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Original Article

Relationship between flat-water performance and slalom race outcomes

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Abstract
Canoe slalom is a sport defined by intricate technical and physical challenges within rapidly changing whitewater environments. Coaches and sport scientists counter difficulties in finding reliable diagnostic tools that accurately predict race outcomes. Although flat-water tests are commonly used in training, there is limited evidence supporting their effectiveness in predicting competition performance in slalom events. Aim: The aim of the study is to determine whether there is a statistically significant relationship between performance in the 12x15 m test on flat water and performance in canoe slalom competitions. Materials and Methods: The sample included twenty-eight Slovak elite slalom athletes were assessed, divided equally into four categories: K1 men (n = 7), K1 women (n = 7), C1 men (n = 7), and C1 women (n = 7). We used a 12x15 m test on flat water. The test was performed with gates placed directly opposite each other at 15 m, according to Vajda and Piatrikova (2021). The flat-water test was conducted under standardized conditions in September 2024, and competitive results were obtained from the Slovak Championships in Čunovo (Bratislava) later that month. Performance data were analysed using descriptive statistics and Pearson's correlation. Results: Mean times in the 6×30 m test were 93.9±1.59 s (K1M), 103.0±2.21 s (K1W), 104.0±2.93 s (C1M), and 113.0±1.75 s (C1W). At the Slovak Championships, clean final-run times were 96.8±1.98 s (K1M), 106.0±3.78 s (K1W), 107.0±9.8 s (C1M), and 111.0±10.4 s (C1W). Statistical analysis revealed a significant positive correlation between test and race performance ($r = 0.570$, $p = 0.002$), corresponding to a large effect size according to Cohen (1988). Conclusion: The findings indicate that the 12x15 m shuttle test provides a valid and race-relevant diagnostic tool for canoe slalom athletes. Coaches are encouraged to incorporate this test not only for performance monitoring but also as a specific training stimulus, since it replicates race demands in a controlled environment. Regular implementation of the test may enhance athlete preparation, support individualized training adjustments, and contribute to long-term performance development in canoe slalom.
Key Words: canoeing; field-based testing; kayaking; performance diagnostics; whitewater

Introduction

Canoe slalom is a branch of canoeing that has been regularly featured in the Olympic Games since its debut in Barcelona in 1992. Competitions take place on white-water courses, which may be naturally occurring or artificially created specifically for the sport (ICF, 2022). Race durations typically range from 90 to 120 seconds, influenced by factors such as water flow complexity, course length, and the number and placement of gates (Nibali et al., 2011). According to the International Canoe Federation (ICF), courses are required to have between 18 and 25 gates, with 6 to 8 designated as upstream gates, ensuring that there are at least three on each side. During competitions, athletes must skillfully navigate their boats through both upstream and downstream gates (ICF, 2022). The sport consists of four events: men's kayak (K1M), men's canoe (C1M), women's kayak (K1W), and women's canoe (C1W), with competitors allowed to participate in both kayak and canoe categories (ICF, 2022).

Canoe slalom is a complex sport that requires both technical precision and physical strength. Athletes must not only master water dynamics and effectively harness the power of the flow, but also demonstrate the ability to execute precise movement patterns under challenging conditions. Performance in this discipline is determined by the interaction of multiple factors, including physical, technical, mental, and tactical components (Zamparo et al., 2006). As Pitsiladis et al. (2016) highlight, sport performance arises from the interplay of genetic predispositions, physiological determinants, and external conditions, which underlines the need for multifactorial approaches to studying and monitoring athletes.

