Lokaverkefni B.Sc. í íþróttafræði

The difference between swimmers with and without intellectual disabilities in the 6x50m pacing test.

Maí, 2021

Nafn nemanda: Dadó Fenrir Jasminuson

Kennitala: 050595-3669

Leiðbeinandi: Ingi Þór Einarsson

12 ECTS ritgerð til BSc í íþróttafræði

Abstract

Pacing is a skill of distributing energy optimally during a race or training. Pacing is considered an important tool in athletic performance. Athletes with intellectual impairment (II) have shown to have decreased abilities at pacing in time-based sports. The purpose of this study is to observe how swimmers with II differ from swimmers without II. In this study the 6x50m pacing test was used to acquire the data needed to understand how the swimmers invest energy while pacing. Swimmers (n=48) form different nations took roll in the study, of which 34 are swimmers with II, and 14 swimmers without II. The results show that the group with II were significantly inferior at hitting target time in all the six 50m sprints, when both externally and internally paced. The swimmers with II show to have more difficulties matching the pre-planned pace given before the test. The group with II were on average 2,55 seconds away from their target times, and the biggest difference between the two groups was 2,65 seconds ($p<0,0001$) in the 4th 50m sprint. The difference in stroke length (SL) was significant ($p=0,05$) in all six 50m sprints. Swimmers with II show to have shorter SL than swimmers without-t II. The difference between the two groups in stroke-rate (SR) was significant ($p=0,05$) in all but the 3rd and 6th 50m sprints. This study shows that individuals with II have difficulties holding a consistent pace and show difficulties with a sudden change of a targeted pace. The conclusion is that individuals with II show to have a harder time at holding a certain pace and have difficulties of a sudden change of pace. Coaches should invest more time in pace work with individuals with II.

Preface and acknowledgments

The reason I chose this topic is because of the passion I have for the sport of swimming and how much the sport can give to so many different groups of people The intellectually impaired are different in many ways, some can be demanding but many of their different ways can be so rewarding, and you can learn so much about them and yourself by working with people who are intellectually impaired and helps you to grow as a person. Having a boy diagnosed with II being in my training group opened my eyes to how genuinely special they are. The motivation for writing this essay came from my professor Ingi Þór Einarsson. He opened my eyes to how interesting and often difficult it is to work around individuals with II, especially the classification criteria's.

The process of the study was both demanding and very informative. The testing of the individuals taught me how time-consuming testing can be and how one's patience can be tested.

The writing of the easy was challenging but the further into the essay the more interesting it got.

I want to thank all the swimmers that took part in this study. My Belgian colleges Pieter Marien and Hannah Luts for helping me with the testing. My two colleges Hafþór Haukur Steinþórsson and Helgi Arnar Jónsson, for helping me and encouraging me through this easy. The club SH for letting me use their swimming pool and equipment for the tests. My mother, brother, and my girlfriend Jóhanna Elín for emotional help, the Icelandic federation for supporting me through this study, and special thanks to my professor Ingi Þór Einarson for helping me and guiding me through this study.

Table of Contents

Table of Figures

Theoretical background

Pacing in sports

In time-based sports, whether the goal is to finish in the fastest possible time or a time limit is set, pacing themselves optimally during that period has been shown to be a key factor in achieving success (Smits et al., 2014). In swimming the only successful tactic has been shown to pace oneself evenly throughout the entire race (Lipińska, 2012). Though other sport do differ as can be seen in team sports, where teams pace themselves differently according to the dynamic of the team or whom they might be facing (Ferraz et al., 2018). Elite athletes in time-based sports have shown to have most success in competition when repeatedly practicing hitting their goal pace in training (Elferink-Gemser & Hettinga, 2017) thus making the goal pace more natural to perform in a race (Foster et al., 2003).

Pacing

The skill of distributing energy optimally during a race or training is known as pacing. Pacing is considered an important tool in athletic performance (*The Importance of Pacing*, n.d.) Pacing is composed of many factors, of which are both physical and mental (*The Importance of Pacing*, n.d.). The physical factors are mainly the aerobic and anaerobic capacities and the physical strength of the athletes (Andrews et al., 2012). The mental aspects are experience and tactics (Abbiss & Laursen, 2008; Smits et al., 2014). Through repetitive training and practice of pacing athletes gain experience of how to optimally withhold certain speed or intensity, during a race, competition or training (Foster et al., 2003). Also pacing in training has been shown to be a substantial way of developing aerobic and anaerobic capacity (Andrews et al., 2012). Thus pacing is a component which is vital in obtaining succusses in ones event or sport (Smits et al., 2014). Especially in time-dependent sports, such as running cycling and swimming (*The Importance of Pacing*, n.d.). To be successful in each distance, energy must be utilized effectively during the whole race, to avoid premature fatigue (Foster et al., 2003). Athletes often naturally show a drop in speed in, and after the midpoint of a race, thus pacing has a crucial role in avoiding deacceleration of speed (Smits et al., 2014). There have been shown differences in pacing when athletes are self-paced and evenly-paced, where the evenly-paced athletes showed lower rating of perceived exertion (RPE) (Thomas et al., 2012).

