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COMPARISON OF COMPETITIVE ACTIVITY INDICATORS AT 100 M DISTANCES OF LATVIAN AND EUROPEAN SWIMMERS

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Abstract. *The research aimed to study the performance characteristics of male and female finalists at a 100m distance when swimming at the Latvian swimming championships in a period from 2018 to 2020 (in the 50m pool). 262 final heats got analyzed. The results of the 3 best Latvian swimmers, males=36, and females-36, at each 100m distance (freestyle, breaststroke, backstroke, and butterfly) at championships in 2018, 2019, and 2020 have been analysed. The parameters for overcoming competitive distance: competitive result in the 100-meter distance; the start reaction time; time for the 15 meters mark; speed to the 15 meters mark; the time of the turn 5 meters up to the wall and 15 meters after the turn; underwater distance and time after the start and after turning; time of "clear" swimming. The obtained results were compared to the characteristics of overcoming the same competitive distance by the finalists of the European Championship 2016. As a result of comparative analysis, statistically, significant differences were found in such parameters of competitive activity as the overall result, overcoming of starting and turning parts, and the distance covered under water after the turn and start. Statistically significant differences were not found in the reaction time to the start signal and in the speed of "clear" swimming. The comparative analysis of the performance characteristics of the European Championships finalists showed possibilities for further improvements of Latvian swimmers. The aim: is to determine the performance parameters of the Latvian best swimmers and compare them with the same parameters of the finalists of the European Championship 2016.*
Keywords: *competitive analysis 100m, sport swimming, underwater part in swimming,*

Introduction

Competition analysis is to provide the coach and swimmer with a clear and concise summary of each event in a swimming meet. The analysis is designed to identify where, why, and how some swimmers perform better than others. The primary reason that coaches of elite swimmers use competition analysis is to

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develop, and then progressively refine, a competition model for a swimmer. This can be done most successfully using the information provided from the competition analysis at important meets where a swimmer is providing an effort of 100%. Competition analysis is also used to identify relative weaknesses in a swimmer's performance, so that any competitive weaknesses may be eradicated. Swimming performance is highly dependent on the underwater phase, which begins with the start and turn, consisting of gliding and kicking during the first 15 m of the distance (Arellano, Brown, Cappaert & Nelson, 1994; Veiga & Roig 2017; Cossor & Mason, 2001; Smith, et al. 2002).

It is accepted to distinguish the following parameters of the distance of the competition: reaction to the start signal, then jump from the start in elevated swimming in breaststroke, breaststroke, and the butterfly or start from water swimming on the back. After taking off the feet from the starting elevation, the flight phase begins, which ends when the athlete touches the water's surface. After full body submersion, the underwater part says the water. According to international rules, underwater wave-like movements of the legs are allowed in the first 15 meters after the start, except for breaststroke swimming, where athletes use the "long stroke". After the athlete appears on the surface of the water, the segment of "clean swimming" is said, when the swimmer performs cyclic movements with the arm and legs according to the selected type of swimming, if the underwater part is used perfectly, the distance in the segment of "clean swimming" is 30 meters (50 meters in the pool). Turn - five meters to the wall of the pool, turn and 15 meters after pushing off from the wall of the pool, where the use of underwater movements of the legs is allowed. After the athlete appears on the surface of the water, says the second segment of "pure swimming", the frequency of movements and the length of the stroke depend on the type of swimming and the individual characteristics of the swimmer. The last five meters of the distance is considered the finish segment (Kennedy et al., 1990; Arellano et al., 1994; Cossor & Mason, 2001; Blanksby et al., 2001; Smith et al., 2002). When swimming in a 25-meter pool, both the number of turns and the segments of "clean" swimming increase to three.

The aim of the research is to determine the performance parameters of the Latvian best swimmers in 100m distance, swimming freestyle, backstroke, breaststroke, and butterfly and compare them with the same parameters of the finalists of the European Championship 2016.

