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# Analysis of 50 m backstroke class S4 disabled swimmers race parameters

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## 1. Introduction

The freedom of movement in the water and the ability to exercise muscles which, on land, have difficulty overcoming gravitational constraints makes swimming and related aquatic activities invaluable for persons with a wide range of physically disabling conditions [1-3]. Swimming propulsion of disabled swimmers is dependent on a number of fundamental mechanical and biomechanical factors: range of motion, propulsive forces, contribution of muscles of upper extremities, minimizing frontal resistance and the importance of body position in the water [3, 4]. Swimming mechanics is divided into two branches of study. Kinematics deals with the description of spatial and temporal parameters of movement measured as linear and angular displacements, velocities, and accelerations. Kinetics examines the forces that lead to the resulting kinematic changes [5, 6].

In competitions the training efficiency of elite swimmers is revealed. However, to be successful the swimmer is not only do his best in competitions, but also to practice the rhythm of the moves during the training process, to control the swimming technique and various breathing techniques consistent with his individual abilities. The role of the coach is to impart his knowledge for the athlete to master controlling the number of strokes at a specified speed range at various distances along with the heart rate. In elite competitions tactical readiness plays an essential role. Being able to distribute the strength properly during all the distance is a very important factor improving the results [7-9]. In respect of tactic, the most important parts of the race are considered to be the ones influencing the final results of the race and in which there is a major competition for a higher ranking. Swimmers, who are able to reach higher speeds than their competitors in those parts, usually perform better at the finish. Lately swimmers aiming at the highest results have been organizing their performance in the way that the second part of the race is done at a minimally lower speed that the first one. However, even final heat swimmers do not always manage to finish the distance at a steady speed. A direct reflection of the effectiveness of the training process is the athlete's race performance. Different parameters of race distance swimming technique – the start, the swimming, the turns, the finish – characterize different components of competition performance.

Studies have found that speed after the jump start, the turn and at the finish is higher than during the swimming [7-12]. Since the techniques of these parameters are different and are loosely connected, they are analysed separately. Swimming speed is constant when the average speed of the cycle is the same as in the previous cycle. However, swimming speed is never constant either in short or long distance races. During swimming performance speed changes can be analysed in two aspects: in one swimming cycle and in body movement while swimming. The average speed can be calculated as the length of the average stroke multiplied by its frequency. The length of the average stroke – the average horizontal body glide in one cycle. It is obligatory to observe competition performance parameters and their variation during each phase of training and change the training process accordingly [9, 13-18]. The final results of Disabled Swimming World Championships show a very high and versatile qualification of athletes and prove the importance of tactic. The athlete's tactic, his strengths and weaknesses, the level of training can be evaluated according to the changes in the average swimming speed, the average stroke frequency and the average stroke length in different race distance parts.

The aim of the research – to analyze theoretical aspects of swimming mechanics in disabled swimming and to determine and compare biomechanical parameters and tactic of Lithuanian Disabled Swimming Championships S4 class 50 m backstroke winner and World Disabled Swimming Championships S4 class 50 m backstroke finalists.

## 2. Methods

Different biomechanical parameters were evaluated: the start, the swimming, the finish. The average length of the strokes – the average horizontal glide of the body in one cycle, calculated according to the formula: $L_{str} = S / C_{no}$, when $S$ is the distance, $C_{no}$ is the number of the cycles. The average frequency of the strokes – the number of full cycles during a time unit. Each speed is characterized by an optimal ratio between the stroke length and frequency with the minimum energy use. The swimming speed was calculated according to the formula: $V = S / t$, when $S$ is the swimming distance and $t$ is the swimming time.

The results of 2013 Lithuanian Disabled Swimming Championships 50 m backstroke winner were recorded by stopwatches. The race distance was divided into parts (15 m for start, swimming part, 5 m for finish). The winner's speed (m/s), the average number of stroke cycles (cycles/minute) and the average stroke length (m) were calculated, as well as the means of same data of the finalists and winners of 2010 and 2013 World Disabled Swimming Championships. One movement cycle began at the moment of deepening of the wrist in water and was completed by another deepening of the wrist of the same hand.

