

Swimming turn performance: the distinguishing factor in 1500m World championship freestyle races?

Marek Polach (✉ marek.polach01@upol.cz)

Palacký University, Olomouc <https://orcid.org/0000-0002-9531-5130>

Dan Thiel

Charles University Faculty of Physical Education and Sport: Univerzita Karlova Fakulta telesne vychovy a sportu

Jan Kreník

Czech Swimming Federation

Dennis-Peter Born

Swiss Federal Institute of Sport Magglingen: Eidgenossische Hochschule fur Sport Magglingen

Research note

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Abstract

Objective

Turn sections represent the second largest part of total race time in 1500 m freestyle races and may substantially affect race results. Therefore, the aim of the study was to investigate individual race strategies and compare the effect of start, swim, and turn performances between short-course and long-course races. Video footages were collected from all male finalists at the 2018 short- (n = 8, age 22.8 ± 2.4 years, FINA points 953 ± 27) and 2019 long-course World swimming championships (n = 8, age 23.3 ± 2.2 years, FINA points 951 ± 23) for subsequently analysis of start, turn, and swim performance.

Results

The larger number of turns in short-course races resulted in significantly faster race times ($p < 0.001$), but slower mean turn times compared to long-course races ($p < 0.001$). Total race time closely correlated with swim and turn but not start section time in short- ($r \geq 0.76$, $p \leq 0.030$) and long-course races ($r \geq 0.96$, $p < 0.001$). Analysis of individual race strategies showed that turn performance affected race results in 9 of the 16 world-best 1500 m swimmers and improved medal standing of 1st, 3rd, and 4th ranked short- as well as 1st and 2nd ranked long-course finalist. Coaches, athletes, and performance analysts may carefully consider the importance of turn performance additionally to free-swimming skills.

Introduction

Performance analysis has become routine procedure in high-performance sports, in order to evaluate the training process, discover potentials, and investigate key performance indicators [1, 2]. As pool swimming is affected by little environmental factors, swimming performance can be assessed based on real race scenarios with no equipment interfering with the swimmer's movement pattern [3, 4]. Performance analysts commonly divide swim races into several sections. The start section involves the first meters of the race and includes the jump from the starting block, flight phase, underwater phase, and transition to full-stroke swimming [5, 6]. Contribution of start performance in 50 m events was 26.1% [7] but continuously decreased for 100 m and 200 m races [8, 9] and may be of minor importance for 1500 m freestyle [8, 10]. Here, turns that are used for directional change and to reaccelerate the swimmer by pushing of the pool wall at the beginning of each lap may substantially affect the race result [11]. The turn sections are commonly analyzed from 5 m before wall contact until resurfacing after the underwater phase, which varies in its length depending on the race distance [12, 13]. Distance between the start and turns determine swim section [3, 8, 14].

While parameters related to free-swimming have been extensively investigated [1, 15–17], turns represent $19.69 \pm 0.24\%$ [8] and $36.87 \pm 0.61\%$ [18] of total race time in 100 m and 1500 m long-course freestyle races, respectively. Significant performance variations were attributed to turn parameters, i.e. 5 m in (time before wall contact), breakout time, breakout distance, 15 m out (time after wall contact) [8, 10, 18].

However, in these particular studies, turn sections were based on FINA rules that allow an underwater phase up to the 15 m mark [19]. As mean breakout distance was 5.48 ± 0.87 m in these 1500 m races [18], free-swimming skills may have large affected turn performance. Therefore, previous studies suggested to isolate the turn and swim sections [12, 13] with particular attention to the last 5 m before and initial 5 m after wall contact [20, 21].

In long-course races (50 m pool length), the effect of turn performance on race results increased with race distance, hence number of turns involved [8–10, 18]. As the number of turns is twice as high in 1500 m short-course races (25 m pool length), turn performance may show an even larger effect on race results. While analysis of world-class athletes provides unique insights into human's highest possible performance, such analyses are naturally limited by a small number of subjects [22, 23]. Hence, performance at World championship level should be investigated based on individualized responses and case reports in addition to the assessment of mean values [24–26]. Therefore, the aim of the study was to investigate individual race strategies of World championship finalists and compare the effect of start, swim, and turn performances on results of 1500 m freestyle events between short-course and long-course races.