Pacing varies by the distance of the race. In the 50m freestyle, an all-out effort could be most beneficial, but for longer distances such as the 400m freestyle, which takes approximately 4 minutes to complete, pacing strategy is critical for success (Abbiss & Laursen, 2008). Pacing is also used in other events, such as team-sports where the whole team must pace themselves throughout the match to have a higher probability of success, though pacing is more infamous in time-based sports (Waldron & Highton, 2014). It has been shown that runners that trained with a lot of pacing work had performed better than runners with a weaker pacing profile (Swain et al., 2020). It has been shown that the more experience the athletes have at pacing at the recommended speed the more likely they will be able to hold the optimal pace for success, while athletes with less experience are more likely to deaccelerate mid-race (Swain et al., 2020). Pacing is a skill athletes develop from childhood, and is vital, not specifically for competitions but also for longer periods of time, therefore, coaches are advised to monitor the development of pacing in their athletes (Menting et al., 2019).

Swimming

In the sport of competitive swimming, the objective is to finish the race in the fastest time possible or to win all other competitors (McGibbon et al., 2018).

There are 18 individual disciplines for both male and female athletes at the Olympic games, which are divided into four different strokes, butterfly, backstroke, breaststroke, and freestyle. Freestyle is the most used stroke for it is the fastest and most efficient (Pelayo et al., 1996). Out of the 18 Olympic individual disciplines, freestyle is swum in eight of them. Each of the other strokes has three disciplines and three are individual medley (IM) where each stroke is swum by the decided length of the races (*Swimming History and Presentation*, n.d.).

Many components in competitive swimming contribute to a good performance.

In competitive swimming the most important element to be considered is the athletes' endurance capacity.(Vasile, 2014). It has been shown that individuals that underwent a six week endurance program, showed significant improvements in maximal power output, maximal minute ventilation and a decrees in maximal respiratory exchange ratio (RER) (Vollaard et al., 2009). Aerobic endurance in swimming is the energy system that is under the most strain (Vasile, 2014). Through aerobic adaptation, the body is more efficient at using oxygen while both exercising and at rest (Vasile, 2014). It has been shown that the higher aerobic capacity an individual has the quicker the individual is at removing lactic acid from the body while exercising and/or resting which is highly beneficial in competitive swimming (Denadai et al., 2004). Strength and power are factors that are immensely important in the sport of competitive swimming (Morouço et al., 2012). Swimmers that have higher muscle strength showed to have more propulsive power and longer SL compared to swimmers with less muscle strength (Gola et al., 2018). In sprint swimming, a counter movement jump (CMJ) has been shown to have direct corelation with the 50m sprint events, where the higher the individuals score in the CMJ they usually showed faster times in the 50m events, though it can be due to the contribution of the swimming start and turn. (Pérez-Olea et al., 2018). The swimming start is performed off of a starting block and can contribute between 0.8-26.1% of total race time depending on the distance, the higher the percentage the shorter the distance of the event (Tor et al., 2014). The turn phase in swimming is when a swimmer need to perform more than one length of the pool and thus need to turn and swim back (Chakravorti et al., 2012). The flip-turn is a technique used while swimming freestyle and backstroke and is the most efficient technique used to turn on a wall while swimming distances longer than one length of the pool (Araujo et al., 2010). It has been shown to achieve the best possible performance with proper tactics, an individual has to pace himself and distribute maximum velocity throughout the whole race (Lipińska, 2012).

Swim speed and drag.

The goal in competitive swimming is to achieve maximum velocity (v) throughout the whole race. Velocity in swimming is governed by stroke length (SL) and stroke rate (SR) (Franken et al., 2013). Stroke rate has been shown to have a strong correlation with maximum effort swimming time in elite-level swimmers (Funai et al., 2019). It has also been shown that a decrease in SR mid-race directly negatively influences swimming speed (Fritzdorf et al., 2009).