The criterion of a steady swimming speed, the average stroke frequency and the average stroke length was the limit of ± 1% value change. Such criterion helps to distinguish substantial changes in swimming speed, the average frequency of strokes and the average stroke length. The research was carried out April 4-5, 2013, in Alytus Swimming Pool (50 m) at Lithuanian Disabled Swimming Championships. 2nd, 3d and 4th year students and teachers of Adapted Physical Activity course at Lithuanian Sports University recorded the data. The data were collected during competitions. 2010 and 2013 World Disabled Swimming Championships (at 50 m swimming pool) data on different race parts and the number of cycles of 50 m finalists were taken from the International Paralympic Committee protocols [19-20]. According to the data the values of the average stroke length in different race parts.

## 3. The results

Analysis of biomechanical parameters of disabled swimmers. In 2013 Lithuanian Disabled Swimming Championships the 50m backstroke winner finished the race in 48.38 s. In 2010 World Disabled Swimming Championships (WDSC) the average results among 1-8 places were equal 51.85 ± 3.7 s. Lithuanian Swimming Championships winner's result was 7.64 s better than the 8$^{th}$ place result (55.92 s.). Lithuanian Swimming Championships winner used the tactic of slow start and fast finish. The athlete swam the first 15 m. slowly at a speed of 1.03 m/s which was the slowest speed in comparison with 2010 WDSC results of the finalists. In the final 5 m. part of the distance Lithuanian Swimming Championships winner swam at a speed of 0.85 m/s and reached one of the fastest speed values in this part in comparison with the results of WDSC finalists. Slow start tactic is typical of endurance swimmers, not of fast swimmers performance. In 2010 World Disabled Swimming Championships the finalists used fast start tactic typical of athletes with a great speed potential. They swam the first part of 15 m at a speed 1.1% higher than average: the average distance speed was 0.97 ± 0.07 m/s (100%). In the final finish part of 5 m the speed of all the finalists 0.73 ± 0.07 m/s dropped by 1.3% of the average distance speed. Table 1 and Fig. 1.

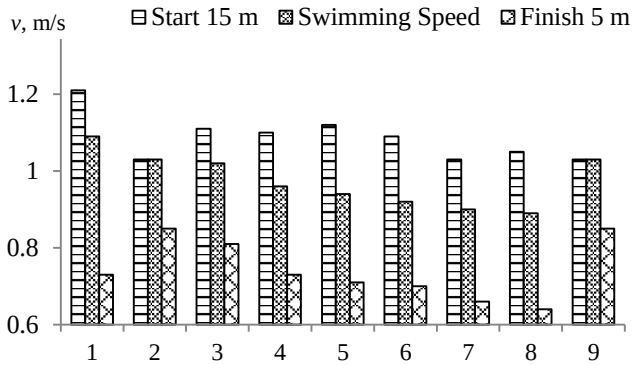


Fig. 1 Swimming speed at the start, during the distance and at the finish in 2010 WDSC: *1* – first swimmer; *2* – second swimmer; *3* – third swimmer; *4* – fourth swimmer; *5* – fifth swimmer; *6* – sixth swimmer; *7* – seventh swimmer; *8* – eighth swimmer; *9* – the winner of Lithuanian championship

In 2013 World Disabled Swimming Championships the average of results was 51.68 s. Though the difference between the average results of 2010 and 2013 World Disabled Swimming Championships is slight – 0.24 s, but the race was completed using different tactic. In 2010 WDSC the average distance speed of the finalists was 0.97±0.05 m/s (100%). The first part of 15 m was swam at a speed of 1.08 ± 0.01 m/s, 1.3% faster than the average distance speed. In the final finish part of 5 m the speed of the finalists dropped to 0.78 ± 0.08 m/s in comparison with the average distance speed. But 2013 WDSC finalists (0.78 m/s) finished at a higher speed than 2010 WDSC (0.73 m/s) finalists Table 2 and Fig. 2.

