




Contribution of breaststroke start and turn parameters to competitive performance in elite male swimmers

-  **Luboš Grznár**  . Department of Outdoor Sports and Swimming. Faculty of Physical Education and Sport. Comenius University in Bratislava. Bratislava, Slovakia.
-  **Jana Labudová**. Department of Outdoor Sports and Swimming. Faculty of Physical Education and Sport. Comenius University in Bratislava. Bratislava, Slovakia.
- Marek Hromník**. Department of Outdoor Sports and Swimming. Faculty of Physical Education and Sport. Comenius University in Bratislava. Bratislava, Slovakia.

ABSTRACT

This study examined the relationship between selected temporal parameters of the breaststroke start and turn and overall race performance in elite male swimmers. The analysis included the 50 m, 100 m, and 200 m breaststroke events at the World Aquatics Championships. Race performance was defined as final race time (FT). Start-related variables included reaction time (RT) and time at 15 m after the start (T15S). Turn-related variables included time at 5 m before the wall (T5BT), turn duration (TT), and time at 15 m after the turn (T15T). Relationships were assessed using Pearson's correlation coefficient (r) with effect size interpretation. In the 50 m event, FT was significantly associated with T15S ($r = .534, p < .05$), whereas RT showed no significant relationship. In the 100 m event, start variables were not significantly related to FT; however, T15T demonstrated a significant correlation ($r = .511, p < .05$). In the 200 m event, start variables were not significant, while TT ($r = .824, p < .05$) and T15T ($r = .667, p < .05$) showed strong associations. The findings indicate distance-specific contributions of race segments, with increasing importance of turn efficiency as race distance increases.

Keywords: Performance analysis, Race analysis, Performance metrics, Swimming, Efficiency.

Cite this article as:

Grznár, L., Labudová, J., & Hromník, M. (2026). Contribution of breaststroke start and turn parameters to competitive performance in elite male swimmers. *Journal of Human Sport and Exercise*, 21(3), 828-836. <https://doi.org/10.55860/5f8anv65>

 **Corresponding author.** Univerzita Komenského v Bratislave Fakulta telesnej výchovy a športu, Nábr. arm. gen. L. Svobodu 9, 814 69 Bratislava.

E-mail: lubos.grznar@uniba.sk

Submitted for publication March 04, 2026.

Accepted for publication April 06, 2026.

Published May 07, 2026.

[Journal of Human Sport and Exercise](#). ISSN 1988-5202.

©Asociación Española de Análisis del Rendimiento Deportivo. Alicante. Spain.

doi: <https://doi.org/10.55860/5f8anv65>

INTRODUCTION

Swimming performance at the elite level is strongly determined by technical precision, where small temporal differences frequently decide final rankings. In modern competitive swimming, race analysis has increasingly adopted a segment-based framework that distinguishes between start, clean swimming, turn, and finish phases. Within this framework, non-cyclical race segments—particularly the start and the turn—represent critical opportunities to gain or lose time.

The start phase has been widely recognized as a decisive determinant of performance, especially in sprint events. Cossor and Mason (2001) demonstrated that the start up to 15 m may account for more than one quarter of total race time in 50 m events. Subsequent biomechanical analyses have shown that start performance is influenced not only by reaction time but also by take-off force production, flight trajectory, underwater path, and transition efficiency (Vantorre et al., 2014, Matúš et al., 2024). Although reaction time is commonly measured in competition, its relative contribution to overall performance appears limited among elite swimmers, where inter-individual variability is small (Silva et al., 2019, Tor et al., 2015). Therefore, performance analysis frequently emphasizes early split times (e.g., 15 m) as more comprehensive indicators of start effectiveness.

Breaststroke presents unique biomechanical characteristics compared with other competitive strokes. It is characterized by pronounced intracyclic velocity fluctuations and alternating propulsive and resistive phases, requiring precise coordination to minimize drag and maintain forward momentum (Maglischo, 2003, Barbosa et al., 2005). The underwater pull-out and glide phases following both the start and turns are especially important in breaststroke due to their potential to maximize propulsion while reducing resistance (Seifert et al., 2007). Recent performance-analysis research has highlighted that underwater actions can significantly influence outcomes in short-course 50 m and 100 m breaststroke events (Sánchez et al., 2021), reinforcing the performance value of optimizing transitional phases beyond surface stroking.

