Year: 2013

Differences in swimming speed on short course and long course for female and male breaststroke swimmers: A comparison of swimmers at national and international level

Koch-Ziegenbein, P ; Knechtle, B ; Rüst, C A ; Rosemann, T

Abstract: Background: The aims were to examine (i) the difference in swimming speed in breaststroke swimmers between short (SC) and long course (LC) and (ii) the change in swimming speed across years for elite female and male swimmers competing at national and international level. Methods: Swimming speed of breaststroke swimmers at national level (i.e. athletes listed in Swiss swimming high score list between 2000 and 2011) and at international level (i.e. finalists of World Championships between 2001 and 2012) were analyzed for three course distances (i.e. 50m, 100m and 200m) using linear regression analyses and analysis of variance. Results: Swimming speed was faster in SC than in LC in 50m (1.8-2.6%), 100m (2.2-3.6%) and 200m (2.6-4.2 %), respectively. Swimming speed increased between 1.2% and 5.2% both for SC and LC across years, independently of the sex and the distance. For all distances, the sex difference was greater in LC than in SC. Mean values for the sex difference in swimming speed at national level were 12.1% in SC versus 11.9% in LC for 50 m, 11.9% in SC versus 11.3% in LC for 100m and 11.0% in SC versus 10.7% in LC for 200m, with significant difference only for 200m LC (p=0.03). Mean values for sex difference in swimming speed at international level were 13.3% in SC versus 12.7% in LC for 50m, 12.6% in SC versus 11.9% in LC for 100m and 12.1% in SC versus 11.2% in LC for 200m, only with significance for 100m SC (p=0.01). Conclusion: Elite breaststroke swimmers were 3% faster on SC compared to LC. The sex difference in breaststroke swimming speed from 50m to 200m events was 11% (with significance at national level on 200m LC and on international level on 100m SC) but appeared slightly greater in LC compared to SC.

Originally published at:
Koch-Ziegenbein, P; Knechtle, B; Rüst, C A; Rosemann, T (2013). Differences in swimming speed on short course and long course for female and male breaststroke swimmers: A comparison of swimmers at national and international level. OA Sports Medicine, 1(2):18.

OA Sports Medicine
Open Access

Koch-Ziegenbein P, Knechtle B, Rüst CA, Rosemann T, Lepers R. Differences in swimming speed on short course and long course for female and male breaststroke swimmers: A comparison of swimmers at national and international level. OA Sports Medicine 2013 Sep 01;1(2):18.

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

Section: Training, Performance & Rehabilitation

Differences in swimming speed on short course and long course for female and male breaststroke swimmers: A comparison of swimmers at national and international level

P Koch-Ziegenbein [1], B Knechtle [1,2], Ch Alexander Rüst [1], T Rosemann [1], R Lepers [3]

[1] Institute of General Practice and for Health Services Research, University of Zurich, Zurich, Switzerland
[2] Gesundheitszentrum St. Gallen, St. Gallen, Switzerland
[3] INSERM U1093, Faculty of Sport Sciences, University of Burgundy, Dijon, France

Emails:
Pia Koch-Ziegenbein | inops@web.de
Beat Knechtle | beat.knechtle@hispeed.ch
Christoph Alexander Rüst | christoph.ruest@bluewin.ch
Thomas Rosemann | thomas.rosemann@usz.ch
Romuald Lepers | romuald.lepers@u-bourgogne.fr

Research article

All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.

All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

Competing interests: none declared

Conflict of interests: none declared

Corresponding author
PD Dr. med. Beat Knechtle
Facharzt FMH für Allgemeinmedizin
Gesundheitszentrum St. Gallen
Vadianstrasse 26
9001 St. Gallen
Switzerland
Telefon +41 (0) 71 226 82 82
Telefax +41 (0) 71 226 82 72
e-mail: beat.knechtle@hispeed.ch

Abstract

Background: The aims were to examine (*i*) the difference in swimming speed in breaststroke swimmers between short (SC) and long course (LC) and (*ii*) the change in swimming speed across years for elite female and male swimmers competing at national and international level.