In line with this perspective, Bishop (2008) argues that sport-specific testing protocols integrating physiological and technical elements provide more accurate insights into competitive potential than isolated laboratory assessments. This is particularly relevant for canoe slalom, where technical efficiency is often as decisive as physical fitness. Reliable and objective performance testing is therefore central to both sport science and coaching practice, especially when the goal is to identify markers capable of predicting outcomes in white-water competition. Recent studies have specifically examined the connection between performance on flat water and competitive results in slalom, although most of this research has been limited to straight sections (Bílý,

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2012). At the same time, Kellmann (2010) stresses that systematic monitoring of performance and recovery is essential, as athletes who lack regular assessment face a significantly higher risk of overload. Flat-water training plays a fundamental role in building motor skills that can be transferred to the dynamic environment of white-water courses (Vondra, 2016). Empirical evidence confirms significant associations between physiological characteristics, somatic variables, and competitive performance in slalom. For instance, Vondra (2016) reported a strong correlation between 200 m flat-water test results and white-water race outcomes ($r = 0.78$, $p < 0.01$), indicating that aerobic capacity and strength endurance are critical predictors of success. Similarly, Busta, Bílý, and Suchý (2021) demonstrated that both laboratory and field tests can yield meaningful indicators of competitive potential. Beyond physical and physiological aspects, technical and psychological factors also play a decisive role. Biomechanical analysis, as emphasized by Bartlett (2007), allows for the identification of technical determinants of performance, including movement coordination and efficiency, which are directly transferable from flat-water testing to white-water racing. Moreover, psychological variables such as reaction time and course visualization have been shown to correlate with high-level performance, with elite athletes demonstrating superior mental preparation (Makovsky, 2006; Buchtel, 2007). Taken together, these findings suggest that evaluating canoe slalom performance requires an integrative approach that considers physical conditioning, technical proficiency, and psychological readiness. Despite increasing research efforts, only a limited number of testing protocols have proven suitable for routine implementation in training practice. As Zagatto et al. (2009) note, the validity and reliability of tests are crucial if they are to provide actionable data and guide evidence-based coaching decisions.

Building on this background, the present study aims to investigate the relationship between performance in the 12 × 15 m all-out flat-water test and competitive outcomes in canoe slalom. By examining this connection, the study seeks to demonstrate the predictive value of sport-specific field testing and contribute to more effective monitoring and training practices in elite slalom athletes.

Materials and Methods

A total of twenty-eight ($n = 28$) elite canoe slalom athletes from the Slovak national team, competing in the K1 men (K1M) (n=7), K1 women (K1W) (n=7) C1 men (C1M) (n=7), and C1 women (n=7) categories, volunteered to participate in this study. Participation in the testing was voluntary, and the measurements were conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. Detailed information about their characteristics is presented in Table 1

Table 1 General characteristics of the groups (X±SD)

	K1M (n=7)	K1W(n=7)	C1M(n=7)	C1W(n=7)
Age (y)	19,5±2,6	19,1±2,5	18,6±2,7	19,1±1,8
Height (cm)	178,6±2,0	166,2±7,6	180,2±6,7	170,0±3,8
Weight (kg)	71,8±7,2	55,1±5,7	72,5±3,3	57,4±7,7

K1M, kayak men; K1W, kayak women; C1M, canoe men; X±SD, mean±standard deviation.

Athletes' performance times were recorded using all-out shuttle testing (AOT) on flat water. The assessments took place at the Ondrej Cibák Canoe Slalom Complex in Liptovský Mikuláš in September 2024, under stable and favorable weather conditions regarding temperature, wind strength, and speed. Testing sessions were scheduled between 10:00 and 12:00. Each participant received a specific time slot in advance, allowing for optimal preparation, particularly in terms of nutrition and performance readiness. Athletes were advised to reduce training intensity during the 48 hours preceding the test and to refrain from additional physical activity on the testing day. Before commencing the test, each athlete performed a personalized warm-up.

The testing was conducted on flat water with gates positioned directly opposite each other at 15 m, following the arrangement described by Vajda and Piatrikova (2021) (as shown in Figure 1). This approach effectively integrates both technical and fitness demands of the sport while minimizing the environmental variability typical of white-water courses. Athletes assumed a starting position with the bow of the boat aligned with the starting gate. Upon the examiner's signal, they paddled at maximum effort towards the opposite gate, circled it to the left, and returned to the starting gate, turning to the right. This sequence was repeated for six rounds. Competitors were free to choose their turning technique, provided they adhered to standard white-water canoeing rules to ensure correct gate navigation. The total time required to complete all six 30 m rounds was recorded for each athlete.