Turn performance becomes increasingly relevant in races longer than one pool length, as its cumulative effect grows with distance. The breaststroke turn requires a simultaneous two-hand touch followed by rapid body repositioning and a streamlined push-off, making it a technically demanding transition. Biomechanical investigations have demonstrated that post turn velocity and underwater efficiency significantly influence overall race outcomes (Veiga & Roig, 2017). Moreover, recent analyses have documented meaningful relationships between turn related kinematic variables and competitive performance in elite swimmers (Gonjo et al., 2020). Intra and inter-individual variability in underwater pull-out techniques during 200 m breaststroke turns further suggests that turn execution remains a performance differentiating factor even at high levels of competition (Gonjo et al., 2023). Additionally, evidence indicates that the contribution of turn and underwater phases to overall performance may increase with race distance (Morais et al., 2019).

Although previous studies have examined start and turn phases independently, fewer investigations have directly compared their relative contribution across multiple race distances within the same stroke and competition context. Given the increasing importance of marginal gains in elite swimming, understanding how the relevance of start- and turn-related parameters differs between 50 m, 100 m, and 200 m breaststroke events is of both theoretical and practical importance.

Therefore, the aim of this study was to examine the relationship between selected temporal indicators of the start and the breaststroke turn and overall race performance in elite male swimmers competing at the World Aquatics Championships.

MATERIALS AND METHODS

Participants

The research sample consisted of elite male swimmers competing at the highest international level. The analysis included performances achieved in the 50 m, 100 m, and 200 m breaststroke events during the World Aquatics Championships held in Fukuoka in 2023.

For each event, data from sixteen swimmers competing in the semifinal heats were analysed. The inclusion of semifinal performances ensured a high and relatively homogeneous performance level while providing a larger sample size compared to final-only analyses.

All races were conducted in a 50 m long-course swimming pool under standardized competition conditions and in accordance with World Aquatics regulations. The study focused exclusively on male swimmers to eliminate the potential influence of sex-related physiological and biomechanical differences on start and turn performance.

The final dataset consisted of officially recorded race times and phase-specific timing data obtained from electronic timing systems and official race analysis protocols provided by the event organizers.

Variables and measurements

This study employed a cross-sectional correlational design aimed at examining the relationships between selected temporal parameters of the start and the breaststroke turn and overall race performance in elite male swimmers.

Race performance was assessed using the final race time (FT, s) in each breaststroke event (50 m, 100 m, and 200 m). Selected temporal parameters related to the start and the breaststroke turn were obtained from official semifinal race analyses.

Start performance was evaluated using reaction time (RT, s), defined as the time interval between the starting signal and the initiation of the swimmer's movement, and the time at 15 m after the start (T15S, s), representing the time elapsed from the starting signal until the swimmer reached the 15 m mark.

Turn performance was assessed using the time at 5 m before the turn (T5BT, s), defined as the time recorded from the start of the race until the swimmer reached the 5 m mark before the wall. The duration of the turn (TT, s) was defined as the time interval between the swimmer reaching the 5 m mark before the wall and the 5 m mark after the wall. Additionally, the time at 15 m after the turn (T15T, s) was analysed as the time elapsed from the wall push-off until the swimmer reached the 15 m mark after the turn.

Video analysis

The analysed races were sourced from publicly available broadcast footage of the semifinal heats. Video analysis was conducted using iMovie and DaVinci Resolve software. All measurements were performed using frame-by-frame inspection of the video recordings. Temporal reference points used for the determination of RT, T15S, T5BT, TT, and T15T were identified visually, including the start signal, movement initiation, reaching the 15 m mark after the start, approach to the wall, wall contact, push-off, and reaching the 15 m mark after the turn.

Distance reference points corresponding to T5BT, T15S, and T15T were determined based on official pool markings visible in the broadcast footage. Corresponding timestamps were extracted directly from the video timeline. Given the frame rate of 30 frames·s⁻¹, the temporal resolution of the measurements was 0.033 s. The temporal resolution of the analysis was limited by the video frame rate.

All analysed variables (RT, T15S, T5BT, TT, and T15T) were derived consistently using the same methodological procedure across all performances.

Statistical analysis

Relationships between race performance (FT) and selected start- and turn-related variables (RT, T15S, T5BT, TT, and T15T) were examined using Pearson's correlation coefficient (*r*). Alongside statistical significance testing, the practical relevance of relationships was evaluated using effect size interpretation based on the magnitude of *r*. Correlation magnitudes were classified according to Hopkins (2002) as trivial (<.10), small (.10 – .29), moderate (.30 – .49), large (.50 – .69), and very large (.70 – .89). Statistical significance was set at $p < .05$.

All statistical analyses were conducted using standard statistical software.

RESULTS

The relationships between race performance (FT) and selected start- and turn-related variables are summarized in Table 1. The magnitude of correlations ranged from trivial to very large across the analysed events, indicating variability in the contribution of start and turn phases depending on race distance.