Stroke-length is the most accurate statistic to show an individual's efficiency in competitive swimming (Funai et al., 2019) although SL is affected by the individual's body structure, swimmers with longer SL have shown to have more probability of success (Barbosa et al., 2011). When looked into international competitions has shown that to obtain maximum velocity in each race is highly individual to each athlete (Pelayo et al., 1996). Other than SL and SR, the individual’s body influences stroke mechanics, such as the size of the individual's arms, legs, surface area, floating ability, and area of propulsion (Toussaint et al., 1991). „Drag in swimming is influenced by velocity, shape, size, and the frontal surface area.“(Kjendlie & Stallman, 2008). For a swimmer to swim faster, they must either increase the propulsive force, reduce the drag force, or do both (Alcock & Mason, 2007). The technique shows a direct correlation with drag. Thus it is important for coaches to enforce correct techniques for improved performance (Alcock & Mason, 2007).

Intellectual Impairment

Intellectual disability (II) is a term used to refer to individuals who have difficulty in learning and understanding new and complex information and skills (*The American Association on Intellectual and Developmental Disabilities (AAIDD) Diagnostic Criteria for Intellectual Disability*, n.d.). The individuals show limitations in intellectual functioning and adaptive behaviour (Burns et al., 2020). Over the past few decades, the definition of II has been altered due to people's understanding of the disability. American Association on Intellectual and Developmental Disabilities (AAIDD) applied the definition of intellectual disability and is the most widely accepted definition of the criteria (Shree & Shukla, 2016). The primary eligibility criteria based from AAIDD to be able to compete in Para sports are significant intellectual impairment, significant limitations in adaptive behaviour, and age of onset before the age of 18 (Tassé et al., 2016). The diagnostic component of intellectual impairment is that the individual has a below-average IQ score (IQ ≤74) (Burns et al., 2020). A study has shown that swimmers with II have less physical capacity than swimmers without II and have shown to have more variance between competitions than swimmers without II (Vliet et al., 2006). The instability in results is mainly caused by clean swimming speed which was mostly caused by sr. The biggest difference between swimmers was found in sr, which shows us the inconsistency in efficiency between competitions (Einarsson, n.d.). Individuals with II have shown to have poorer cardiorespiratory endurance capacity than individuals without II (Vliet et al., 2006).

II pacing

Studies have shown that athletes with II have trouble holding certain paces without continued auditory feedback while running (Van Biesen et al., 2017). The main difficulty that the II athletes had was maintaining velocity. The problem was not a decrease in velocity but a premature acceleration (Burns et al., 2020). While researching pacing abilities in children without II and individuals with II, there has been an assumption that intellectual functioning is involved in pacing (Van Biesen et al., 2017). The assumption rose as studies have shown that elite athletes with II have difficulties maintaining a pre-planned race strategy and exercise intensity compared to athletes without II (Burns et al., 2020). An individual with II has a strong pattern in where deceleration accrues earlier during distances involving pacing (Van Biesen et al., 2016).

Down syndrome

Down syndrome (DS) is the most common genomic disorder of intellectual disability. One in every 600 individuals born in the United States of America is born with DS(Sanyer, 2006). DS is a disability that affects multiple systems in the body such as cardiovascular, neurological, and musculoskeletal systems, which affect overall health and performance in sport (Antonarakis et al., 2020) and various other health issues (Kumar et al., 2015). Due to imbalances of hormones, the motor functions in individuals with DS are often diagnosed with hypotonia and hyper-flexibility, resulting in dislocations of joint and abnormal motor skills (Hawli et al., 2009).

Due to the complexity of the medical issues DS can have, specifically with orthopedic and cardiovascular disorders, a physician must be able to evaluate the individual so that he can direct the individual's activities in a safe and reasonable manner (Sanyer, 2006). It has been shown that individuals diagnosed with DS, whom participate in physical activity weekly have shown better overall wellbeing over individuals that do not participate in any physical activities (Fiorilli et al., 2016).

Overall aims of the study and hypotheses.

What is the difference between swimmers with and without intellectual disabilities in the 6x50m pacing test?

- What is the difference between the groups when externally paced and internally paced?
    - The hypothesis is that swimmers with intellectual disabilities should show a less consistent pattern of pacing in the 6x50m test.
- What is the difference in stroke length between the two groups in the 6x50m test?
    - The hypothesis is that swimmers with intellectual disabilities will have shorter SL than swimmers without intellectual disabilities.
- Is there a difference in stroke rate between the groups?
    - The hypothesis is that the swimmers with intellectual disabilities will show less consistency in stroke rate throughout the 6x50m test.