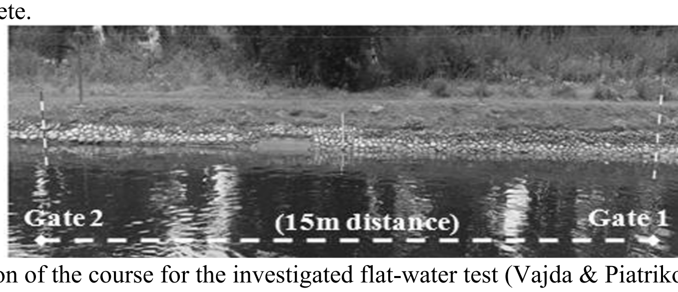

Figure 1 Representation of the course for the investigated flat-water test (Vajda & Piatrikova, 2021)

The results obtained from flat-water testing were compared with performance outcomes from the Slovak Canoe Championships, held at the Areal Divoká voda in Čunovo, Bratislava, on 22–23 September 2024. The competition consisted of two runs in accordance with the Slovak Canoe Slalom Racing regulations, with the first run serving as a qualifying round and the second as the final. For the purposes of this study, only the results from the final run were used, and the recorded times reflect clean runs without any penalties. Flat-water measurements were conducted during the week preceding the competition to ensure that the most current performance data were available.

The data were analyzed using basic descriptive and mathematical statistical methods. All statistical analyses were conducted in Jamovi (The Jamovi Project, Sydney, Australia), with results presented as mean ± standard deviation (SD) and 95% confidence intervals (95% CI). Prior to further analysis, all variables were tested for normality using the Shapiro-Wilk test. Statistical significance was set at $p \leq 0.05$. Pearson's correlation coefficient (r) was interpreted according to Cohen (1988), with values from 0.1 to 0.3 indicating a weak correlation, 0.3 to 0.5 a moderate correlation, and values above 0.5 considered strong. The collected data were systematically organized in tables and visualized graphically. For qualitative analysis, fundamental logical methods such as analysis, synthesis, induction, deduction, and comparison were applied.

Results

In the group of athletes included in the study (n = 28), results from the 12x15 m flat-water shuttle test were analysed across four canoe slalom categories (as describe in Table 2): K1 men (K1M), K1 women (K1W), C1 men (C1M), and C1 women (C1W), with each category comprising seven athletes.

In the K1M group, the average performance time was 93.9 s (SD = 1.59), ranging from a minimum of 91.9 s to a maximum of 96.0 s, with a 95% confidence interval of 92.5 to 95.4 s. The K1W category displayed a higher mean time of 103.0 s (SD = 2.21), with individual results ranging between 101.0 and 106.0 s, and a 95% confidence interval of 101.0 to 105.0 s. In the male C1 category, athletes recorded an average time of 104.0 s (SD = 2.93), with individual results ranging from 101.0 to 108.0 s, and a 95% confidence interval of 102.0 to 107.0 s. The C1W category showed the slowest average performance among all groups, with a mean time of 113.0 s (SD = 1.75), a minimum of 111.0 s, and a maximum of 115.0 s. The 95% confidence interval for this group ranged from 111.0 to 115.0 s.

Table 2 Descriptive parameters derived from flat water test

	K1M (n=7)	K1W (n=7)	C1M (n=7)	C1W (n=7)
X±SD (s)	93,9±1,59	103,0±2,21	104,0±2,93	113,0±1,75
Min (s)	91,9	101,0	101,0	111,0
Max (s)	96,0	106,0	108,0	115,0
95% CI (s)	92,5-95,4	101,0-105,0	102,0-107,0	111,0-115,0

K1M, kayak men; K1W, kayak women; C1M, canoe men; X±SD, mean±standard deviation; CI 95% –95% of confidence interval.