Methods: Swimming speed of breaststroke swimmers at national level (*i.e.* athletes listed in Swiss swimming high score list between 2000 and 2011) and at international level (*i.e.* finalists of World Championships between 2001 and 2012) were analyzed for three course distances (*i.e.* 50m, 100m and 200m) using linear regression analyses and analysis of variance.

Results: Swimming speed was faster in SC than in LC in 50m (1.8-2.6%), 100m (2.2-3.6%) and 200m (2.6-4.2 %), respectively. Swimming speed increased between 1.2% and 5.2% both for SC and LC across years, independently of the sex and the distance. For all distances, the sex difference was greater in LC than in SC. Mean values for the sex difference in swimming speed at national level were 12.1% in SC *versus* 11.9% in LC for 50 m, 11.9% in SC *versus* 11.3% in LC for 100m and 11.0% in SC *versus* 10.7% in LC for 200m, with significant difference only for 200m LC (p=0.03). Mean values for sex difference in swimming speed at international level were 13.3% in SC *versus* 12.7% in LC for 50m, 12.6% in SC *versus* 11.9% in LC for 100m and 12.1% in SC *versus* 11.2% in LC for 200m, only with significance for 100m SC (p=0.01).

Conclusion: Elite breaststroke swimmers were ~3% faster on SC compared to LC. The sex difference in breaststroke swimming speed from 50m to 200m events was ~11% (with significance at national level on 200m LC and on international level on 100m SC) but appeared slightly greater in LC compared to SC.

Keywords: sex difference, performance, endurance

Introduction

Indoor swimming competitions are usually held in short course (25m) and long course (50m) pools.[1] Blanksby reported that swimming world records were faster in 25m pools due to the higher number of turns and push offs. [2] The higher number of turns and push offs leads to a redistribution of muscular load, reduced blood lactates and physiological recuperation can occur during the turn.[2] With increasing race distance, swimmers perform more turns on long course than on short course.[2]

Breast stroke is a swim style with a discontinuous technic like butterfly.[3-5] The variation in velocity in breast stroke and butterfly were twice as large as in freestyle swimming.[4] Butterfly presented higher velocity than breast stroke and back stroke. The stroke frequency is also higher than in breast stroke and the stroke length is higher than in crawl.[3] High intracyclic variation in the average impulse can be found in butterfly and breast stroke which results from the large acceleration and deceleration phases within the stroke cycle. Energetic cost is greater in butterfly, followed by breast stroke, back stroke and freestyle.[3]

Breast stroke turns can account to one third of race time in 25m pools in all 200m events and longer.[2] Thereby the oxygen costs through the acceleration are considerably.[4] In breast stroke swimming, velocity increases by increasing stroke frequency and decreasing distance per stroke.[4] Summarizing biomechanical factors such as stroking parameters characterize swimming speed improvements best followed by physical factors like body height and arm-span and physiological factors like peak oxygen consumption.[6-8]

To the best of our knowledge, there were no other studies focusing on (*i*) the change in swimming speed across years and (*ii*) the difference in swimming speed between long course and short course only for a single discipline like breaststroke. Therefore, the aims of this study were to examine (*i*) the difference in swimming speed between short and long course for breaststroke and (*ii*) the change in swimming speed in breast stroke swimming across years.

To achieve these aims, we compared the swimming speeds of elite breaststroke swimmers at national level from the Swiss swimming high score list between 2000 and 2011 and at international level from the finals of the FINA World Championships between 2001 and 2012. The advantage of the Swiss data was that they were recorded annually. Data from the world championships were, however, only every two years available.

Materials and Methods

All procedures used in the study met the ethical standards of the Swiss Academy of Medical Sciences[9] and were approved by the Institutional Review Board of Kanton St. Gallen, Switzerland with a waiver of the requirement for informed consent of the participants given the fact that the study involved the analysis of publicly available data.

Data sampling and data analysis

The data set from this study was obtained for national swimmers from the Swiss Swimming Federation[10] and for international swimmers from the European Swimming Federation[11]. Breaststroke swimmers at national level (*i.e.* athletes ranked in the Swiss swimming high score list between 2000 and 2011) and breaststroke swimmers at international level (*i.e.* finalists from the FINA World Championships between 2001 and 2012) were included. We compared the change in breaststroke swimming speed across years and the difference in breaststroke swimming speed between long course and short course.