Materials And Methods

Participants

Video footages were collected from all 8 male finalists of the 1500 m freestyle events at the Hangzhou 2018 (age 22.8 ± 2.4 years, FINA points 953 ± 27) short-course (25 m pool length) and Gwangju 2019 (age 23.3 ± 2.2 years, FINA points 951 ± 23) long-course (50 m pool length) World championships for subsequent analyses of start, turn, and swim sections. All participants of the FINA World swimming championships provided written informed consent to the organizer that all video material collected during competition can be used for television broadcasting and race analyses by the participating nations. All data were anonymized before the analyses. The Institutional review board of the Palacký University of Olomouc approved the procedure and that the present study is in accordance with the Declaration of Helsinki (Registration-Number: 77/2020).

Data collection

For the short-course World championships, a camera (Canon XA35, Canon Inc., Tokyo, Japan) was positioned on top of the stands 30 m above water level and about 100 m from the side of the pool. The camera was placed perpendicular to the direction of swimming and exactly in the middle of the pool (12.5 m apart from both pool ends). The camera zoom was set before the races to assure clear vision across the entire pool. To ensure same conditions for the long-course World championships (50 m pool length), two cameras of the same type used before, were positioned 12.5 m apart from both ends of the pool. Cameras were synchronized via wireless LAN connection and recorded half to the pool each. Videos footages were recorded as mp4 format with 50 frames-per-seconds and an image quality of 1920×1080 full HD.

Data analysis

Split times for start, swim, and turn sections were analysed using Dartfish (Team pro Data 9, Dartfish, Fribourg, Switzerland). The light flash of the timing system that was synchronized to the starting signal was used to synchronize video footages for the race analysis. As described previously [27], reference markers at on the lane ropes at 5 m, 20 m, and 45 m, were used for the distance measures. Before the race, accuracy of the markers was checked using a measuring tape. Race results were obtained from the official electronic timing system (Omega Timing, Biel/Bienne, Switzerland).

Based on the mean breakout distances of 10.69 ± 1.18 m and 10.11 ± 1.25 m for short- and long-course races, respectively, start section was determined by the time from the starting signal until top of the swimmer's head passed the 10 m mark. Based on previously reported breakout distances between 4.64 ± 0.23 m and 5.48 ± 0.87 m in 1500 m freestyle races [18, 28], turn sections were analysed from 5 m before until 5 m after wall contact. Swimmer's head passing the 5 m marks were used as reference points. Race sections beyond start and turn section determined the swim section.

Statistical analysis

The data are presented in mean \pm standard deviation (SD). After verification of normality with Shapiro-Wilks test, Pearson's correlation coefficient was used to assess relationship between split times and ranking in all race sections. Differences of mean turn times at the short-course and long-course World championships were determined using a *T*-test for independent samples with $p < 0.05$ indicating statistical significance. To investigate accuracy of the race analyses, fifty percent of all races were analysed by another experienced race analysts. Inter-rater reliability was assessed using Intraclass-correlation coefficient (ICC) between the repeated measures and showed an ICC of 0.988–0.989 and 0.991–0.992 for short-course and long-course World championships, respectively. Statistical analysis was performed using the STATISTICA software version 13.4.0.14. (StatSoft Inc., Tulsa, USA).

Results

The times for start, swim, and turn sections are presented in Table 1 (mean \pm standard deviation) for short-course and long-course 1500m races. Short-course races showed a significantly faster total race time ($p < 0.001$) compared to long-course races. Additionally, in short-course races, swimmers spent significantly less time in the swim (64.52% vs. 83.04%, $p < 0.001$) and more time in the turn sections (35.04% vs. 16.53%, $p < 0.001$) compared to long-course races, respectively. However, mean turn time was significantly ($p < 0.001$) faster for long-course compared to short-course races (5.07 ± 0.18 vs. 5.14 ± 0.10 s).