Methods

In this study, data was gathered both by testing and received from a previous testing.

Participants

The subjects of this study were a total of 48 swimmers, of which 34 are diagnosed with II (28 males and 6 females; age = 21,9 ± 5) and a comparison group of 14 swimmers without impairment (7 males and 7 females; age = 18,3 ± 0,6).
11 of the 34 swimmers with II were diagnosed with DS.
In the study, two swimmers diagnosed with autism took part, due to the goal of the study the two swimmers were not included.

The 6x50m test

The purpose of the 6x50m test was to evaluate the pacing abilities of elite swimmers, mainly in 200m pace.
The test was set up as 2x(3x50m) descending 1-3^{rd} and 4-6^{th} 50m. The 1^{st} and 4^{th} 5m were 6 seconds slower than the individuals 200m pace, 2^{nd} and 5^{th} were 3 seconds from their 200m pace and the 3^{rd} and 6^{th} 50m were at 200m pace.

- Swimmers did a light 12min swimming warmup.
- The test was explained to the swimmers before the start of the test.
- The intervals were on 2min.
- The test was conducted in a long course (50m) swimming pool.
- 1^{st} – 3^{rd} 50m were externally paced.
- 4^{th} – 6^{th} 50m were internally paced.

Testing environment and equipment

The swimming pool was a standard 27,5 degrees Celsius. The individuals were tested in a lane of their own without outer interference. The 1^{st}, $2^{nd,}$ and 3^{rd} 50m were externally paced with indico virtual swim trainer, and the 4^{th}, $5^{th,}$ and 6^{th} 50m were internally paced.
The timed results were taken with a SEIKO water-resistant stopwatch.
The tester started the clock the moment the swimmers’ feet left the wall and stopped the clock the moment the swimmer touched the opposite wall with their hand.

Data analysis

The testing was recorded with a Casio Exilim Ex F1. The distance of the camera was set to overlook at least 25m of the swimming pool. The video data was transferred to a computer where it was analysed with Kinovea, a sports analysis application.

Swim-speed (SS)

Swim-speed measurements were conducted by taking a 10m split time. The time was taken when the top of the swimmers' head passed the 15m mark and stopped when the top of the swimmers' head passed the 25m mark. The units used to measure the ss of the swimmers were meters per second (m/s).

Stroke-rate (SR)

The stroke rate was measured by taking the time of three full freestyle cycles. The time was taken when the swimmer fully extended his hand forward and stopped and stopped after three full cycles. The units used to measure the SR of the swimmers were strokes per minute (SR/min).

Formula: 60/((start of first stroke – end of the third stroke)/3)

Stroke-length (SL)

The Stroke-length is measured by dividing swim speed/stroke rate. The units used to measure the SL of the swimmers were meters per stroke (m).

Formula: swim-speed /(stroke-rate/60)

Statistics Analysis

Once all the data was collected, the data was analysed with the use of IBM SPSS statistics data editor and Windows Excel 2020. Results were analysed with T.test done with excel t.test function with two-tailed and unequal variances. IBM SPSS statistics data editor was used to find the Mean and Std.

The results are depicted as mean, standard deviation, and sample t.test (p=0,05).

Results

Table one depicts the absolute time difference between the actual time and the planned time in the 6x50m pacing test. The biggest difference between the group was 2,65 (p<0,0001) seconds in the 4th sprint.

Table 1. The difference in every 50m and 1-3rd and 4-6th in the absolute average difference between swimmers with and without II.

Sprint	Without II (14)	With II (34)
Diff.1(s)	0,20(+/-0,13)	1,61(+/-1,67) *
Diff.2(s)	0,22(+/-0,17)	1,38(+/-1,38) *
Diff.3(s)	0,18(+/-0,17)	1,45(+/-2,29) *
Ave-Diff.1-3(s)	0,11(+/-0,06)	1.30(+/-1,60) *
Diff.4(s)	0,90(+/-0,50)	3,55(+/-2,39) *
Diff.5(s)	0,47(+/-0,20)	3,06(+/-2,02) *
Diff.6(s)	0,46(+/-0,33)	2,02(+/-1,50) *
Ave-Diff.4-6(s)	0,37(+/-0,23)	2,51(+/-1,87) *

Results marked with * = p<0.05

The group with II has a minimum of 1,38 second average from target time, while the group without II has a maximum of 0,90 seconds from their target time. Both groups were furthest from their target times in the 4th 50m sprint.