The annual top ten (*i.e.* ten fastest swimming times) men and women for the three race distances (*i.e.* 50m, 100m, 200m) were determined for long course and short course and analysed regarding the change in swimming speed and sex difference over time. The annual top ten athletes per sex, distance and course length were pooled (*i.e.* 12 years x 10 athletes = n=120 per distance and course length) and analysed regarding the interaction between sex and course length on swimming speed. In order to increase the comparability of the results with similar studies, all race times were converted to swimming speed prior to analysis. Swimming speed was calculated using the equation [swimming speed in m/s] = [race distance in m] / [race time in s]. The sex difference in performance was calculated using the equation ([swimming speed in women] – [swimming speed in men]) / [swimming speed in men] × 100, where sex difference was calculated for every pairing of equally placed athletes (*e.g.* between men and women 1st place, between men and women 2nd place, etc.) before calculating mean value and standard deviation of all the pairings. In order to facilitate reading all sex differences were transformed to absolute values prior to analyses. To compare top swimming speed between long course and short course swimmers, the overall top ten (*i.e.* ten fastest swimming speed) female and male swimmers from the Swiss swimming high score list between 2000 and 2011 and the eight finalists from the FINA World were determined for long course and for short course swimming and compared regarding swimming speed and sex difference.

Statistical analysis

In order to increase the reliability of the data analyses, each set of data was tested for normal distribution as well as for homogeneity of variances prior to statistical analyses. Normal distribution was tested using a D'Agostino and Pearson omnibus normality test and homogeneity of variances was tested using a Levene's test in case of two groups and with a Bartlett's test in case of more than two groups. Linear regression was used to find significant changes in a variable across years. A Student's *t*-test with Welch's correction in case of unequal variances was used to find significant differences between two groups. A one-way analysis of variance (ANOVA) with subsequent Dunnett post-hoc analysis was performed to find significant differences between more than two groups (*i.e.* the fastest age group and the other age groups). A two-way-ANOVA (sex × course length) was performed to determine the interaction between sex and course length on swimming speed. Statistical analyses were performed using IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA) and GraphPad Prism (Version 5, GraphPad Software, La Jolla, CA, USA). Significance was accepted at $P<0.05$ (two-sided for *t*-tests). Data in the text are given as mean ± standard deviation (SD).

Results

Data from the Swiss swimming high score list were available from 26,556 athletes, including 13,277 women and 13,279 men on short course and from 25,111 athletes, including 12,627 women and 12,484 men on long course. Data from 125 finalists from the FINA World Championships were available, including 56 women and 69 men on short course and from 112 athletes, including 54 women and 58 men on long course.

Comparison of swimming speed in breaststroke between short and long courses

Swimming speed was faster on short than on long course for 50m, 100m and 200m for both courses. Differences in swimming speed between 25m and 50m pools for the elite Swiss swimmers were 2.7%±0.9 [range 1.8-3.6%] (Table 1). The mean differences in swimming between 25m and 50m pools at the FINA World Championships were 3%±1.15 [range 1.9-4.2%] (Table 2).

Change in breaststroke swimming speed across the years

Breaststroke swimming speed increased for both short and long courses over the years independent of sex and race distance for both courses. Male Swiss swimmers improved swimming speed significantly by 1.2% (p=0.04) on 50m short course and 2.63% (p=0.03) in 100m short course. Female Swiss swimmers improved swimming speed significantly by 2.78% (p=0.004) on 50m long course, by 3.03% (p=0.01) on 100m long course and by 4.09% (p=0.04) on 200m long course. Male Swiss swimmers showed a significant improvement of 2.44% (p=0.0003) in 50m long course, 3.36% (p=0.01) in 100m long course and 5.15% (p=0.003) in 200m long course, respectively (Figure 1 and Table 3).

The mean improvement of the two distances for men on short course was 1.9±0.7% and of the three distances for long course 3.6±1.1%. The mean improvement of the three distances for women on long course was 3.3±0.6%.