Table 1

Research data of 2010 Disabled Swimming World Championships S4 50 m backstroke finalists

| Swimmers Ranking | Results, s | Start 15 m | | 30 m swimming distance | | | Finish 5 m | |
|---|---|---|---|---|---|---|---|---|
| | | *t*, s | *v*, m/s | *v*, m/s | Number of cycles | Length of strokes, m | *t*, s | *v*, m/s |
| First swimmer | 45.9 | 12.38 | 1.21 | 1.09 | 46 | 1.09 | 6.68 | 0.73 |
| Second swimmer | 48.46 | 14.54 | 1.03 | 1.03 | 38 | 1.32 | 5.6 | 0.85 |
| Third swimmer | 48.87 | 13.48 | 1.11 | 1.02 | 46 | 1.09 | 6.49 | *0.81* |
| Fourth swimmer | 52.11 | 13.58 | 1.10 | 0.96 | 43 | 1.16 | 6.72 | 0.73 |
| Fifth swimmer | 53.45 | 13.44 | 1.12 | 0.94 | 44 | 1.14 | 6.71 | 0.71 |
| Sixth swimmer | 54.45 | 13.78 | 1.09 | 0.92 | 47 | 1.06 | 6.75 | 0.70 |
| Seventh swimmer | 55.62 | 14.56 | 1.03 | 0.90 | 48 | 1.04 | 7.89 | 0.66 |
| Eighth swimmer | 55.92 | 14.3 | 1.05 | 0.89 | 42 | 1.19 | 7.67 | 0.64 |
| The winner of Lithuanian championship | 48.38 | 14.51 | 1.03 | 1.03 | 39 | 1.28 | 5.89 | 0.85 |

Elite swimmers aim at maintaining a high speed during the whole race. As swimming speed is highly influenced by changes in tempo and stroke length, it is important to be able to alter them during the race. At the increase of stroke length the tempo decreases. While increasing one of these parameters, the athlete has to consider the change in the other one as speed equals multiplication of their values. It is important for the athlete to be able to achieve the same speed by different optimal stroke length and tempo. In 2013 Lithuanian Disabled Swimming Championship the 50 m backstroke winner finished the distance at a slower than average tempo (39 cycles) and with a longer than average

stroke (1.23 m and 1.13 m) in comparison with the results of the finalists at World Disabled Swimming Championships. In 2010 World Disabled Swimming Championships 50 m backstroke finalists maintained the average tempo of 44.25 ± 3.24 cycles. The average stroke length in 50 m backstroke race was 1.14 ± 0.09 m. In 2013 World Disabled Swimming Championships the average tempo of 50 m backstroke 1st-8th place finalists was 44.63 ± 3.25 cycles. In comparison with 2010 WDSC finalists' results the value changed slightly 44.25 ± 3.24 s. In 2006 the average stroke length of WDSC finalists in the distance was 1.13 ± 0.08 m. This value differed slightly from 2010 finalists – 1.14 m. In 2010 World Disabled Swimming Championships 50m backstroke finalists applied the fast start tactic. The average speed of the finalists was 1.08 ± 0.07 m/s. However, the second place winner chose the slow race start and fast finish tactic. The same tactic was applied by Lithuanian Disabled Swimming Championship winner. In 2013 WDSC and LDSC the tactic tendencies remain similar. Most WDSC finalists applied the fast start (1.08 ± 0.07 m/s) tactic, while LDSC winner applied the slow start (1.03 m/s) and fast finish (0.85 m/s) tactic.

Table 2

Research data of 2013 Disabled Swimming World Championships S4 50 m backstroke finalists