The organization and methods of the research

The best three swimmers from every final heat of 100m distance are both male and female (36 men and 36 women) swimming every swimming stroke (butterfly, backstroke, breaststroke, freestyle). The data was collected from the Latvian open swimming championships 94th-2018, 95th-2019, and 95 th-2020.

The results were collected for 3 years, from June 2018 until March 2020 in the Latvian open swimming championships. Latvian 94th open swimming championships were held on the 19th-21st of June 2018. Latvian 95th open swimming championship was held on the 1st-3rd of March 2019. The Latvian 96th open swimming championship was held from the 28th of February – the 1st of March 2020. The final heats of the Latvian championship were recorded by the stationary camera "PANASONIC 4K" (f=60fps).

Analyzing the results of the Latvian open swimming championships for a period of three years (starting from 94th- 2018 and to96th- 2020) 262 final heats got analyzed (72 heats from the 94th Latvian championships, 83 heats – from the 95th Latvian championships, 107 heats – from the 96th Latvian championships) for both males and females. For further processing and analysis, 100m heats were selected (24 heats from the 94th Latvian championships, 24 heats from the 95th Latvian championships, and 24 heats from the 96th Latvian championships) for both males and females. Those included: the start and turn sections. The best 3 results of Latvian swimmers from every final heat were selected for the additional analysis.

The selected parameters of competitive performance are accepted in sports swimming as the components of competitive distance (Craig & Pendergast,1979; Tourny-Chollet, Chollet, Hogie, & Papadopoulos, 2002; Hubert, Silveira, Freitas, Pereira, & Roesler, 2006; Ruschel, Araujo, Pereira, & Roesler, 2007; Veiga & Roig, 2017).

The following parameters were applied to each finalist:

1. 100-m performance (competitive result in the 100-meter distance in seconds).
2. The reaction time (time lag between the start signal and the moment a swimmer`s feet leave the starting block).
3. Time is taken to the 15 meters mark (from the start signal till the moment when a swimmer's head crosses the 15 meters mark).
4. Speed to the 15 meters mark (from the start signal till the moment when a swimmer's head crosses the 15 meters mark).
5. The time of the turn (Total turning time, 5 meters up to the wall and 15 meters after the turn).
6. Underwater distance (distance swimmer spends underwater after start and pushing back from the wall after turning)
7. Underwater time after the start and the turn (time swimmer spends underwater after start and pushing back from the wall after turning)
8. Time of "clear" swimming (time a swimmer spends on the water surface while swimming.)

The special program "Videoanalyzer 50p fp" processed all the collected video materials. All the data received were compared to the European elite swimmers' performance results from the European swimming championships that were held in London in 2016, (Morais, Marinho, Arellano, & Barbosa, 2018).

Results of the research

The parameters of swimmers during Latvian open swimming championships, 94th-2018, 95th-2019, 96th-2020 are presented in Table 1. When swimming 100 m distance, both genders were faster in freestyle, followed by butterfly, backstroke, and breaststroke. The largest difference in results was found between freestyle and breaststroke in both male and female heats (male: Δ=11.44s, female: Δ=16.54s). The smallest difference in results was found in between butterfly and backstroke heats, for both genders (male: Δ=0.67s, female: Δ=2.33s). The fastest times for the first 15 meters were recorded for men in freestyle (6.8 ± 0.04 s) and for women in freestyle (6.96 ± 0.06 s). The slowest times were recorded in the breaststroke in both male and female heats. (Male: 7.14± 0.04 s, female: 8.44± 0.11 s). The highest swimming speed m/s for the first 15 meters was in men`s freestyle (2.38±0.2 m/s) and women`s freestyle (2.17±0.04 m/s).