Figure 3 and Table 4 show the same trend for the FINA World Championships. Female swimmers at international level improved swimming speed significantly by 2.4% (p=0.0183) on 50m short course, by 3.4% (p=0.0023) on 100m short course and by 2.8% (p=0.0138) on 200m short course, respectively. Male swimmers showed a significant improvement by 2.7% (p=0.0168) on 50m short course, by 2.9% (p=0.0023) on 100m short course and by 3.8% (p=0.01) on 200m short course, respectively. Women achieved a significant improvement of 2.5% (p=0.02) on 50m long course and 2.7% (p=0.03) on 100m long course.

The mean improvement in three distances for men on short course was 3.19±0.5%. The mean improvement of the three distances for women on short course was 2.9±0.5%. Women showed a mean improvement of 2.6±0.1% on long course during the studied period.

Sex difference in breaststroke swimming speed

For all distances, the sex difference in breaststroke swimming speed was greater on short than on long course (Table 1 and 2). The sex difference in swimming speed at national level was on average 11.3±1.6% [range 9.7-12.9%] (Table 1 and Figure 2). Among the finalists from the World Championship the sex difference was higher on short course than on long course, too. The sex difference in swimming speed was on average 12.3±1.1% [range 11.2-13.3%] in all three distances.

Figure 2 shows that the longer the swim distance the lower the sex difference in swimming speed. Women at national level were 14% slower than men on short course and 13% slower on long course, with a significant difference in 200m long course (p=0.03). In finalists from the World Championship, the sex differences were higher, but not significant, on 50m short than on 50m long course to (Figure 4). Women were 11.8% slower than men on short and 11.1% slower on long course, with no difference for 50m short course (*i.e.* with significant difference in 100m 10.7% *versus* 10.3% p=0.01; 200 m 11% *versus* 9.7%, no significance).

Discussion

The aims of this study were to examine (*i*) the difference in breaststroke swimming speed between short and long course and (*ii*) the change in swimming speed across the years in elite swimmers at both national and international level. The main findings of this study were (*i*) breaststroke swimming speed was 1.8-4.2% faster on short than on long course, (*ii*) swimming speed improved for both short and long course during the last decade independently of sex and race distance, (*iii*) the sex difference in swimming speed was greater on short than long course for all distances, and (*iv*) the longer the distance the more the sex difference in swimming speed decreased.

Breaststroke swimming speed was faster on short than on long course

Swimming speed was faster on short than on long course for 50m, 100m and 200m. Due to the higher number of turns and push offs swimming speed is faster on short than on long course.[2] Breaststroke turns can account to one third of race time in 25m pools.[2] The anaerobic metabolism predominates on short events.[5, 12] This means an improvement in short events can be achieved by enhancement of anaerobic training.[5] The connection between local fatigue due to increasing lactate values and increasing energy costs may explain the decrease in swimming skills.[13] Stroke length decreases dramatically at a given lactate value and stroke rate increases in anaerobic sections.[3, 14] Therefore, the longer the race the lower the velocity[15] which can be shown in our results.

Improvement in breaststroke swimming speed across the years

The second important finding was that swimming speed increased in both women and men on both courses over the years for swimmers at both national and international level. However, the improvements in swimming speed in athletes at international level were lower compared to swimmers at national level. Competitors at international level are closer on the maximum physiologically possible human frontiers[16] so they cannot improve as much as national swimmers.

In addition to changes in anthropometric characteristics[17, 18], improvements in training[17, 19], and psychological aspects[17] a new generation of swimsuits affected swimming speed.[20] Wearing this new full-body swim suits reduced passive drag.[19] This was associated with a decreased energy coast and an increased distance per stroke.[20] Although FINA prohibited wearing full-body wetsuits, swimming speed did not fall.[19] The reason could be the use of new angled starting blocks, where the kick start was significantly faster than on the older starting blocks.[21, 22]

Sex difference in breaststroke swimming speed in short versus long course

The third important finding was that the sex differences in swimming speed were greater in short than in long course. Women achieved approximately 90% of the swimming speed of men in short course which is in line with international data. Sharp et al.[23] described that world records were faster in 25m pools than in 50m pools due to more turns and push offs and reduced blood lactate values.[24] Additionally, the turns lead to a redistribution of the muscular load and physiological recuperation can occur.