| Swimmers Ranking | Results, s | Start 15 m | | 30 m swimming distance | | | Finish 5 m | |
|---|---|---|---|---|---|---|---|---|
| | | *t*, s | *v*, m/s | *v*, m/s | Number of cycles | Length of strokes, m | *t*, s | *v*, m/s |
| First swimmer | 45.82 | 11.88 | 1.26 | 1.09 | 43 | 1.16 | 6.65 | 0.79 |
| Second swimmer | 49.79 | 14.84 | 1.01 | 1.00 | 39 | 1.28 | 5.89 | 0.89 |
| Third swimmer | 51.81 | 13.78 | 1.09 | 0.97 | 46 | 1.09 | 6.17 | 0.80 |
| Fourth swimmer | 52.81 | 13.58 | 1.10 | 0.95 | 49 | 1.02 | 6.53 | 0.78 |
| Fifth swimmer | 53.08 | 13.64 | 1.10 | 0.94 | 43 | 1.16 | 6.86 | 0.79 |
| Sixth swimmer | 53.21 | 13.98 | 1.07 | 0.94 | 46 | 1.09 | 6.95 | 0.78 |
| Seventh swimmer | 53.29 | 14.26 | 1.05 | 0.94 | 48 | 1.04 | 7.09 | 0.67 |
| Eighth swimmer | 53.61 | 14.2 | 1.06 | 0.93 | 43 | 1.16 | 7.18 | 0.69 |
| The winner of Lithuanian championship | 48.38 | 14.53 | 1.03 | 1.03 | 39 | 1.28 | 5.89 | 0.85 |

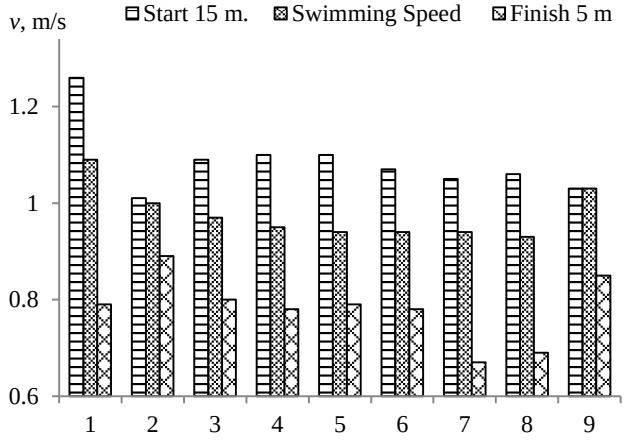


Fig. 2 Swimming speed at the start, during the distance and at the finish in 2013 WDSC: *1* – first swimmer; *2* – second swimmer; *3* – third swimmer; *4* – fourth swimmer; *5* – fifth swimmer; *6* – sixth swimmer; *7* – seventh swimmer; *8* – eighth swimmer; *9* – the winner of Lithuanian championship

During the race the speed choice in separate distance parts – the start, the swimming, and the finish – plays a very important role. It depends on the athlete's speed, strength, endurance as well as tactical and psychological readiness.

The start speed is a very important race part, especially in short distances. Most start speed values of 2010 and 2013 WDSC finalists (with an exception of the winner) were similar or changed slightly (Fig. 3). This could be explained by athletes' nature of disability and high start speed results recorded in 2010 WDSC. Start speed mostly depends on the strength of pushing off at the start block. In disabled swimming competitions S4 class swimmers have different physical disabilities which determine different athletes' start techniques (using one foot, one hand, both feet or both hands). Due to this some athletes start faster than others.

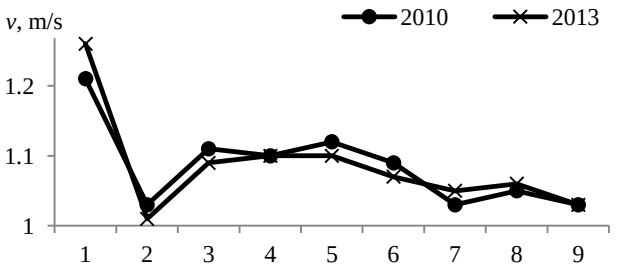


Fig. 3 Start speed of 2010 and 2013 WDSC finalists and Lithuanian champion: *1* – first swimmer; *2* – second swimmer; *3* – third swimmer; *4* – fourth swimmer; *5* – fifth swimmer; *6* – sixth swimmer; *7* – seventh swimmer; *8* – eighth swimmer; *9* – the winner of Lithuanian championship

Most of 2010 WDSC participants (up to the fifth result according to the place) speed was higher than in 2013 (Fig. 4). These data show that maintaining steady speed during all distance was more important for 2010 WDSC finalists in comparison with 2013 WDSC data.