Table 1 ***The performance parameters of the best Latvian swimmers on 100m distances*** *(created by the authors)*

Latvia		Males n=36				Females n=36			
		free	Back stroke	Breast stroke	fly	free	Back stroke	Breast stroke	fly
100 m (s)	$\bar{x}$	52.62± 0.3	57.32± 1.47	64.06± 0.32	57.99± 2.04	57.2± 0.72	62.47± 1.10	73.74± 1.45	64.8± 7.6
Start									
Reaction time (s)	$\bar{x}$	0.65± 0.01	0.65± 0.06	0.67± 0.02	0.71± 0.01	0.69± 0.01	0.71 ±0.01	0.7± 0.01	0.72± 0.03
15-m time (s)	$\bar{x}$	6.28± 0.04	7.11± 0.21	7.14± 0.04	6.56± 0.29	6.96± 0.06	7.94± 0.23	8.44± 0.11	7.88± 0.16
15-m speed (m/s)	$\bar{x}$	1.88± 0.02	1.73± 0.06	1.56± 0.01	1.73± 0.06	1.75± 0.02	1.6± 0.02	1.35± 0.03	1.45± 0.04
Turn									
Total turn (s)	$\bar{x}$	10.72± 0.09	11.46± 0.59	12.94± 0.12	11.59± 0.12	11.58± 0.01	12.2± 0.25	14.98± 0.2	14.22± 0.33
Start + Turn time (s)	$\bar{x}$	17.02± 0.15	18.57± 0.8	20.07± 0.16	18.51± 0.69	18.54± 0.07	20.14± 0.48	23.38± 0.02	22.13± 0.47
Underwater start and turn (m)	$\bar{x}$	15.91± 1.16	18.56± 1.08	21.5± 1.01	18.58± 1.18	13.67± 0.61	21.16± 0.86	16.44± 0.41	17.86± 1.96
Clean swim speed (m/s)	$\bar{x}$	1.81± 0.03	1.67± 0.04	1.48± 0.01	1.67± 0.03	1.69± 0.03	1.54± 0.01	1.32± 0.04	1.41± 0.03

The slowest swimming speed for men was in backstroke (2.07±0.1m/s) and for women in breaststroke (1.80±0.1m/s). Regarding the distance a swimmer spends underwater, the highest result was recorded in women's backstroke (12.83 ±1.04m) and men's breaststroke (12.44±1.35m), the shortest distance was recorded in freestyle for both men (9.72±1.18m) and women (9.06±0.82m). When making a turn (5 meters up to the wall and 15 meters after pushing back from it) the highest speed was for men and women in freestyle (men: 10.72 ± 0.09 s, women 11.58 ± 0.01 s).

Combining the first 15 meters and the turning time the best results were shown by the freestyle representatives (men: 18.48 ± 0.12 s; women: 18.48 ± 0.12 s). The athletes spent ~30% of the distance time at the start and turn part combined, this applies to all four swimming strokes. The research results prove that the start and the turn sections greatly influence the overall results. Distance after the turn: the best results were achieved by men in breaststroke at 9.06±0.34m and by women in the backstroke at 8.33±0.76 m. The shortest were in freestyle for men (6.19±1.3 m) and women 4.61±0.35m.

Swimming speeds of the different parts of the distance

Interesting data was collected while making the comparing analysis of swimming speeds. The highest swimming speed was reached at the first 15 meters after the start – 2.14 m/s, the average turning speed was 1.71 m/s, and the "clean" swimming speed turned out to be the slowest at 1.64 m/s (Figure 1).