Table 2. Difference in stroke-length between swimmers with and without II, in all six 50m.
SL= stroke-length   m= meters

Sprint	Without II (14)	With II (34)
SL.1(m)	2,03(+/-0,2)	1,74(+/-0,56) *
SL.2(m)	1,85(+/-0,2)	1,63(+/-0,28) *
SL.3(m)	1,87(+/-0,21)	1,63(+/-0,26) *
SL.4(m)	1,95(+/-0,22)	1,69(+/-0,32) *
SL.5(m)	1,91(+/-0,24)	1,65(+/-0,30) *
SL.6(m)	1,83(+/-0,19)	1,61(+/-0,29) *

Results marked with * p<0,05

The results in table 2. show us that the group without II have significantly longer strokes than the group with II.

Table 3. Difference in stroke-rate (SR) between swimmers with and without II, in all six 50m.
SR= stroke-rate   min=minutes

Sprint	Without II (14)	With II (34)
SR.1(str/min)	34,98(+/-3,79)	41,86(+/-8,28) *
SR.2(str/min)	41,72(+/-3,37)	44,91(+/-5,09) *
SR.3(str/min)	45,66(+/-4,16)	48,79(+/-6,43)
SR.4(str/min)	37,00(+/-5,08)	43,39(+/-5,78) *
SR.5(str/min)	40,97(+/-4,31)	47,94(+/-6,76) *
SR.6(str/min)	46,54(+/-4,21)	49,76(+/-8,05)

Results marked with * P<0,05

Table 3. shows us that the group with II has a higher overall SR than the group without II.

Discussion

The aim of this study was to see the difference between swimmers diagnosed with II and swimmers without II in the 6x50m pacing test. The first aim was to see the difference between the two groups when externally and internally paced. The results show that the swimmers with II show to have difficulties hitting the set paces than swimmers without II, and even more difficulties when internally paced. As shown, athletes with II have trouble holding certain paces without continued auditory feedback (Van Biesen et al., 2017), which confirms the hypothesis that the group with II show a less consistent pattern in pacing when internally paced. Both groups showed to have the most difficulties hitting their target times in the 4th 50m sprint in the 6x50m pacing test. The 4th 50m sprint is the first externally paced sprint. Though the group with II had substantially more difficulties, swimming an average of 3,55(+/-2,39) seconds ($P<0,0001$) from their target time, while the group without II a mere 0,90(+/-0,50) seconds from their targeted time.

The next aim of the study was to see the difference in stroke length between the two groups. The results showed that the group with II have significantly($P=0,05$) shorter strokes in comparison to the group without II. Swimmers with II may have difficulties with technique and overall efficiency. Stroke length is an accurate component when observing the efficiency of swimmers (Funai et al., 2019). The reason for the lack of efficiency could be that swimmers with II are less self-conscious of how they move in water (Burns et al., 2020). Thus, it might be that swimmers with II should emphasize more on technique than swimmers without II. The last aim of this study was to see the difference in stroke rate between the two groups. It appeared that swimmers with II have a higher overall stroke rate than swimmers without II. As was shown earlier, the group with II has shorter SL and less efficiency than the group without II ($p<0,05$). The group with II has a higher stroke rate because of the lack of efficiency. Interestingly, the 3rd and 6th 50m sprints have no significant difference between the groups. Which could either be that elite swimmers with II swim technically better at higher or swim better at a swim speed where more emphasis on technique is set on, the other option is that the group without II may lose efficiency at higher speed in comparison to the group with II.

The 6x50m pacing test was a test of pacing for elite athletes, though during the analysis of the results, it was found that the 4th sprint was usually the sprint where the swimmers had the most difficulties. The hypothesis is that the swimmers get used to the 200m pace and speed in the 3rd sprint and find it challenging to slow down their pace internally. That could have had a minor effect on the results of the test by swimmers getting used to a higher speed in the 3rd 50m sprint. Having 11 individuals with DS out of the 34 with II could have influenced the outcome of the test. As has been shown that individuals with DS have issues with multiple systems in the body such as cardiovascular, neurological, and musculoskeletal, which could have had an influence on the II group performance in test. Individuals with DS are still categorized as II even though they show to have more disabilities than individuals diagnosed only with intellectual impairment. (Antonarakis et al., 2020).