Most of 2013 WDSC participants finish was faster in comparison with 2010 WDSC participants. These data show that high results in 2013 WDSC were determined by speed maintainance at the finish (Fig. 5).

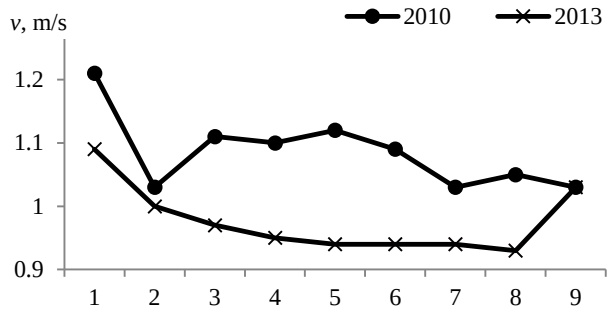


Fig. 4 Distance speed of 2010 and 2013 WDSC finalists and Lithuanian champion: *1* – first swimmer; *2* – second swimmer; *3* – third swimmer; *4* – fourth swimmer; *5* – fifth swimmer; *6* – sixth swimmer; *7* – seventh swimmer; *8* – eighth swimmer; *9* – the winner of Lithuanian championship

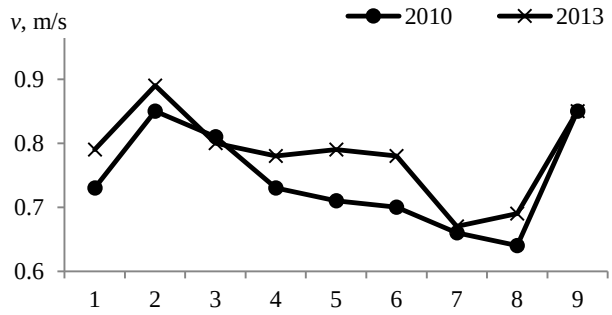


Fig. 5 Finish speed of 2010 and 2013 WDSC finalists and Lithuanian champion: *1* – first swimmer; *2* – second swimmer; *3* – third swimmer; *4* – fourth swimmer; *5* – fifth swimmer; *6* – sixth swimmer; *7* – seventh swimmer; *8* – eighth swimmer; *9* – the winner of Lithuanian championship

## 4. Conclusions

1. 2013 Lithuanian Disabled Swimming Championship 50 m backstroke winner started the race slowly (first 15 m), maintained a similar speed in the next 30 m part, and applied the tactic of slow start, steady swimming and fast finish.

2. Most 2010 World Disabled Swimming Championship 50 m backstroke finalists applied the fast start tactic.

3. 2013 World Disabled swimming Championships 50 m backstroke finalists applied the steady swimming speed tactic and swam the last 5 meters faster than the finalists of 2010 World Disabled Swimming Championship.