Correlation analysis revealed close correlations between the final ranking with swim and turn section ranking in both, short- ($r \geq 0.74$, $p \leq 0.037$) and long-course races ($r = 0.93$, $p < 0.001$). Additionally, total race time correlated with swim and turn section time in short- ($r \geq 0.76$, $p \leq 0.030$) and long-course races ($r \geq 0.96$, $p < 0.001$). Start performance was not related to final ranking or total race time.

Figure 1 illustrates the individual response of the swimmer's swim and turn performance on final ranking. Turn performance affected final ranking in 9 out of 16 World championship finalists. In particular, for the highest ranked swimmers, turn performance improved medal standing, i.e. 1st, 3rd, and 4th ranked short-course finalist as well as 1st and 2nd ranked long-course finalist. For instance, in short-course races, the swimmer ranked 2nd (545.35s) swam 4.71s faster than the winner of the race (550.06s) but lost 5.18 s in the turn sections. Moreover, swimmer ranked 3rd only showed the 6th fastest swimming time. However, this swimmer gained up to 14.9s due to the turns and outperformed the 4th, 5th, and 6th ranked swimmers with second fastest total turn time. In long-course races, swimmer ranked 3rd swam 1.69s and 1.86s faster than the 1st and 2nd ranked swimmer. However, final ranking was determined by faster turn times for 1st (3.56s) and 2nd (2.72s) compared to 3rd ranked swimmers.

Discussion

The aim of the study was to investigate individual race strategies of World championship finalists and compare the effect of start, swim, and turn performances on results of 1500m freestyle events between short-course and long-course races. The larger number of turns in short-course races resulted in faster race times, but slower mean turn times compared to long-course races. The race result closely correlated with swim and turn section time in both, short- and long-course races. Analysis of individual race strategies showed that turn performance affected final ranking in 9 out of 16 World championship finalists and improved ranking for the 1st, 3rd, and 4th short-and 1st and 2nd long-course finalist.

The present study showed importance of turn performance in 1500m freestyle short- and long-course races. The push-off from the pool wall and subsequent underwater phase with application of undulating kicking technique accelerates swimmer above free-swimming speed [29]. Swimmers aim to maximize length of the underwater phase, as drag forces are lower under water than at its surface [30]. However, excess breath holding increases anaerobic demand and may interfere with swimmers free-swimming abilities [31]. Therefore, with increasing race distance, swimmers successively reduce length of underwater phase down to 4.64 ± 0.23 m in the 1500m freestyle [28] While long-distance swimmers apply rather slow and energy saving leg kicking [32], push-off from the pool wall and undulating kicking during the underwater phase place a high demand on the leg muscles [11]. Future research needs to investigate whether length of the underwater phase and conditioning of leg muscles may provide potential for future performance developments in long-distance swimmers.

In the present study, race times were significantly faster in short- compared to long-course races probably due to twice the number of turns involved, hence repeated velocity gains from wall push-off [29,33]. However, mean turn performance was slower in short-course races. The high demand for leg muscles [11,32] and repeated breath holding during the underwater phase [31] may have resulted in more careful pacing and energy conserving turns. The question arises whether the in average 0.07s faster turn times seen in long-course races could be applied in 25m pool competition, hence short-course races. With 30 additional turns this would add up to a performance gain of 2.03s and beat the current world record [34]

by 0.95 and 0.22s for the 1st and 2nd ranked swimmer of the recent 2018 World short-course swimming championships. Although, multiple variables interact in a 1500m freestyle race, these findings show the potential for future swimming performance and that human in-water locomotion may have not yet found its limit [35].

Conclusion

The present study showed that turn performance could be the distinguishing factor in World-championship 1500 m freestyle races. Analysis of individual race strategies revealed that turn performance affected final ranking in 9 of the 16 world-best short- and long-course swimmers. Coaches, athletes, and performance analysts should carefully consider the importance of turn performance in addition to free-swimming skills.