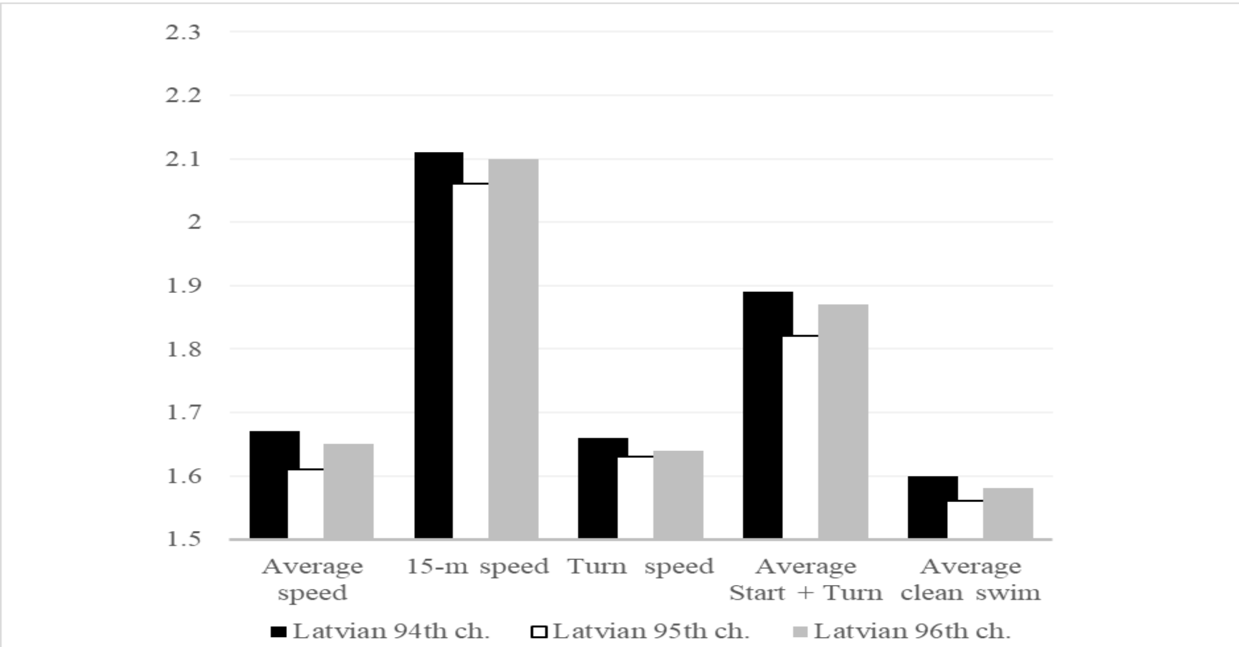

Figure 1 ***The speed in distance parameters of the Latvian championships, (average results from 2018-94th-,2019-95th, and 2020- 96th Latvian championships)*** *(created by the authors)*

Comparison of competitive activity indicators

To compare the parameters of the swimmers of the Latvian national team with the European elite swimmers' results, the performance parameters of the finalists of the 100m heats of the European Championship 2016 were studied (Table 2). The heats of all 64 (32 males and 32 females) finalists of 100m distance at the LEN European Championship 2016, (long course), were analyzed; 8 finalists in every swimming stroke: freestyle, backstroke, breaststroke, butterfly, men, and women. The organizers of the championships provided all the competition.

Records in high-quality (HD) video (f = 50 Hz). The system delivered real-time records from multiple angles. A set of 10 „pan-tilt-zoom" cameras tracked the swimmers. One camera was covering one lane (ass v5915, Lund, Sweden). Each swimmer during the heat was followed by a camera. Two fixed cameras (AXIS q1635, Lund, Sweden) recorded both ends of the pool, giving the opportunity to analyze the start and the turn.