## References


1. **Daly, D.J.; Vanlandewijck, Y.** 1999. Some criteria for eveluating the "fairness" of swimming classification, Adapt Phys Act Q. 16: 271-89. http://dx.doi.org/10.1016/j.pmr. 2009.07.002.
2. **Dummer, G.M.** 1999. Classification of swimmers with physical disabilities, Adapt Phys Act Q 16(3): 216-218. Available from: http://ezproxy.deakin.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=6194378&site=rrc-live. 2010.07.12.
3. **Prins, J.; Murata, N.** 2008. Stroke mechanics of swimmers with permanent physical disabilities, Palaestra 24(1): 19-25. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=sph&AN=32855701&site=ehost-live. 2009.01.07.
4. **Oh, Y.T.; Burkett, B.; Osborough, C.; Formosa, D.; Payton, C.** 2013. London 2012 Paralympic swimming: passive drag and the classification system, Br J Sports Med. 47: 838-843. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23935028. http://dx.doi.org/10.1136/bjsports-2013-092192.
5. **Griffiths, I.W.** 2009. Principles of biomechanics and motion analysis, Int. J. Sport. Sci. Coach. 1: 421–3. http://dx.doi.org/10.1260/174795406779367783.
6. **Kreighbaum, E.** 1996. Biomechanics: a qualitative approach for studying human motion, 4th ed. MA: Ellyn and Bacon, pp 655.
7. **Daly, D.J.; Malone, L.A.; Smith, D.J.; Vanlandewijck, Y.; Steadward, R.D.** 2001. The contribution of starting, turning, and finishing to total race performance in male Paralympic swimmers, Adapt Phys Act Q. 18(3): 316-333. http://dx.doi.org/10.1123/apaq.18.3.316.
8. **Wu, S.K.; Williams, T.** 1999. Paralympic swimming performance, impairment, and the functional classification system, Adapt Phys Act Q. 16(3): 251-270. http://dx.doi.org/10.1123/apaq.16.3.251.
9. **Lepore, M.; Gayle, G.W.; Stevens, S.F.** 2007. Adapted Aquatics Programming:A Professional Guide - 2nd Edition. Human Kinetics, pp. 254.
10. **Colwin, C.** 2002. Breakthrough Swimming. Human Kinetics, pp. 189
11. **Counsilman, J.E.; Councilman, B.E.** 1994. The New Science of Swimming, Englewood Cliffs, NJ: Prentice Hall, p 352
12. **Hannula, D.** 1995. Coaching Swimming Successfully. Champaign, IL: Human Kinetics, pp. 87.
13. **Maglischo, E.W.** 2003. Swimming Fastest. Champaign, IL: Human Kinetics, pp. 658.
14. **Sweetenham, B.; Atkinson, J.** 2003. Championship swim training. Champaign, IL: Human Kinetics, 255-258.
15. **Dummer, G.; Bare, J.** 2001. Including swimmers with a disability: A guide for coaches, Coach Q. 7(2): 18-26.
16. **Sherrill, C.; Dummer, G.M.** 2003. Adapted Aquatics, Champaign, IL: Human Kinetics, pp. 250.
17. **Tweedy, S.M.; Vanlandewijck, Y.C.** 2011. International Paralympic Committee position stand-background and scientific principles of classification in Paralympic sport, Br J Sports Med. 45: 259-269. http://dx.doi.org/10.1016/j.jsams. 2009.04.009.
18. **Rutemiller, B.** 1991. The sculling sensation, Swim Tech. 28(2): 14-23.
19. International Paralympic Committee. 2010. IPC Swimming World Championship Result Book, 10-15.
20. International Paralympic Committee. 2013. IPC Swimming World Championship Results Book, 12-21.

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ANALYSIS OF 50M BACKSTROKE CLASS S4 DISABLED SWIMMERS RACE PARAMETERS

S u m m a r y

The aim of the article – to analyze theoretical aspects of swimming mechanics in disabled swimming and to determine and compare S4 disabled swimmers 50 m backstroke race parameters and tactic of Lithuanian Disabled Swimming Championships winner and World Disabled swimming Championships finalists. The results of 2013 Lithuanian Disabled Swimming Championships 50 m backstroke winner were recorded by hand stopwatches. The race distance was divided into parts (15 m for start, 30 m swimming, 5 m for finish). The winner's speed (m/s), the average length of strokes (cycles/minute) and the average stroke length (m) were calculated, as well as the means of same data of the finalists and winners of 2010 and 2013 World Disabled Swimming Championships. 2010 and 2013 World Disabled Swimming Championships (at 50 m swimming pool) data on different race parts and the number of cycles of 50 m finalists were taken from the International Paralympic Committee protocols. The results of the research showed that disabled swimmer's speed is determined largely by their capacity to produce propulsion with sculling movements effectively while minimising the resistive or drag forces from the water. 2013 Lithuanian Disabled Swimming Championships 50 m backstroke winner started the race slowly (first 15 m), maintained a similar speed in the next 30 m part, and applied the tactic of slow start, steady swimming and fast finish. Most 2010 World Disabled Swimming Championships 50 m backstroke finalists applied the fast start tactic. 2013 World Disabled Swimming Championships 50 m backstroke finalists applied the steady swimming speed tactic and swam the last 5 meters faster than the finalists of 2010 World Disabled Swimming Championships.

**Keywords:** race parameters, average swimming speed, average stroke frequency, average stroke length, disabled swimmers.

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