Limitations

The present study is the first analysing individual race strategies based on start, swim, and turn section times in 1500 m freestyle finalists at short- and long-course World championships. Due to low number of subjects available when analysing world-class performance, results cannot be translated to a general population of competitive swimmers. Further studies need to verify these findings based on data collections across finalists of multiple World championships. Additionally, individualized distances measurements of underwater phase and breakout distances after the turn would allow further insights and a detailed analysis of turn strategies [12].

Declarations

Ethics approval and consent to participate

All participants of the FINA World swimming championships provided written informed consent to the organizer that all video material collected during competition can be used for television broadcasting and race analyses by the participating nations. All data were anonymized before the analyses. The Institutional review board of the Palacký University of Olomouc approved the procedure and that the present study is in accordance with the Declaration of Helsinki (Registration-Number: 77/2020).

Consent for publication

Not applicable.

Availability of data and material

All data can be requested at the corresponding author at any time.

Competing interests

There are no competing interests

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Author's contributions

Development of study design (MP, DT, JK, DPB); data collection at Hangzhou short-course championships (DT and JK), data collection at Gwangju long-course championships (MP and DPB); data analysis (MP, DT, JK, DPB); data interpretation (MP, DT, JK, DPB); preparation of the manuscript (MP, DT, JK, DPB). All authors read and approved the final version of the manuscript.

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Tables

| Table 1 – Descriptive data with mean ± standard deviation (SD) for section time analysis. | | | | | | |
|--|---|--------------------|--------------------|---|--------------------|--------------------|
| | Short-course World championships <i>25m pool length – Hangzhou 2018</i> | | | Long-course World championships <i>50m pool length – Gwangju 2019</i> | | |
| | Mean ± SD | 95% CI | | Mean ± SD | 95% CI | |
| | | lower bound | upper bound | | lower bound | upper bound |
| Total race time [s] | 865.09 ± 12.90 * | 856.16 | 874.02 | 889.57 ± 13.98 * | 879.88 | 899.26 |
| Total start section time [s] | 3.77 ± 0.16 | 3.66 | 3.88 | 3.77 ± 0.17 | 3.65 | 3.89 |
| Total swim section time [s] | 558.12 ± 9.47 * | 551.56 | 564.68 | 738.68 ± 9.47 * | 732.35 | 745.01 |
| Total turn section time [s] | 303.14 ± 5.71 * | 299.18 | 307.10 | 147.12 ± 5.71 * | 143.58 | 150.66 |
| Mean start section time [s] | 3.77 ± 0.16 | 3.66 | 3.88 | 3.77 ± 0.17 | 3.65 | 3.89 |
| Mean swim section time [s] | 9.30 ± 0.16 * | 9.19 | 9.41 | 24.62 ± 0.33 * | 24.39 | 24.85 |
| Mean turn section time [s] | 5.14 ± 0.10 * | 5.07 | 5.21 | 5.07 ± 0.18 * | 4.95 | 5.19 |
| Note: | | | | | | |
| * significant difference between short- and long-course races ($p < 0.05$) | | | | | | |

Table 2 – Pearson’s correlation coefficient between final ranking and section rankings as well as total race time and section times.