European Champ.		Males n=32				Females n=32			
		Free style	Back stroke	Breast stroke	fly	Free style	Back stroke	Breast stroke	fly
100 m time (s)	$\overline{x}$	48.55 ±0.22	54.20 ±0.24	60.33± 0.96	51.84± 0.64	54.40± 1.19	60.04± 0.92	67.43±0 .71	57.70± 1.15
Start									
Reaction time (s)	$\overline{x}$	0.70± 0.03	0.63± 0.03	0.69± 0.06	0.69± 0.03	0.72± 0.05	0.63± 0.04	0.69± 0.06	0.70± 0.04
15-m time (s)	$\overline{x}$	5.82± 0.13	6.38± 0.11	6.78±0 .26	5.71± 0.14	6.68± 0.28	7.39± 0.26	7.81± 0.26	6.75± 0.25
15-m speed (m/s)	$\overline{x}$	2.58± 0.06	2.35± 0.04	2.21± 0.08	2.48± 0.06	2.25± 0.09	2.03± 0.07	1.92± 0.07	2.22± 0.08
Turn									
Total turn (s)	$\overline{x}$	9.55± 0.13	10.43 ±0.16	12.04± 0.23	10.53± 0.31	10.78± 0.28	11.47± 0.23	13.51± 0.25	11.71± 0.20
Start + Turn time (s)	$\overline{x}$	15.40 ±0.20	16.81 ±0.23	18.82± 0.39	17.16± 1.27	17.45± 0.54	18.85± 0.44	21.33± 0.49	18.46± 0.41
Under water start+turn (m)	$\overline{x}$	19,19 ±1.56	23.36 ±1.18	22.76± 0.68	23.32± 1.57	17.35± 1.8	23.46± 1.69	19.59± 1.15	20.00± 1.06
Clean swim									
speed (m/s)	$\overline{x}$	1.96± 0.02	1.67± 0.02	1.56±0 .04	1.87±0 .04	1.76± 0.04	1.57± 0.03	1.47± 0.03	1.65± 0.05

Table 2 ***Descriptive statistics about the 100m distances of finalists at the European Swimming Championships 2016*** *(created by the authors)*

Both gender representatives were faster in freestyle than in butterfly, backstroke, and breaststroke. The largest difference between freestyle and breaststroke was found for both male and female swimmers (male: d = 11.71 s, female: d = 13.02 s). The smallest difference in results was found for both gender swimmers in between backstroke and butterfly (male d=2.35 s, female d=2.15 s).

The fastest times for the first 15 meters were recorded for men in the butterfly (5.71 ± 0.14 s) and in Freestyle for women (6.68 ± 0.28 s). The slowest times for the first 15 meters were recorded in breaststroke for both genders (males:

6.78± 0.25 s, females: 7.81± 0.27 s). The highest swimming speed was m/s for the first 15 meters in men`s butterflies (2.63±0.7 m/s) and in women's freestyle (2.25±0.09m/s). The slowest swimming speed for both genders was in the breaststroke (males: 2.21±0.8 m/s, females: 1.92±0.07 m/s).

According to the distance spent underwater, the longest result was recorded for men in the breaststroke (13.02 ± 0.99m) and for women in backstroke (12.86±1.22m). The shortest distance was in freestyle for both genders (males: 11.43 ± 1.17m, females: 10.74 ± 1.05m).

During the turn (5 meters up to the wall and 15 meters after pushing off it) the highest speeds are recorded for men and women in freestyle (males: 9.56 ± 0.13 s, females: 10.78 ± 0.28 s).

Combining the first 15 meters and the turning time, the freestyle representatives showed the best results (males: 15.41 ± 0.21 s, females: 17.46 ± 0.54 s). The athletes spent 30% of the distance time at the start and turn part combined, this applies to all four swimming strokes. The research results prove that the start and the turn sections greatly influence the overall results.

Distance after the turn: the best results were shown by men and women in backstroke (males: 11.02±1.29 m, females: 10.62±2.02 m). The shortest distance was in freestyle, male swimmers: 7.77±1.85 m, female swimmers: 6.62±0.76 m).

Comparative analysis

Recent research (Veiga & Roig 2017), on an effective swimming technique, indicates that more and more athletes are trying to lengthen (within the rules of competitions) the underwater part. The study of indicators of competitive activity at a distance of 100 m is presented in figures 3 and 4.

The distance that swimmers spent underwater after the start, the longest results were recorded for the European elites' swimmers: men in breaststroke – 13.02±1.01m and women in backstroke – 12.85±1.24 m. The shortest distance was both for men and women in freestyle (males: 10.74±1.07m, females: 11.43±1.20m). After the turn, the best results were for men's and women's backstroke (males: 11.02±1.31 m, females: 10.61±2.05 m). The results in freestyle for both genders: males at 7.76±1.88 m, and females at 6.61±0.77 m).