Figure 2 presents a box plot illustrating the results of the 12x15 m all-out shuttle test for the four slalom categories: K1 men (K1M), K1 women (K1W), C1 men (C1M), and C1 women (C1W). The plot indicates that the fastest times were recorded by the K1 men, whose results also exhibited the least variability. They were followed by K1 women, C1 men, and lastly C1 women, who showed both the highest median times and the greatest range of results. Overall, the trend suggests that male athletes achieve faster times than female athletes, and kayakers tend to outperform canoeists.

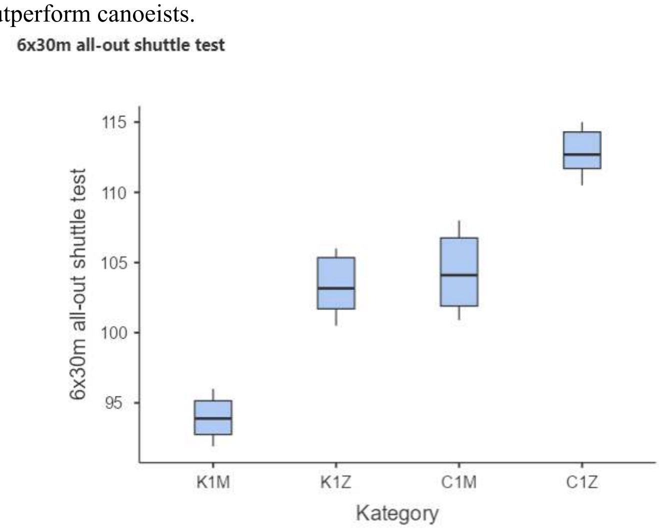

Figure 2 Graphical representation of the parameters in the flat-water test

Table 3 provides descriptive statistics for the performances of competitors across different canoe slalom categories during the Slovak Championships in Bratislava. Each category—K1 men (K1M), K1 women (K1W), C1 men (C1M), and C1 women (C1W)—included seven participants (n = 7).

In the K1M group, athletes recorded the fastest average time of 96.8 s (SD = 1.98), with individual results ranging from 94.0 to 99.1 s and a 95% confidence interval of 94.9 to 98.6 s. The K1W category showed a higher mean time of 106.0 s (SD = 3.78), with performances spanning from 101.0 to 111.0 s and a 95% confidence interval of 103.0 to 110.0 s. In the C1M category, the mean time was 107.0 s, with a standard deviation of 9.8 s, reflecting considerable variability among athletes. Times in this group ranged from 95.6 to 120.0 s, with a 95% confidence interval of 98.3 to 116.0 s. The C1W category exhibited both the slowest average time and the greatest spread of results, with a mean of 111.0 s (SD = 10.4), individual times between 97.8 and 126.0 s, and a 95% confidence interval of 101.0 to 120.0 s.

Overall, the pattern mirrors that observed in the flat-water shuttle test, with male athletes and kayakers performing faster and more consistently than female athletes and canoeists, while canoeists—particularly females—demonstrated the highest variability in performance.

Table 3 Descriptive parameters derived from competition in Bratislava

	K1M (n=7)	K1W (n=7)	C1M (n=7)	C1W (n=7)
X±SD (s)	96,8±1,98	106,0±3,78	107,0±9,8	111,0±10,4
Min (s)	94,0	101,0	95,6	97,8
Max (s)	99,1	111,0	120,0	126,0
CI 95% (s)	94,9-98,6	103,0-110,0	98,3-116,0	101,0-120,0

K1M, kayak men; K1W, kayak women; C1M, canoe men; X±SD, mean±standard deviation; CI 95% –95% of confidence interval.