Table 1. Pearson's correlation coefficients (*r*) between final race time (FT) and start- and turn-related variables.

Distance	Variable	Abbreviation	<i>r</i>	Effect size	<i>p</i> -Value
50 m	Reaction time	RT	-.310	Moderate	>.05
	15 m time after start	T15S	.534	Large	<.05*
100 m	Reaction time	RT	.138	Small	>.05
	15 m time after start	T15S	.318	Moderate	>.05
	5 m time before turn	T5BT	-.089	Trivial	>.05
	Turn duration	TT	.066	Trivial	>.05
	15 m time after turn	T15T	.511	Large	<.05*
200 m	Reaction time	RT	.245	Small	>.05
	15 m time after start	T15S	.305	Moderate	>.05
	5 m time before turn	T5BT	.447	Moderate	>.05
	Turn duration	TT	.824	Very large	<.05*
	15 m time after turn	T15T	.667	Large	<.05*

Note. * indicates statistically significant correlations.

50 m Breaststroke

In the 50 m breaststroke event, start performance demonstrated a stronger association with overall race time compared to turn-related parameters, as only the start phase is present in this sprint event. A statistically significant positive correlation was observed between FT and T15S ($r = .534$, $p < .05$), classified as a large effect size. This indicates that swimmers who required more time to reach the 15 m mark after the start tended to achieve slower final race times.

In contrast, reaction time (RT) was not significantly associated with FT ($r = -.310, p > .05$), despite showing a moderate negative correlation. The absence of statistical significance suggests that variability in RT did not meaningfully influence overall sprint performance within this elite semifinal sample.

Overall, for the 50 m event, the underwater and transition phase represented by T15S appeared more closely related to race performance than the initial reaction phase.

100 m Breaststroke

In the 100 m breaststroke event, the relationships between start-related variables and overall performance were weaker compared to the 50 m distance. Neither RT ($r = .138, p > .05$) nor T15S ($r = .318, p > .05$) demonstrated statistically significant associations with FT. Although T15S reached a moderate effect size, the relationship did not achieve statistical significance.

Turn-related variables displayed differentiated patterns. The strongest association within this event was found between FT and T15T ($r = .511, p < .05$), representing a large effect size. This indicates that swimmers with longer post-turn 15 m times tended to record slower final race times.

In contrast, T5BT ($r = -.089, p > .05$) and TT ($r = .066, p > .05$) showed trivial correlations with FT and were not statistically significant. These findings suggest that, in the 100 m event, the phase following wall push-off may be more closely related to overall performance than the approach to the wall or the turn duration itself.

200 m Breaststroke

In the 200 m breaststroke event, start-related variables did not show statistically significant relationships with overall race performance. Reaction time (RT) demonstrated a small positive correlation with FT ($r = .245, p > .05$), while T15S showed a moderate positive correlation ($r = .305, p > .05$), neither reaching statistical significance.

In contrast, turn-related parameters demonstrated substantially stronger associations with FT compared to shorter race distances. A very large positive correlation was observed between FT and TT ($r = .824, p < .05$), indicating that longer turn durations were strongly associated with slower final race times. This was the strongest relationship identified across all analysed events.

Additionally, T15T showed a significant large positive correlation with FT ($r = .667, p < .05$), further emphasizing the importance of post-turn performance in the 200 m event. Although T5BT demonstrated a moderate positive correlation ($r = .447, p > .05$), it did not reach statistical significance.

Overall, the 200 m breaststroke event exhibited the most pronounced relationships between turn performance and final race outcome, whereas start-related variables appeared less influential within this distance.

A comparison across race distances revealed distinct patterns in the relationships between start- and turn-related variables and overall race performance.

In the 50 m event, the only significant association was observed for T15S, indicating that early-phase performance following the start was most closely related to final race time in this sprint distance. No turn-related variables were analysed for this event due to the absence of a turn phase.

In the 100 m event, start-related variables did not demonstrate significant associations with FT. However, among turn-related parameters, T15T showed a significant large correlation with race performance, whereas TT and T5BT did not. This suggests that, in the 100 m distance, the post-turn phase displayed a stronger statistical relationship with final performance compared to both the start phase and the turn duration itself.

In the 200 m event, turn-related variables demonstrated the strongest associations with FT. TT showed a very large correlation, and T15T exhibited a large correlation, both reaching statistical significance. In contrast, start-related variables remained non-significant. The progressive increase in correlation magnitude for TT from the 100 m to the 200 m event indicates a greater statistical association between turn performance and overall race outcome as race distance increased.