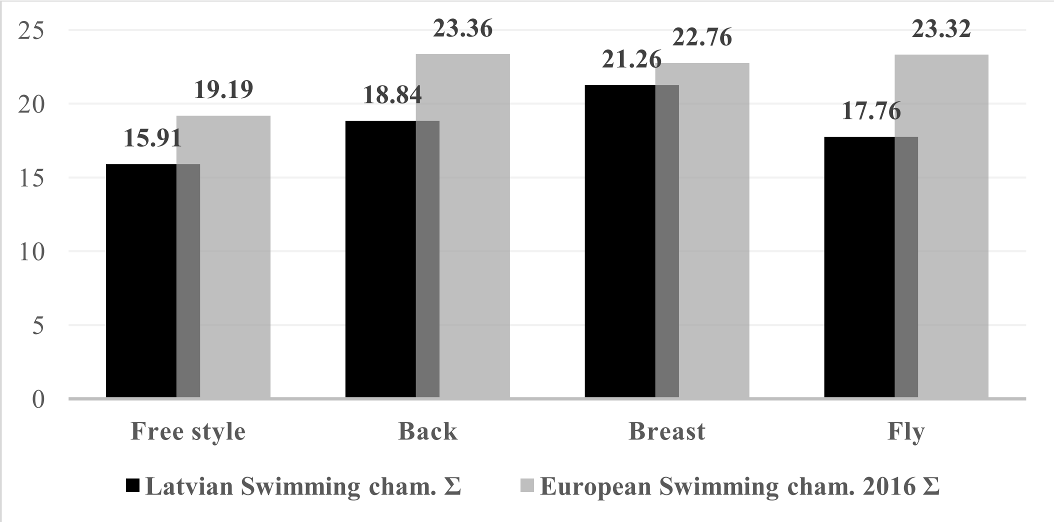

Figure 3 ***The average distances spent underwater, (m) at the Latvian Swimming championships and the European Swimming Championships 2016 (males)*** *(created by the authors)*

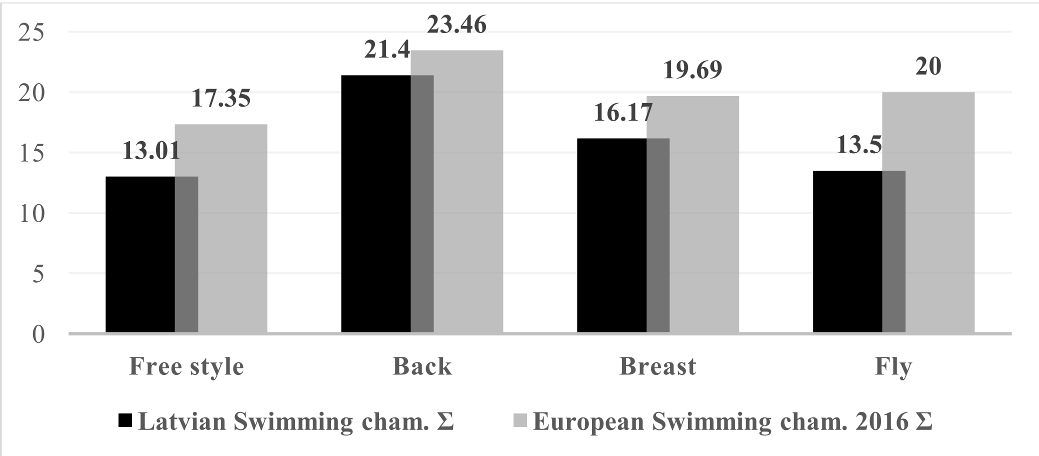

Figure 4 ***The average distances spent underwater at the Latvian Swimming championships and the European Swimming Championships 2016, (females)*** *(created by the authors)*