Figure 3 presents a box plot illustrating the results of the white-water race across four canoe slalom categories: K1 men (K1M), K1 women (K1W), C1 men (C1M), and C1 women (C1W). The plot indicates that the fastest and most consistent performances were recorded by K1M athletes, who had the lowest median times and the narrowest range of results. K1 women (K1W) followed, showing higher median times and a wider spread of results, yet maintaining relatively stable performance overall. Considerable variability was observed in the C1 men (C1M) category, where median times were higher and the range of results broader, reflecting inconsistent performance within this group. Similarly, the C1 women (C1W) category demonstrated the slowest times and the largest dispersion, with median values indicating lower performance compared to the other categories. Overall, the data reinforce the previously observed trend: male athletes tend to achieve faster times than female athletes, and kayakers outperform canoeists while exhibiting less variability in their results.

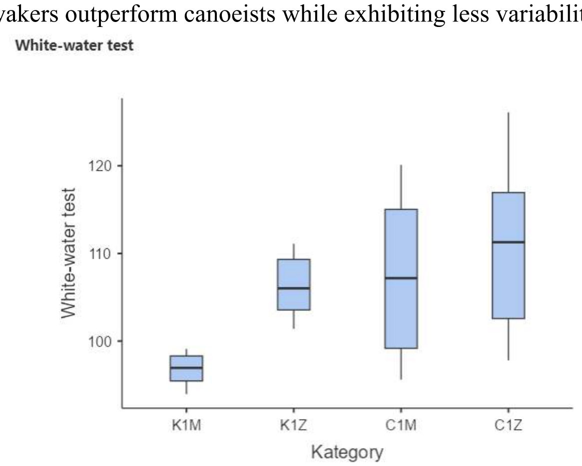

Figure 3 Graphical representation of the parameters in competition in Bratislava

Table 4 presents the results of the Pearson correlation analysis between performances in the 12x15 m all-out shuttle test and outcomes achieved at the Slovak Championships in Bratislava.

The analysis revealed a correlation coefficient of $r = 0.570$, indicating a moderately strong positive relationship between shuttle test results and competition performance. This suggests that athletes who recorded better (lower) times in the shuttle test generally performed better under competitive conditions. Based on Cohen's (1988) guidelines for interpreting r values—0.10–0.29 representing a small effect, 0.30–0.49 a moderate effect, and ≥0.50 a large effect—the observed correlation of $r = 0.570$ reflects a large effect, demonstrating a strong association between test and competition results. The finding was statistically significant ($p = 0.002$), with 26 degrees of freedom ($df = 26$) and a significance threshold of $\alpha < 0.05$.
These findings indicate that the 12x15 m all-out shuttle test could serve as a meaningful predictor of competitive performance in canoe slalom.

Table 4 Pearson correlations between flat-water AOT and competition

12x15 m all-out shuttle test	Slovak Championships in Bratislava	
	Pearson´s r	0,570**
	df	26
	p-value	0,002

Figure 4 illustrates the relationship between flat-water test performance and competition results using a dot plot with a regression line. Each grey dot represents an individual athlete, while the thick black line depicts the regression trend, showing that higher test times generally correspond to higher competition times. The grey shaded area surrounding the regression line represents the 95% confidence interval, reflecting the uncertainty around the estimated line. The widening of the interval at the lower and upper extremes indicates slightly lower confidence in the predictions for extreme test scores. Although a positive trend is evident, the scatter of points around the regression line indicates that the relationship is not perfectly linear, suggesting that additional factors may influence competitive outcomes. Overall, the plot confirms a positive correlation between flat-water test performance and race results.

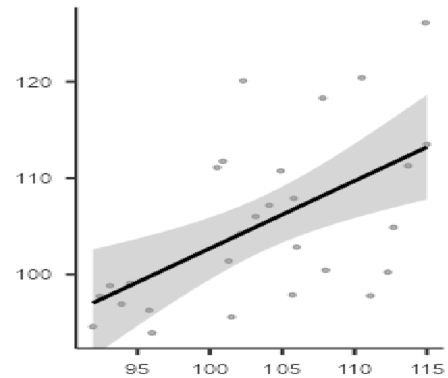

Figure 4 Graphical representation of Pearson correlations between flat-water AOT and competition

