	1.67	1.91	1.49	1.81
8 metres	1.25	1.15	1.24	1.32	1.43	1.17	1.33
9 metres	1.11	1.01	1.10	1.19	1.22	1.04	1.25
Average diving speed	5.39						
Average speed for 9 metres	1.13						

Table 3 shows the results of vertical speed after the grab start from the moment of entering the water until reaching 9 metres. Swimmer 5 reached the highest speed of 7.52 m.s^{-1} while entering the water (he also reached the highest speed after the track start). Female swimmer 2 reached the lowest speed of 4.27 m.s^{-1} . Swimmer 7 reached the highest speed for 9 metres (1.25 m.s^{-1}), female swimmer 2 reached the lowest speed (1.01 m.s^{-1}). The average diving speed was 5.39 m.s^{-1} , which is higher by 0.54 m.s^{-1} than the measured value after the track start. The average speed for distances was 1.13 m.s^{-1} , which is higher by 0.05 m.s^{-1} than the measured value after the track start.

The swimmers with the highest VJ reached the highest VS. The highest correlation rate was measured right after entering the water, with $r = 0.81$, $p < 0.05$. The swimmer, who reaches the highest VJ, has the right predisposition to reach the longest FP after the racing dive. However, the correlation (T: $r = 0.10$, $p < 0.05$; G: $r = 0.78$, $p < 0.05$) between VJ and FP proves that the dependence between these variables is on a low level for T and high level for G. While evaluating the video recording of a racing dive of swimmer 1, we found out that the swimmer pushed off under a low starting angle. That is why he did not reach the FP that would be possible thanks to the explosive strength of the lower limbs. The results for the first 9 metres after the start show a higher rate of dependence in relation to VJ, if between VJ and: 4 m: $r = 0.71$; 5 m: $r = 0.81$; 6 m: $r = 0.68$; 7 m: $r = 0.59$ (the only one with $p > 0.05$); 8 m: $r = 0.71$ and 9 m: $r = 0.78$ ($p < 0.05$). This fact made us believe that apart from the FP, the efficiency of its realization is also a deciding factor (push off angle, landing angle, dive depth, etc.). The interrelation between FP and VS reached the lowest dependence for 7 metres, when $r = 0.59$. This is obvious, since this speed is highly influenced by movement in the water.

We compared the results of VJ and FP for an individually stronger type of the racing dive. Swimmer 5 reached the best results with FP after the grab start = 374 cm, and swimmer 7 with the highest VJ value = 56.9 cm. M. K. reached the FP = 332 cm after the grab start. The difference between swimmer 5 and swimmer 7 was FP = 42 cm (M. T.) and VJ by 1.9 cm. Among women in the observed group, female swimmer 1 reached better results in both parameters with VJ higher by 2.0 cm and FP longer by 10 cm. The only one to reach a longer FP after the track start was swimmer 6. It was longer by 2.0 cm and he was the only one who preferred this type of racing dive during competitions and the training process. On the basis of the measured values, we calculated a low rate of dependence for T and high rate of dependence for G between the two variables, when for T: $r = 0.10$ and for G: $r = 0.78$, while $p < 0.05$. This fact made us believe that apart from the FP, the efficiency of its realization is also a deciding factor (push off angle, landing angle, dive depth, etc.).

The comparison between RT and RSB is better among men. Swimmer 7 reached the best results in both tests (RT = 451 ms, RSB = 771 ms). The differences between the best swimmer 7 and the second best swimmer 5 were: RT = 64 ms and RSB = 10 ms. The differences between the best swimmer 7 and the worst swimmer 3 were: RT = 149 ms and RSB = 130 ms. Among women, swimmer 1 was better in RT by 4 ms and in RSB by 10 ms. We considered the correlation of the measured results and found out that the correlation between RT and RSB reaches: a high level of mutual dependence for T and medium dependence for G, if for T: $r = 0.81$ and G: $r = 0.39$, where $p < 0.05$, which is the total time on the block from the starting signal until the end of the push off. This value is highly influenced by the realization length of the push off, which depends not only on the reaction time, but mostly on the speed of muscle contraction, which means the active realization of the movement.

Conclusion

The goal of the study was to determine what is the influence of the lower limb dynamics on the efficiency of a racing dive in swimming. We focused on men and women from various regions of the Slovak Republic. Through the analysis of the results, we came to the conclusion that swimmer 7 had the best predispositions for an efficient racing dive. He confirmed the best results in most tests by a recent limit fulfilment at the 2010 European Championship. On a jump ergometer, swimmer 7 reached following results: VJ

= 56.9 cm, RT = 451 ms, FP after track start = 308 cm and after grab start = 332 cm. RSB after track start was 851 ms and after grab start 771 ms. The highest speed for 4 metres after track start was 6.62 m.s⁻¹ and after the grab start 7.46 m.s⁻¹. While analysing the track start of swimmer 7, we found out that he directs the movement into the distance, but the vertical direction is too low. This may have caused the short flight distance we measured. We recommend focusing on the improvement of a racing dive technique at the push off. The statistical analysis proved a linear dependence between RT – RSB (T) ($r = 0.81$, $p < 0.05$), between RT – RSB (G) ($r = 0.39$, $p < 0.05$), between VJ - VS ($r = 0.59 - 0.81$, $p < 0.05$), between VJ – FP (T) ($r = 0.10$, $p < 0.05$) and between VJ – FP (G) ($r = 0.78$, $p < 0.05$).

We may conclude that the grab start proved to be more suitable during the swimming pool testing. This may be influenced by the higher preference between men and women of the observed group during the research. However, at most swimming competitions nowadays, we may find starting blocks created for the track start. The track start results were influenced by the fact that we did not have those blocks at our disposal during the research. However, this does not change the fact that the lower limb explosive, or rather dynamic, strength highly influences the efficiency of a racing dive. Therefore, it is necessary to practice the racing dive and improve both swimming starts on new starting blocks.

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