Across all distances, reaction time (RT) did not demonstrate a statistically significant relationship with final race time. Similarly, T5BT did not reach statistical significance in either the 100 m or 200 m events, despite showing a moderate correlation in the 200 m distance.

Overall, the results indicate that the statistical association between turn-related variables and race performance becomes more pronounced with increasing race distance, whereas the contribution of start-related parameters appears relatively stronger in the shortest event.

DISCUSSION

The present study examined the relationship between selected start- and turn-related temporal parameters and overall race performance in the 50 m, 100 m, and 200 m breaststroke events. The findings indicate that the relative contribution of start and turn phases varies as a function of race distance.

In the 50 m breaststroke, time at 15 m after the start (T15S) demonstrated a significant association with final race time (FT), whereas reaction time (RT) did not. These findings align with previous research emphasizing the performance relevance of the start in sprint events. Cossor and Mason (2001) reported that the start phase up to 15 m accounts for a substantial proportion of total race time in 50 m events. Similarly, Mason and Cossor (2000) highlighted the importance of optimizing the underwater phase and transition to surface swimming in short-distance races. The absence of a significant relationship between RT and FT suggests that, in elite swimmers, performance is more strongly influenced by the quality of the underwater and propulsion phases than by reaction time alone, which has also been observed in high-level sprint analyses (Morais et al., 2019, Matúš, et. al. 2024).

In the 100 m breaststroke, start-related variables were not significantly associated with performance, whereas time at 15 m after the turn (T15T) showed a significant correlation with FT. This supports the notion that middle-distance performance depends on the integration of race segments rather than dominance in a single phase. The turn has been described as a complex biomechanical sequence involving approach, wall contact, push-off, streamline, and underwater propulsion (Maglischo, 2003). Previous investigations have demonstrated that post-turn velocity and streamline efficiency significantly influence race outcomes (Veiga & Roig, 2017). The present results reinforce the importance of the post-turn phase over isolated turn duration in middle-distance breaststroke events.

In the 200 m breaststroke, turn-related variables demonstrated the strongest associations with performance, particularly turn time (TT) and T15T. The progressive increase in correlation magnitude with race distance is consistent with literature indicating that turns represent a critical determinant of performance in longer events

(Gonjo et al., 2020). Repeated push-offs and underwater phases may cumulatively influence overall race time, especially as fatigue develops. It has been suggested that technical consistency during turns becomes increasingly important as race distance increases (Morais et al., 2019). The strong association observed in the present study supports the hypothesis that small differences in turn efficiency may accumulate across multiple repetitions and substantially affect final performance.

Breaststroke technique is characterized by alternating propulsive and resistive phases, making velocity maintenance highly dependent on coordination efficiency (Maglischo, 2003). Given the technical demands of breaststroke, performance determinants may differ from other strokes, particularly in the underwater and transitional phases. The present findings suggest that sprint performance is more strongly associated with start efficiency, whereas longer events demonstrate greater sensitivity to turn execution.

Overall, the results confirm the distance-specific contribution of race segments in elite breaststroke swimming. From a practical perspective, sprint-focused training should emphasize start mechanics and underwater propulsion, whereas preparation for longer distances should prioritize turn efficiency, push-off force production, and streamline optimization.

CONCLUSION

The present study investigated the relationships between selected start and turn-related temporal parameters and overall race performance in elite male swimmers competing in the 50 m, 100 m, and 200 m breaststroke events. The findings demonstrate that the contribution of race segments to performance is distance specific.

In the 50 m breaststroke, performance was primarily associated with the time at 15 m after the start, highlighting the importance of start efficiency and underwater propulsion in sprint events. In contrast, start-related variables were not significantly related to performance in the 100 m and 200 m events. Instead, turn-related parameters—particularly turn duration and time at 15 m after the turn—showed stronger associations with race outcome, especially in the 200 m breaststroke.

These results suggest that while explosive start performance is critical in sprint events, turn execution and post-turn efficiency become increasingly influential as race distance increases. From a practical perspective, training programs should adopt a distance-specific approach, emphasizing start mechanics in sprint disciplines and optimizing turn technique and underwater phases in middle- and long-distance breaststroke events.

Future research should integrate biomechanical and physiological analyses to further clarify the determinants of performance in elite breaststroke swimming.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Grznár, Labudová and Hromník wrote the paper and collected the data. All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

FUNDING

This work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research, Development and Youth of the Slovak Republic and the Slovak Academy of Sciences (No. 1/0699/26).