Discussion

This study provides new insights into the relationship between flat-water performance and competitive results in canoe slalom among youth athletes. The findings demonstrate a moderate to strong positive correlation between the 12 × 15 m all-out shuttle test and race outcomes, confirming that controlled flat-water tests can serve as meaningful predictors of competitive performance. These results emphasize the relevance of sport-specific testing for evaluating both technical and physical preparedness. Previous research supports this observation, as López-Plaza et al. (2017) and Baláš et al. (2020) demonstrated that short, specific tests on calm water—although not performed between gates-correlate strongly with competitive performance in kayakers. This confirms that a properly designed test can have high predictive value and directly reflect an athlete’s abilities in real racing conditions. The current study also highlights consistent performance differences across athlete categories. Male athletes and kayakers generally performed better and with less variability compared to female athletes and canoeists. This finding aligns with prior research by Alacid et al. (2015), who observed that gender and type of discipline significantly influence performance parameters. Such differences underscore the importance of considering athlete category when interpreting test results and applying them to training programs.

Furthermore, the study illustrates that controlled flat-water conditions effectively reflect key motor and technical abilities, such as balance, paddling efficiency, and rapid acceleration, which are essential for navigating competitive slalom courses. These findings build upon earlier work by Vajda and Piatrikova (2022) and Hunter et al. (2008), confirming that specific test protocols can provide objective, practical information for coaches aiming to monitor athlete development and optimize training. The results also demonstrate the practical utility of implementing regular flat-water testing. As Seiler (2010) points out, the optimal distribution of training load and its long-term periodization have a decisive influence on athletic progress. Incorporating specific tests at regular intervals can serve as an important tool for detecting stagnation, balancing training intensity with recovery, and preventing overtraining. Coaches can use such assessments to identify individual weaknesses, adjust training programs, and support long-term athletic development. Moreover, the observed correlation between test performance and competition results reinforces the idea that pre-season and mid-season assessments can be effective for tracking progression and predicting performance under the more complex and variable conditions of white-water courses. Overall, the findings of this study confirm that controlled flat-water tests provide reliable and actionable information for both athlete evaluation and training prescription. By highlighting the predictive value of these tests, the study contributes to a growing body of evidence supporting sport-specific assessment as a cornerstone of performance monitoring in youth canoe slalom.

Conclusion

Based on the findings, it is evident that the systematic inclusion of flat-water-specific testing is highly beneficial for youth canoe slalom athletes. Such testing provides an objective and reliable measure of both physical and technical abilities, enabling coaches to tailor training programs, focus on key performance determinants, and enhance the overall development of young athletes.

The study underlines that better results in flat-water testing are associated with superior competitive performance, supporting the notion that targeted diagnostics can guide training more effectively. Regular application of these assessments can also help detect performance stagnation early, optimize training loads, and contribute to long-term improvements in race outcomes. In conclusion, this research advances knowledge in the field of canoe slalom performance diagnostics and provides actionable recommendations for coaching practice. The integration of flat-water testing into routine training offers a strategic advantage for preparing young athletes, enhancing their technical-physical skills, and ultimately improving their success in this demanding Olympic sport. By highlighting the link between controlled testing and real-world competition, the study offers a foundation for more effective training approaches and sets the stage for further research in optimizing athlete development.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Alacid, F., Marfell-Jones, M., Muyor, J. M., López-Miñarro, P. A., & Martínez, I. (2015). Kinanthropometric comparison between young elite kayakers and canoeists. *Collegium antropologicum*, *39*(1), 119–124.

Baláš, J., Busta, J., Bílý, M., and Martin, A. (2020). Technical skills testing of elite slalom canoeists as a predictor of competition performance. *Int. J. Perform. Anal. Sport* 20, 870–878. doi: 10.1080/24748668.2020.1801200

Bartlett, R. (2007). *Introduction to sports biomechanics: Analysing human movement patterns* (2nd ed.). Routledge. https://doi.org/10.4324/9780203462027.