Short-course World championships

25m pool length – Hangzhou 2018

| Final ranking | Section ranking | | | Total race time | Section time [s] (+/- difference to race winner) | | |
|-----------------|-----------------|-------|-----------------|------------------|--|------------------|-------------------------------|
| | Start | Swim | Turn | | Start | Swim | Turn |
| 1. place | 5. | 2. | 1. ^a | 849.14 | 3.82 | 550.06 | 295.26 ^a |
| 2. place | 8. | 1. | 4. ^b | 849.87 (+ 0.73) | 4.08 (+ 0.26) | 545.35 (- 4.71) | 300.44 (+ 5.18) ^b |
| 3. place | 3. | 6. | 2. ^a | 859.39 (+ 10.25) | 3.64 (- 0.18) | 559.91 (+ 9.85) | 295.84 (+ 0.58) ^a |
| 4. place | 4. | 5. | 3. ^a | 863.44 (+ 14.30) | 3.74 (- 0.08) | 559.66 (+ 9.60) | 300.04 (+ 4.78) ^a |
| 5. place | 6. | 4. | 6. ^b | 864.00 (+ 14.86) | 3.86 (+ 0.04) | 553.40 (+ 3.34) | 306.74 (+ 11.48) ^b |
| 6. place | 1. | 3. | 8. ^b | 867.73 (+ 18.59) | 3.56 (+ 0.26) | 553.00 (+ 2.94) | 310.74 (+ 15.48) ^b |
| 7. place | 7. | 7. | 5. | 875.94 (+ 26.80) | 3.88 (+ 0.06) | 566.28 (+ 16.22) | 305.78 (+ 10.52) |
| 8. place | 2. | 8. | 7. | 891.22 (+ 42.08) | 3.60 (- 0.22) | 577.32 (+ 27.26) | 310.30 (+ 15.04) |
| <i>r</i> -value | -0.36 | 0.74 | 0.81 | <i>r</i> -value | -0.52 | 0.91 | 0.76 |
| <i>p</i> -value | 0.385 | 0.037 | 0.015 | <i>p</i> -value | 0.189 | 0.002 | 0.030 |

Long-course World championships

50m pool length – Gwangju 2019

| Final ranking | Section ranking | | | Total race time | Section time [s] (+/- difference to race winner) | | |
|---------------|-----------------|------|-----------------|-----------------|--|-----------------|------------------------------|
| | Start | Swim | Turn | | Start | Swim | Turn |
| 1. place | 2. | 2. | 1. ^a | 876.54 | 3.62 | 731.06 | 141.86 ^a |
| 2. place | 4. | 3. | 2. ^a | 877.63 (+ 1.09) | 3.70 (+ 0.08) | 731.23 (+ 0.17) | 142.70 (+ 0.84) ^a |
| 3. place | 7. | 1. | 4. ^b | 878.75 (+ | 3.96 (+ | 729.37 (- | 145.42 (+ |

| | | | | | | | |
|-----------------|-------|--------|--------|---------------------|------------------|---------------------|---------------------|
| | | | | 2.21) | 0.34) | 1.69) | 3.56) ^b |
| 4. place | 3. | 4. | 5. | 884.72 (+ 8.18) | 3.68 (+ 0.06) | 735.30 (+ 4.24) | 145.74 (+ 3,88) |
| 5. place | 1. | 5. | 3. | 885.35 (+ 8.81) | 3.50 (- 0.12) | 738.75 (+ 7.69) | 143.10 (+ 1.24) |
| 6. place | 6. | 6. | 6. | 892.05 (+ 15.51) | 3.92 (+ 0.30) | 740.27 (+ 9.21) | 147.86 (+ 6.00) |
| 7. place | 8. | 7. | 7. | 901.04 (+ 24.50) | 4.02 (+0.40) | 744.22 (+ 13,16) | 152.80 (+ 10.96) |
| 8. place | 5. | 8. | 8. | 920.47 (+ 43.93) | 3.74 (+ 0.12) | 759.25 (+ 28.19) | 157.48 (+ 15.62) |
| <i>r</i> -value | 0.43 | 0.93 | 0.93 | <i>r</i> -value | 0.24 | 0.99 | 0.96 |
| <i>p</i> -value | 0.289 | <0.001 | <0.001 | <i>p</i> -value | 0.561 | <0.001 | <0.001 |