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

REFERENCES

- Barbosa, T. M., Lima, F., Portela, A., Novais, D., Machado, L., Colaço, P., Gonçalves, P., Fernandes, R. J., Keskinen, K. L., & Vilas-Boas, J. P. (2005). Relationships between energy cost, swimming velocity and speed fluctuation in competitive swimming strokes. *Portugese Journal of Sport Sciences*, 5, 192-194.
- Brooks, M. (2011). Developing swimmers. *Human Kinetics*, 101-118. <https://doi.org/10.5040/9781718219427>
- Cossor, J., & Mason, B. (2001). Swim start performances at the Sydney 2000 Olympic Games. *Biomechanics and Medicine in Swimming IX*.
- Gonjo, T., & Olstad, B. H. (2020). Start and Turn Performances of Competitive Swimmers in Sprint Butterfly Swimming. *Journal of sports science & medicine*, 19(4), 727-734.
- Gonjo, T., Olstad, B. H., Štastný, J., Conceição, A., & Seifert, L. (2023). Intra- and inter-individual variability in the underwater pull-out technique in 200 m breaststroke turns. *PLOS ONE*, 18(1), <https://doi.org/10.1371/journal.pone.0283234>
- Hannula, D., & Thornton, N. (2012). *The swim coaching bible: Volume I. Human Kinetics*.
- Hopkins, W. G. (2002). A scale of magnitudes for effect statistics. *A New View of Statistics*. Retrieved from [Accessed 2026, 21 April]: <https://www.sportsci.org/resource/stats/effectmag.html>
- Maglischo, E. W. (2003). Swimming fastest. *Human Kinetics*.
- Mason, B., & Cossor, J. (2000). What can we learn from competition analysis at the 1999 Pan Pacific Swimming Championships? *Proceedings of the XIX International Symposium on Biomechanics in Sports*.
- Matúš, I., Ružbarský, P., Vadašová, B., Eliaš, T., Czarny, W., & Němá, K. (2024). Gender-related differences in kinematic parameters of the start and performance in a 50 m breaststroke swimming. *Journal of Kinesiology and Exercise Sciences*, 34(106), 28-37. <https://doi.org/10.5604/01.3001.0054.2946>
- Matúš, I., Vadašová, B., Eliaš, T., Czarny, W., Labudová, J., & Grznár, L. (2024). Swim start and performance in 50 m freestyle in different age categories of competitive swimmers. *Pedagogy of Physical Culture and Sports*, 28(1), 33-42. <https://doi.org/10.15561/26649837.2024.0104>
- Morais, J. E., Barbosa, T. M., Neiva, H. P., & Marinho, D. A. (2019). Stability of pace and turn parameters of elite long-distance swimmers. *Human movement science*, 63, 108-119. <https://doi.org/10.1016/j.humov.2018.11.013>
- Sánchez, L., Arellano, R., & Cuenca-Fernández, F. (2021). Analysis and influence of the underwater phase of breaststroke on short-course 50 m and 100 m performance. *International Journal of Performance Analysis in Sport*, 21(2), 261-273. <https://doi.org/10.1080/24748668.2021.1885838>

- Seifert, L., Chollet, D., & Rouard, A. (2007). Swimming constraints and arm coordination. *Human movement science*, 26(1), 68-86. <https://doi.org/10.1016/j.humov.2006.09.003>
- Silva, J. K. F., dos Santos, P. S., Favors, S. O. V. B., Lirani, L. D. S. A., & Osiecki, R. (2019). Reaction time on swimming block start in competitors swimmers on World Swimming Championship. *Journal of Physical Education and Sport*, 19(2), 683-689. <https://doi.org/10.7752/jpes.2019.s2056>
- Tor, E., Pease, D. L., & Ball, K. A. (2015). Key parameters of the swimming start and their relationship to start performance. *Journal of Sports Sciences*, 33(13), 1313-1321. <https://doi.org/10.1080/02640414.2014.990486>
- Vantorre, J., Seifert, L., Fernandes, R. J., Vilas-Boas, J. P., & Chollet, D. (2014). Kinematical profiling of the front crawl start. *International Journal of Sports Medicine*, 35(5), 395-402. <https://doi.org/10.1055/s-0033-1358470>
- Veiga, S., & Roig, A. (2017). Underwater and surface strategies of 200 m world-level swimmers. *Journal of Sports Sciences*, 35(8), 766-771. <https://doi.org/10.1080/02640414.2015.1069382>



This work is licensed under a [Attribution-NonCommercial-ShareAlike 4.0 International](https://creativecommons.org/licenses/by-nc-sa/4.0/) (CC BY-NC-SA 4.0 DEED).