Bishop, D. (2008). An applied research model for the sport sciences. *Sports Medicine, 38*(3), 253–263. https://doi.org/10.2165/00007256-200838030-00005.

Bílý, M. (2012). *Performance aspects in canoe slalom* [in Czech]. Univerzita Karlova.

Busta, J., Bílý, M., & Suchý, J. (2021). *Fitness and somatic prerequisites in canoe slalom* [in Czech].

Buchtel, M. (2007). *The effect of visualization on athlete performance in canoe slalom* [in Czech]. Univerzita Karlova.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Hunter, A., Cochrane, J., & Sachlikidis, A. (2008). Canoe slalom competition analysis. *Sports Biomechanics*, *7*(1), 24–37. https://doi.org/10.1080/14763140701683155.

International Canoe Federation. (2022). *Canoe slalom – Disciplines of international canoe federation*. https://www.canoeicf.com/disciplines/canoe-slalom.

Kellmann, M. (2010). Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), 95–102. https://doi.org/10.1111/j.1600-0838.2010.01192.x.

López-Plaza, D., Alacid, F., Muyor, J. M., & López-Miñarro, P. Á. (2017). Sprint kayaking and canoeing performance prediction based on the relationship between maturity status, anthropometry and physical fitness in young elite paddlers. *Journal of sports sciences*, *35*(11), 1083–1090. https://doi.org/10.1080/02640414.2016.1210817.

Makovský, M. (2006). *The effect of reaction ability on performance in canoe slalom* [in Czech]. Univerzita Karlova.

Messias, L. H. D., Reis, I. G. M. D., Bielik, V., Garbuio, A. L. P., Gobatto, C. A., & Manchado-Gobatto, F. B. (2021). Association Between Mechanical, Physiological, and Technical Parameters With Canoe Slalom Performance: A Systematic Review. *Frontiers in physiology*, *12*, 734806. https://doi.org/10.3389/fphys.2021.734806.

Nibali, M., Hopkins, W. G., & Drinkwater, E. (2011). Variability and predictability of elite competitive slalom canoe-kayak performance. *European Journal of Sport Science, 11*(2), 125–130. https://doi.org/10.1080/17461391.2010.487121.

Pitsiladis, Y. P., Tanaka, M., Eynon, N., Bouchard, C., North, K. N., Williams, A. G., Collins, M., Moran, C. N., Britton, S. L., Fuku, N., Ashley, E., Klissouras, V., Lucia, A., Zhang, Y., de Geus, E. J. C., Delmonico, M. J., Gollnick, P. D., & Vlahovich, N. (2016). Athlome Project Consortium: A concerted effort to discover genomic and other "omic" markers of athletic performance. *Physiological Genomics, 48*(3), 183–190. https://doi.org/10.1152/physiolgenomics.00105.2015.

Seiler, S. (2010). What is best practice for training intensity and duration distribution in endurance athletes? *International Journal of Sports Physiology and Performance, 5*(3), 276–291. https://doi.org/10.1123/ijspp.5.3.276.

Vajda, M., & Piatrikova, E. (2021). Relationship Between Flat-Water Tests and Canoe Slalom Performance on 4 Different Grades of Water Terrain Difficulty. *International journal of sports physiology and performance*, *17*(2), 185–194. https://doi.org/10.1123/ijspp.2021-0115.

Vondra, J. (2016). *The influence of selected fitness factors on performance in canoe slalom* [in Czech]. Univerzita Karlova.

Zagatto, A. M., Beck, W. R., & Gobatto, C. A. (2009). Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. *Journal of strength and conditioning research*, *23*(6), 1820–1827. https://doi.org/10.1519/JSC.0b013e3181b3df32.

Zamparo P., Tomadini S., Didonè F., Grazzina F., Rejc E., Capelli C. (2006). Bioenergetics of a slalom kayak (K1) competition. *Int. J. Sports Med.* 27 (7), 546–552. doi:10.1055/s-2005-865922.