Swimmers seemed to have improved their technic of turns over the years as well as their anaerobic performance (*i.e.* sprint).[2, 12] The decrease in velocity on long course could be related to the fact that endurance performance suffered due to the improved anaerobic performance due to larger muscle mass. This means the longer the course the higher the muscle fatigue which might impair the swimming technic because of less streamlining resulting in increasing drag. Thereby an increase in energy coast and velocity cannot be sustained.[13, 14]

The fourth important finding was the longer the competition distance the lower were the differences in swimming speed between men and women. Lower energy costs are reported for women due to anthropometric values for long distances in swimming.[25] Women have a lower hydrodynamic resistance and are more streamlined than men.[25] Zuniga et al.[18] suggested that women could improve their performances by reducing body fat, because a greater percentage of body fat may adversely affect swimming speed. Additionally, they have to build up fat-free weight to generating power.

The aerobic capacity is the main base for endurance performance.[26] High endurance allows maintaining a high average velocity. Lower lactate levels were reported for women after competitions, which means a slower fatigue.[13] Women competing at national level may have to have a higher percentage of slow twitch fibers and thereby improve endurance performance on the long course.[12] Or they take more advantage of turns with longer wall push-off times resulting in faster final push-off velocities.[2] The maximum power depends on metabolic energy, which depends on the anthropometric and technical character of the athlete.[6] In well trained swimmers, the size scaled cost of swimming is not depending upon age and sex.[27] Additionally, psychological aspects may play a role[17] and the greater expectation to win.[28]

Conclusion

Elite breaststroke swimmers at both national and international level were ~3% faster in 25m pools compared to 50m pools for distances between 50 and 200m, breaststroke swimming speed increased on short and long course over the years between 1.2% and 5.2% in elite swimmers competing at both national and international level independently of the sex and the distance. The sex difference in breaststroke swimming speed from 50m to 200m was close to 11% but appeared slightly greater in 50m pools compared to 25m pools. Future studies should investigate sex differences in short and long course for other swim strokes.

References

1. Fédération Internationale de Natation (FINA) [homepage on the Internet, facilities rules last updated on Friday, 8 Jan 2010, cited 1 Sept 2013]. Available from: http://www.fina.org

2. Blanksby BA. Gaining on turns. XVII International Symposium on Biomechanics in Sports, Perth, WA, No volume, pp. 11-20.

3. Barbosa TM, Keskinen KL, Fernandes R, Colaço P, Carmo C, Vilas-Boas JP, Relationships between energetic, stroke determinants, and velocity in butterfly, Int J Sports Med. 2005 Dec;26(10):841-6

4. Craig AB Jr, Pendergast DR, Relationships of stroke rate, distance per stroke, and velocity in competitive swimming, Med Sci Sports. 1979 Fall;11(3):278-83

5. Neiva HP, Fernandes RJ, Vilas-Boas JP, Anaerobic critical velocity in four swimming techniques, Int J Sports Med. 2011 Mar;32(3):195-8.

6. Jürimäe J, Haljaste K, Cicchella A, Lätt E, Purge P, Leppik A, Jürimäe T. Analysis of swimming performance from physical, physiological, and biomechanical parameters in young swimmers. Pediatr Exerc Sci. 2007 Feb;19(1):70-81.

7. Lätt E, Jürimäe J, Haljaste K, Cicchella A, Purge P, Jürimäe T. Physical development and swimming performance during biological maturation in young female swimmers. Coll Antropol. 2009 Mar;33(1):117-22.

8. Lätt E, Jürimäe J, Haljaste K, Cicchella A, Purge P, Jürimäe T. Longitudinal development of physical and performance parameters during biological maturation of young male swimmers. Percept Mot Skills. 2009 Feb;108(1):297-307.