Conclusion

By the results of this study, coaches should know that the intellectual impaired show differences to individuals without II, not only in pacing but in stroke length and stroke rate, which ultimately tells us there is a lack of efficiency and technique.

Coaches who work with intellectually impaired individuals should know that the athletes have difficulties, not only in holding a certain pace but also show difficulties in a change of pace. That is why coaches should emphasize on pacing when coaching intellectually impaired athletes in time-based sports.

Athletes diagnosed with DS have been shown to be different than individuals diagnosed only with II. Thus a sports category specifically made for individuals with DS could be a reasonable idea for the future.

References

Abbiss, C. R., & Laursen, P. B. (2008). Describing and Understanding Pacing Strategies during Athletic Competition. *Sports Medicine*, *38*(3), 239–252. https://doi.org/10.2165/00007256-200838030-00004

Alcock, A., & Mason, B. (2007). BIOMECHANICAL ANALYSIS OF ACTIVE DRAG IN SWIMMING. *ISBS - Conference Proceedings Archive*. https://ojs.ub.uni-konstanz.de/cpa/article/view/438

Andrews, N. E., Strong, J., & Meredith, P. J. (2012). Activity Pacing, Avoidance, Endurance, and Associations With Patient Functioning in Chronic Pain: A Systematic Review and Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *93*(11), 2109-2121.e7. https://doi.org/10.1016/j.apmr.2012.05.029

Antonarakis, S. E., Skotko, B. G., Rafii, M. S., Strydom, A., Pape, S. E., Bianchi, D. W., Sherman, S. L., & Reeves, R. H. (2020). Down syndrome. *Nature Reviews Disease Primers*, *6*(1), 1–20. https://doi.org/10.1038/s41572-019-0143-7

Araujo, L., Pereira, S., Gatti, R., Freitas, E., Jacomel, G., Roesler, H., & Villas-boas, J. (2010). Analysis of the lateral push-off in the freestyle flip turn. *Journal of Sports Sciences*, *28*(11), 1175–1181. https://doi.org/10.1080/02640414.2010.485207

Barbosa, T. M., Marinho, D. A., Costa, M. J., & Silva, A. J. (2011). Biomechanics of Competitive Swimming Strokes. In *Biomechanics in Applications*. IntechOpen. https://doi.org/10.5772/19553

Burns, J., Sakalidis, K., Van Biesen, D., Dreegia, W., & Hettinga, F. (2020). The impact of cognitive functions and intellectual impairment on pacing and performance in sports. *Psychology of Sport and Exercise*, *52*. https://doi.org/10.1016/j.psychsport.2020.101840

Chakravorti, N., Slawson, S. E., Cossor, J., Conway, P. P., & West, A. A. (2012). Swimming Turn Technique Optimisation by Real-Time Measurement of Foot Pressure and Position. *Procedia Engineering*, *34*, 586–591. https://doi.org/10.1016/j.proeng.2012.04.100

Denadai, B. S., Figueira, T. R., Favaro, O. R. P., & Gonçalves, M. (2004). Http://www.scielo.br/scielo.php?script=sci_abstract&pid=S0100-879X2004001000015&lng=en&nrm=iso&tlng=en. *Brazilian Journal of Medical and Biological Research*, *37*(10), 1551–1556. https://doi.org/10.1590/S0100-879X2004001000015

Einarsson, I. Þ. (n.d.). *A COMPARISON OF RACE PARAMETERS IN ICELANDIC SWIMMERS WITH AND WITHOUT INTELLECTUAL DISABILITIES*. 72.

Elferink-Gemser, M. T., & Hettinga, F. J. (2017). Pacing and Self-regulation: Important Skills for Talent Development in Endurance Sports. *International Journal of Sports Physiology and Performance*, *12*(6), 831–835. https://doi.org/10.1123/ijspp.2017-0080

Ferraz, R., Gonçalves, B., Coutinho, D., Marinho, D. A., Sampaio, J., & Marques, M. C. (2018). Pacing behaviour of players in team sports: Influence of match status manipulation and task duration knowledge. *PLOS ONE*, *13*(2), e0192399. https://doi.org/10.1371/journal.pone.0192399

Fiorilli, G., di Cagno, A., Iuliano, E., Aquino, G., Calcagnile, G., & Calcagno, G. (2016). Special Olympics swimming: Positive effects on young people with Down syndrome. *Sport Sciences for Health*, *12*(3), 339–346. https://doi.org/10.1007/s11332-016-0293-x

Foster, C., De Koning, J. J., Hettinga, F., Lampen, J., La Clair, K. L., Dodge, C., Bobbert, M., & Porcari, J. P. (2003). Pattern of Energy Expenditure during Simulated Competition. *Medicine & Science in Sports & Exercise*, *35*(5), 826–831.