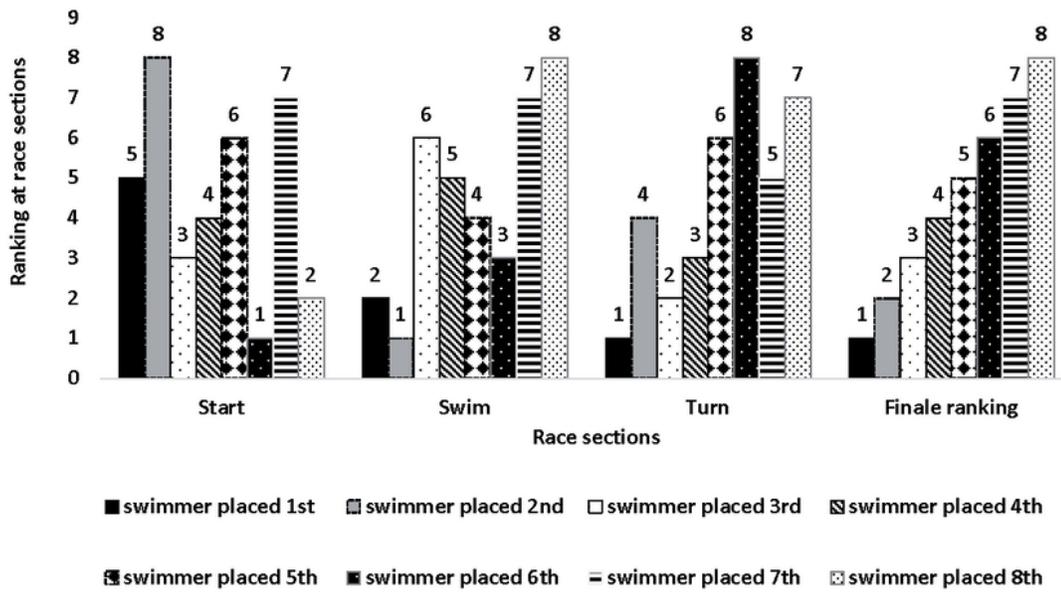
Note:

^a increased final ranking due to turn performance

^b decreased final ranking due to turn performance

Figures

**Short-course World championships
25m pool length – Hangzhou 2018**



**Long-course World championships
50m pool length – Gwangju 2019**

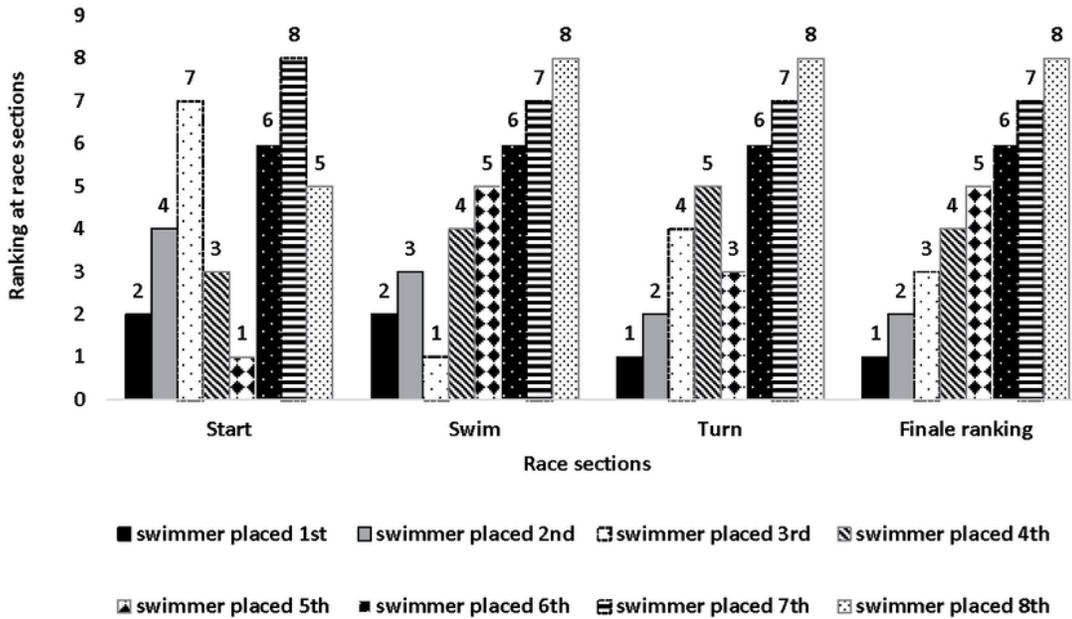


Figure 1

Individual ranking for start, swim, and turn section at the short-course and long-course World championships.