Conclusion and discussion

The collected results proved the assumption that the fastest swimming section in a distance is the first 15 meters after the dive; this applies to all swimming strokes for both men and women. Especially for the high-level swimmers, who can develop higher speeds than in other sections of competition distance, which is 2.58 ± 0.06 m/s in men`s freestyle, compared to the 2.39±0.01 m/s of the fastest Latvian swimmers. The speed that athletes performed while turning (5 meters up to the wall and 15 meters after the turn) swimming between 2.09 ± 0.08 – 1.66 ± 00.21 m/s for the European elite swimmers and between

1.86 ± 0.02 and 1.55 ± 0.02 m/s for Latvian swimmers. Compared to the start and turn section of the distance, the "clean" swimming section is the slowest. European elite male swimmers achieved an average speed of 1.96 ± 0.23 m/s in freestyle and 1.56 ± 0.09 m/s in breaststroke. Among the female swimmers, the speed is from no 1.87 ± 0.09m/s in freestyle and to 1.41 ± 0.07 m/s in breaststroke. Latvian male swimmers achieved an average speed of 1.81 ± 0.03 m/s in freestyle and 1.48 ± 0.01 m/s in breaststroke. Meanwhile, Latvian female swimmers achieved 1.69 ± 0.03 m/s in freestyle and 1.32 ± 0.04 m/s in breaststroke.

The speed distribution in a distance described above is relatively simple to explain and justify. The high speed in the first 15 meters after the start signal and after every turn swimmer is mostly provided by maintaining the high speed which is reached after the start dive (about 6±0,56 m/s) and after pushing away from the wall during the turn (about 2,4±0,23 m/s).

The assumption refers to the best Latvian and European swimmer`s results, regardless of swimming stroke, length of the distance, a swimmer's age, training level (Cossor & Mason, 2001; Veiga, Cala, Mallo, & Navarro, 2013) and also in this research.

Depending on the distance European Championship's swimmers spend underwater after the start dive and after the turn, male swimmers, about 23.36 ± 1.03m in backstroke and about 17.35 ± 0.92m in freestyle. For female swimmers, the distance is about 23.47 ± 1.64 m in backstroke and 17.35 ± 0.92 m in freestyle. The results of Latvian swimmers are remarkably lower. For male swimmers, the distance is about 18.84 ± 0.99m in backstroke and 15.91 ± 1.15 m in freestyle. For female swimmers, the result is 21.5 ± 1.06 m in backstroke and about 13.01 ± 0.12 m in freestyle.

The results of the research showed that there are opportunities for improvement in the underwater phase for Latvian swimmers. According to the regulations of the International Swimming Federation (FINA SW 5.3), after the dive, and after every turn, the swimmer is allowed to swim no more than 15 meters underwater, using underwater wave kicks. The maximum permitted distance when swimming, then in a 100 meters event, a swimmer is allowed to swim 30 meters underwater. The average distance spent underwater during a 100 m race for the European elite swimmers is about 21.13 ± 2.38 m which is 70.43 % of the permitted distance and for Latvian swimmers, it is 17.66 ± 2.84 m which is 58.87% of the permitted distance.

A comparison of the obtained data showed that there are differences in the parameters of competitive performance demonstrated by the European championship finalists and the best Latvian swimmers. No, statistically significant differences were found between competition performance: reaction time, where the result of the 2016 European Championships finalists was 0.68±0.03 s and the Latvian swimmers had the result of 0.69 ± 0.03 s (P - 0.9419), and in 'clean' swimming, where the result of the European Championships finalists was 1.68±0.18 m/s and the Latvian swimmers had the result of 1.57±0.16 m/s (P - 0.1158).

In all other components of competitive swimming: the speed of the first 15 meters (P – 0.0101), turning speed (P – 0.0091), underwater distance after the start and turn (P – 0.0099), as well as the race general result (0.0375), Latvian swimmers are losing to the European Championships finalists. There were statistically significant differences found in the studied results.

The collected results allowed for getting data about the performance characteristics of Latvian swimmers. The comparative analysis of the performance characteristics of the European Championships finalists showed opportunities for further improvements of Latvian swimmers.

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