Franken, M., Diefenthaeler, F., Moré, F. C., Silveira, R. P., & Castro, F. A. de S. (2013). Critical stroke rate as a parameter for evaluation in swimming. *Motriz: Revista de Educação Física*, *19*(4), 724–729. https://doi.org/10.1590/S1980-65742013000400009

Fritzdorf, S. G., Hibbs, A., & Kleshnev, V. (2009). Analysis of speed, stroke rate, and stroke distance for world-class breaststroke swimming. *Journal of Sports Sciences*, *27*(4), 373–378. https://doi.org/10.1080/02640410802632623

Funai, Y., Matsunami, M., & Taba, S. (2019). Physiological Responses and Swimming Technique During Upper Limb Critical Stroke Rate Training in Competitive Swimmers. *Journal of Human Kinetics*, *70*, 61. https://doi.org/10.2478/hukin-2019-0026

Gola, R., Urbanik, C., Iwańska, D., & Madej, A. (2018). Relationship between muscle strength and front crawl swimming velocity. *Human Movement*, *15*(2), 110–115. https://doi.org/10.2478/humo-2014-0011

Hawli, Y., Nasrallah, M., & Fuleihan, G. E.-H. (2009). Endocrine and musculoskeletal abnormalities in patients with Down syndrome. *Nature Reviews Endocrinology*, *5*(6), 327–334. https://doi.org/10.1038/nrendo.2009.80

Kjendlie, P.-L., & Stallman, R. K. (2008). Drag Characteristics of Competitive Swimming Children and Adults. *Journal of Applied Biomechanics*, *24*(1), 35–42. https://doi.org/10.1123/jab.24.1.35

Kumar, A., Muthuswamy, S., Jain, S., & Agarwal, S. (2015). “Down syndrome: An insight of the disease”. *Journal of Biomedical Science*, *22*(1), 41. https://doi.org/10.1186/s12929-015-0138-y

Lipińska, P. (2012). BALTIC JOURNAL OF HEALTH AND PHYSICAL ACTIVITY Kinematics Tactics in Swimming Races on the Example of the Beijing 2008 Olympic Games and the Rome 2009 World Championships. In *Baltic Journal of Health and Physical Activity* (Vol. 3). https://doi.org/10.2478/v10131-011-0022-4

McGibbon, K. E., Pyne, D. B., Shephard, M. E., & Thompson, K. G. (2018). Pacing in Swimming: A Systematic Review. *Sports Medicine*, *48*(7), 1621–1633. https://doi.org/10.1007/s40279-018-0901-9

Menting, S. G. P., Hendry, D. T., Schiphof-Godart, L., Elferink-Gemser, M. T., & Hettinga, F. J. (2019). Optimal Development of Youth Athletes Toward Elite Athletic Performance: How to Coach Their Motivation, Plan Exercise Training, and Pace the Race. *Frontiers in Sports and Active Living*, *1*. https://doi.org/10.3389/fspor.2019.00014

Morouço, P. G., Marinho, D. A., Amaro, N. M., Pérez-Turpin, J. A., & Marques, M. C. (2012). Effects of dry-land strength training on swimming performance: A brief review. *Journal of Human Sport and Exercise*, *7*(2), 553–559. https://doi.org/10.4100/jhse.2012.72.18

Pelayo, P., Sidney, M., Kherif, T., Chollet, D., & Tourny, C. (1996). Stroking Characteristics in Freestyle Swimming and Relationships with Anthropometric Characteristics. *Journal of Applied Biomechanics*, *12*(2), 197–206. https://doi.org/10.1123/jab.12.2.197

Pérez-Olea, J. I., Valenzuela, P. L., Aponte, C., & Izquierdo, M. (2018). Relationship Between Dryland Strength and Swimming Performance: Pull-Up Mechanics as a Predictor of Swimming Speed. *The Journal of Strength & Conditioning Research*, *32*(6), 1637–1642. https://doi.org/10.1519/JSC.0000000000002037

Sanyer, O. N. (2006). Down syndrome and sport participation. *Current Sports Medicine Reports*, *5*(6), 315–318. https://doi.org/10.1007/s11932-006-0059-3