9. Swiss Academy of Medical Sciences [homepage on the Internet, Currently valid guidelines]. Available from: http://www.samw.ch, accessed 1 Sept 2013

10. Schweizerischer Schwimmverband [homepage on the Internet, Bestenlisten]. Available from: http://www.fsn.ch, accessed 24 July 2013

11. Swimrankings [homepage on the Internet]. GeoLogix AS, Berne, Switzerland [Bestenlisten]. Available from: http://www.swimrankings.net, accessed 24 February 2013

12. Maglischo EW. Part I: Training Fast Twitch Muscle Fibers: Why and How. J. Swimming Research, Vol. 18 (2011). Available from: http://www.swimmingcoach.org, accessed 29 September 2013

13. Greco CC, Pelarigo JG, Figueira TR, Denadai BS. Effects of gender on stroke rates, critical speed and velocity of a 30-min swim in young swimmers. J Sport Sci Med 2007; 6:441-7

14. Psycharakis SG, Cooke CB, Paradisis GP, O'Hara J, Phillips G. Analysis of selected kinematic and physiological performance determinants during incremental testing in elite swimmers. J Strength Cond Res. 2008 May;22(3):951-7.

15. Dekerle J. The use of critical velocity in swimming: A place for critical stroke rate? Portuguese Journal of Sport Sciences, 2006, Biomechanics and Medicine in Swimming X., 6 (2). pp. 201-205. ISSN 16450523

16. Berthelot G, Thibault V, Tafflet M, Escolano S, El Helou N, Jouven X, Hermine O, Toussaint JF. The citius end: world records progression announces the completion of a brief ultra-physiological quest. PLoS One. 2008 Feb 6;3(2):e1552.

17. Ackland TR. Talent Identification: What makes a champion swimmer? XVII International Symposium on Biomechanics in Sports, Perth, WA, Stand alone, pp. 67-74.

18. Zuniga J, Housh TJ, Mielke M, Hendrix CR, Camic CL, Johnson GO, Housh DJ, Schmidt RJ. Gender comparisons of anthropometric characteristics of young sprint swimmers. J Strength Cond Res. 2011 Jan;25(1):103-8.

19. O'Connor LM, Vozenilek JA. Is it the athlete or the equipment? An analysis of the top swim performances from 1990 to 2010. J Strength Cond Res. 2011 Dec;25(12):3239-41.

20. Chatard JC, Wilson B. Effect of fastskin suits on performance, drag and energy cost of swimming. Med Sci Sports Exerc., 2008 Jun; 40(6): 1149-54

21. Biel, K., Fischer, S. Kibele, A. (2010) Kinematic analysis of take-off performance in elite swimmers: new OSB11 versus traditional starting block. In Kjendlie PL, Stallman RK, Cabri J, editors. Biomechanics and medicine in swimming XI: Proceedings of the11th World Symposium on Biomechanics and Medicine in Swimming; 2010 Jun 16-19; Norway. p. 75.

22. Honda K, Sinclair P, Mason B, Pease D. A biomechanical comparison of elite swimmers start performance using the traditional track start and the new kick start. In: Kjendlie P, Stallman R, Cabri J, editors. Proceedings of the 11th International Symposium for Biomechanics and Medicine in Swimming; June 16–19, 2010; Oslo, Norway.

23. Sharp RL, Costill DL. Influence of body hair removal on physiological responses during breaststroke swimming. Med Sci Sports Exerc. 1989 Oct;21(5):576-80.

24. Telford RD, Hahn AG, Catchpole EA, Parker AR, Sweetnham WF. Postcompetition blood lactate concentration in highly ranked Australian swimmers. In: Swimming Science V (1988), pp. 227-283

25. Zamparo P. Effects of age and gender on the propelling efficiency of the arm stroke. Eur J Appl Physiol. 2006 May;97(1):52-8.

26. Vorontsov AW. Development of basic & special endurance in age-group swimmers. Internett (1997), pp. 1-26, Key: citeulike:6825682

27. Ratel S, Poujade B. Comparative analysis of the energy cost during front crawl swimming in children and adults. Eur J Appl Physiol. 2009 Mar;105(4):543-9.

28. Medic N, Young BW, Starkes JL, Weir PL, Grove JR. Gender, age, and sport differences in relative age effects among US Masters swimming and track and field athletes. J Sports Sci. 2009 Dec;27(14):1535-44.

Distance and sex	Short course (m/s)	Long course (m/s)	Absolute Difference (m/s)	Difference in percent (%)
50m women	1.49± 0.03	1.46±0.02	0.03	1.8
50m men	1.69±0.03	1.66±0.02	0.03	2.0
100m women	1.38±0.02	1.34±0.02	0.04	2.9
100m men	1.56±0.03	1.51±0.02	0.06	3.6
200m women	1.28±0.02	1.24±0.02	0.04	2.8
200m men	1.43±0.03	1.39±0.02	0.05	3.2

Table 1 Mean swim speed of the annual top ten women and men Swiss athletes in breaststroke swimming in 50m, 100m and 200m in short course and long course

Distance and sex	**Short course (m/s)**	**Long course (m/s)**	**Absolute Difference (m/s)**	**Difference in percent (%)**
50m women	1.68±0.01	1.65±0.01	0.03	1.9
50m men	1.90±0.01	1.85±0.01	0.05	2.6
100m women	1.55±0.01	1.52±0.01	0.03	2.2
100m men	1.74±0.01	1.70±0.01	0.05	2.7
200m women	1.45±0.02	1.41±0.00	0.04	2.6
200m men	1.62±0.01	1.56±0.01	0.07	4.2

Table 2 Mean swimming speed of the top eight women and men in World Championship in breaststroke swimming in 50m, 100m and 200m in short course and long course

Distance and sex	**Short course increase absolut (m/s)**	**Long course increase absolut (m/s)**	**Short course increase relative %**	**Long course increase relative %**	**Significance p**	
					Short course	**Long course**
50m women		0.04		2.78+0.57		0.0048
50m men	0.02	0.04	1.20-0.7	2.44+1.13	0.0495	0.0003
100m women		0.04		3.03±0.57		0.0113
100m men	0.04	0.05	2.63+0.7	3.36±1.13	0.0311	0.0132
200m women		0.05		4.09-0.57		0.0417
200m men		0.07		5.15-1.13		0.0038

Table 3 Change in swimming speed of the annual top ten women and men at national level in breaststroke swimming in 50m, 100m and 200m in short course and long course. The missing data were not included because they were not significant

Distance and sex	**Short course increase absolut (m/s)**	**Long course increase absolut (m/s)**	**Short course increase relative %**	**Long course increase relative %**	**Significance p**	
					Short course	**Long course**
50m women	0.04	0.04	2.45+0.46	2.53+0.1	0.0183	0.0247
50m men	0.05		2.73+0.48		0.0168	
100m women	0.05	0.04	3.36±0.46	2.74-0.1	0.0023	0.0269
100m men	0.05		2.98±0.48		0.0023	
200m women	0.04		2.88-0.46		0.0138	
200m men	0.06		3.85-0.48		0.0145	

Table 4 Change in swimming speed of the top eight women and men athletes between 2001-2012 (World Championship, took place alternately on short course and long course) in breaststroke swimming in 50m, 100m and 200m in short course and long course. The missing data were not included because they were not significant

Figure Captions

Figure 1 Swimming speed of the annual top ten women (Panels A, C, E) and top ten men (Panels B, D, F) competing at national level in breaststroke swimming in 50m (Panels A, B), 100m (Panels C, D) and 200m (Panels E, F) in short course and long course.

Figure 2 Swimming speed and sex difference of the overall top ten female and male breaststroke swimmers in 50m (Panel A), 100m (Panel B), and 200m (Panel C) competing at national level between 2000 and 2011. The p-value is given in case of a significant difference between short course and long course swimming. 'NS' means no significance and indicates absence of significant difference.

Figure 3 Swimming speed of the annual top eight women (Panels A, C, E) and men (Panels B, D, F) competing at international level between 2001 and 2012 in breaststroke swimming in 50m (Panels A, B), 100m (Panels C, D) and 200m (Panels E, F) in short course and long course.

Figure 4 Swimming speed and sex difference of the overall top ten men and women breaststroke swimmers in 50m (Panel A), 100m (Panel B), and 200m (Panel C) competing at international level between 2001 and 2012. The p-value is given in case of a significant difference between short course and long course swimming. 'NS' means no significance and indicates absence of significant difference.

Figure 1

Figure 2

Figure 3

Figure 4