Shree, A., & Shukla, P. C. (2016). Intellectual Disability: Definition, classification, causes and characteristics. *Learning Community-An International Journal of Educational and Social Development*, *7*(1), 9. https://doi.org/10.5958/2231-458X.2016.00002.6

Smits, B. L. M., Pepping, G.-J., & Hettinga, F. J. (2014). Pacing and Decision Making in Sport and Exercise: The Roles of Perception and Action in the Regulation of Exercise Intensity. *Sports Medicine*, *44*(6), 763–775. https://doi.org/10.1007/s40279-014-0163-0

Swain, P., Biggins, J., & Gordon, D. (2020). Marathon pacing ability: Training characteristics and previous experience. *European Journal of Sport Science*, *20*(7), 880–886. https://doi.org/10.1080/17461391.2019.1688396

Swimming History and presentation. (n.d.). FINA - Fédération Internationale De Natation. Retrieved 6 March 2021, from www.fina.org/swimming/history-and-presentation

Tassé, M., Luckasson, R., & Schalock, R. (2016). The Relation Between Intellectual Functioning and Adaptive Behavior in the Diagnosis of Intellectual Disability. *Intellectual and Developmental Disabilities*, *54*, 381–390. https://doi.org/10.1352/1934-9556-54.6.381

The American Association on Intellectual and Developmental Disabilities (AAIDD) Diagnostic Criteria for Intellectual Disability. (n.d.). Retrieved 30 April 2021, from https://www.mentalhelp.net/intellectual-disorders/aaidd-diagnostic-criteria-for-intellectual-disability/

The Importance of Pacing. (n.d.). Human Kinetics. Retrieved 7 March 2021, from https://us.humankinetics.com/blogs/excerpt/the-importance-of-pacing

Thomas, K., Stone, M. R., Thompson, K. G., Gibson, A. St. C., & Ansley, L. (2012). The effect of self- even- and variable-pacing strategies on the physiological and perceptual response to cycling. *European Journal of Applied Physiology*, *112*(8), 3069–3078. https://doi.org/10.1007/s00421-011-2281-9

Tor, E., Pease, D., & Ball, K. (2014). *Characteristics of an elite swimming start*. https://doi.org/10.13140/2.1.2350.2087

Toussaint, H. M., Janssen, T., & Kluft, M. (1991). Effect of propelling surface size on the mechanics and energetics of front crawl swimming. *Journal of Biomechanics*, *24*(3), 205–211. https://doi.org/10.1016/0021-9290(91)90178-P

Van Biesen, D., Hettinga, F. J., McCulloch, K., & Vanlandewijck, Y. (2016). Pacing Profiles in Competitive Track Races: Regulation of Exercise Intensity Is Related to Cognitive Ability. *Frontiers in Physiology*, *7*. https://doi.org/10.3389/fphys.2016.00624

Van Biesen, D., Hettinga, F. J., Mcculloch, K., & Vanlandewijck, Y. C. (2017). Pacing Ability in Elite Runners with Intellectual Impairment. *Medicine & Science in Sports & Exercise*, *49*(3), 588–594. https://doi.org/10.1249/MSS.0000000000001115

Vasile, L. (2014). Endurance Training in Performance Swimming. *Procedia - Social and Behavioral Sciences*, *117*, 232–237. https://doi.org/10.1016/j.sbspro.2014.02.206

Vliet, P. V. de, Rintala, P., Fröjd, K., Verellen, J., Houtte, S. V., Daly, D. J., & Vanlandewijck, Y. C. (2006). Physical fitness profile of elite athletes with intellectual disability. *Scandinavian Journal of Medicine & Science in Sports*, *16*(6), 417–425. https://doi.org/10.1111/j.1600-0838.2006.00539.x

Vollaard, N. B. J., Constantin-Teodosiu, D., Fredriksson, K., Rooyackers, O., Jansson, E., Greenhaff, P. L., Timmons, J. A., & Sundberg, C. J. (2009). Systematic analysis of adaptations in aerobic capacity and submaximal energy metabolism provides a unique insight into determinants of human aerobic performance. *Journal of Applied Physiology*, *106*(5), 1479–1486. https://doi.org/10.1152/japplphysiol.91453.2008

Waldron, M., & Highton, J. (2014). Fatigue and Pacing in High-Intensity Intermittent Team Sport: An Update. *Sports Medicine*, *44*(12), 1645–1658. https://doi.org/10.1007/s40279-014-0230-6