Kinanthropometric and Physical Characteristics of Elite Freestyle Paddlers

Sandro Dias[1,2]*, Inês Caetano[1] and Anthony J. Gorman[1]

[1]School of Sport and Exercise Science, University of Lincoln, Lincoln, UK, [2]Great Britain Freestyle Kayaking, Nottingham, UK

*Corresponding author: sdias@lincoln.ac.uk

ABSTRACT

The aim of this study was to explore the kinanthropometric and physiological profile of elite freestyle paddlers. A total of fifteen (male, n = 8; female, n = 7) elite GB Freestyle Kayak Team paddlers participating in the 2023 World Championship volunteered. Anthropometric data were collected on standing height, sitting height, arm span, and body mass. Additionally, field-based tests assessed several functionally relevant attributes: Leg and back flexibility was measured through the sit-&-reach test; handheld dynamometers measured bilateral handgrip strength and an isometric mid-thigh pull assessed lower limb and back strength; and overhead medicine ball throws were performed to gauge upper body power. Within and between-sex comparisons were explored using paired and independent samples t-tests respectively, and Hedges' g effect sizes were calculated to determine the magnitude of difference between conditions, reported as means ± SDs. Z-Scores for all parameters were individually calculated to assess participants in relation to grouped means. Male freestyle paddlers were taller and had greater sitting height and arm span than female paddlers. They were also functionally stronger and more powerful. Generally, freestyle paddlers have similar body proportions to slalom paddlers. Data from this study could be used as normative values for profiling, potentially outlining successful anthropometric and performance attributes. Even though freestyle paddling appears to depend heavily on strength and flexibility, more research is required to identify which performance metrics may be associated with better on-water freestyle performance.

Keywords: Canoeing, kayaking, paddling, performance, profiling.

INTRODUCTION

Freestyle paddling is a whitewater kayak or canoe discipline where competitors aim to accumulate points by performing acrobatic gymnastic and surf-style manoeuvres and tricks against a wave or other stationary river feature (McKenzie & Berglund, 2019). Competitions are contested by four types of boat: kayak, squirt boat, canoe decked, and open canoe. Like flatwater variations of paddling, the type of boat used for freestyle will determine the athlete's body position as kayakers and squirt boaters use a double-bladed paddle whilst seated with their legs out in front, whereas canoeists use a single blade while kneeling (McKenzie & Berglund, 2019).

In flatwater kayaking and canoeing, anthropometric attributes such as body height, sitting height, arm span, body mass, and body composition contribute to optimal performance (Hamano et al., 2015; López-Plaza et al., 2019; van Someren & Palmer, 2003). Similarly, physiological strength, power, and aerobic and anaerobic fitness have each been linked to successful flatwater paddling (Humphries et al., 2000; van Someren & Howatson, 2008; van Someren & Palmer, 2003). Although these characteristics have been associated with flatwater performance, no research has assessed such attributes for freestyle paddling. Despite using similar boats, as the demands of flatwater and freestyle paddling are distinct, both anthropometric and physiological profiles may also inherently differ. Anatomical size, upper body proportions, and flexibility might be important for freestyle success as they could each optimise reach relative to the boat, providing increased options for paddle placement, therefore contributing to more refined boat control. Strength and upper body power are required to overcome turbulent whitewater and accelerate the boat in the required direction for performing more advanced point-scoring moves. Thus, such measures should be assessed in elite freestyle paddling populations.

Therefore, the aim of this study was to explore the kinanthropometric and physiological characteristics of elite freestyle paddlers through several anthropometric and performance tests. Profiling freestyle paddlers could outline attributes for success, exploration of which may influence athlete selection processes, alongside informing training interventions that will promote necessary physiological adaptations to increase performance (Jeffreys, 2015; Thompson et al., 2020).

METHODS

Participants

A total of fifteen (male, n = 8; female, n = 7) elite GB Freestyle Kayak Team paddlers that competed in the 2023 World Championships volunteered to participate in this study. Inclusion criteria were that participants were free from illness and injury and were competing at international level at the time of the study. Institutional Ethical Committee approval was granted for all experimental procedures prior to study commencement, and each participant completed a Physical Activity and Medical Questionnaire and provided informed written consent before taking part.

Experimental Procedures

All tests were conducted during a national team selection training camp in preparation for the World Championships. As the demands of freestyle paddling are generally anaerobic and require physical qualities such as strength and power, it is hypothesised that alongside anthropometry, measures of flexibility, grip strength, leg and back strength, and upper body power contributed a suitable battery of initial profiling tests. Furthermore, these have also been adopted by other paddle sport-related researchers (e.g., Hamano et al., 2015; López-Plaza et al., 2019; van Someren & Palmer, 2003). After a warm-up consisting of 5-minutes general aerobic activity and 5-minutes of specific joint activation and mobilisation activities, a series of field-based tests to measure body dimensions and physical fitness status were completed as follows. Instructions and demonstrations were provided before each test, and participants were allowed familiarisation periods if needed.

Anthropometry

Anthropometric data was collected following the International Society for the Advancement of Kinanthropometry guidelines (Esparza-Ros et al., 2019). Body mass was taken using a balance beam scale (700; seca, Germany). For standing height, participants stood on the baseplate of a stadiometer (213; seca), with heels against the vertical backboard, legs together, arms by their sides and head in the Frankfurt horizontal plane. To measure sitting height, with their hip and knee angles at 90 degrees, arms rested at their sides, and the head in the Frankfurt horizontal plane, participants sat on the baseplate of a stadiometer (HM-250P; Marsden, UK), which was mounted atop a measurement box. Arm span was determined as the distance across the back between the tips of the middle fingers (non-elastic measuring tape, Silverline, UK) with the shoulders at 90 degrees abduction, fully extended elbows and palms facing forwards.

Physical Fitness Measurements

To determine back and leg flexibility, sit-&-reach tests were performed. Test-retest reliability for sit-&-reach tests has been reported as excellent, with intraclass correlation coefficients (ICC) > 0.89 (Ayala et al., 2012). Participants were seated with knees in full extension, ankles in a neutral position and, without shoes, heels against a testing box (Bodycare, UK). With one hand placed on top of the other and maintaining knee and ankle joint positions throughout, the objective was to slowly reach as far forward as possible across the surface of the testing board, holding the final position for 3 seconds. The distance reached by the fingertips from a zero-mark aligned to the plantar surface was measured. Thus, positive values indicated a reach beyond the toes. After three repetitions, the maximum value was considered representative (López-Miñarro et al., 2012). Sit-&-reach measurements in this study showed an ICC of 0.94 for test-retest reliability and a coefficient of variation (CV) of 0.22.

A digital handgrip dynamometer (T.K.K.5002; Takei Scientific Instruments Co., Ltd; Tokyo, Japan) was used to bilaterally assess grip strength. Excellent ICC have been reported when assessing peak grip force of both hands (left = 0.96, right = 0.91; Balogun et al., 1991). While standing, with the elbow fully extended, the shoulder joint adducted and rotated neutrally, and the forearm and wrist joint kept in a neutral position, participants gripped the dynamometer with maximal volitional effort for 5 seconds whilst receiving verbal encouragement. A total of two trials per hand were conducted in a randomised order, with a two-minute break between tests (Balogun et al., 1991). An isometric mid-thigh pull (IMTP) test measured the strength of the legs and the back. This is a highly reliable test of peak force that is strongly correlated with 1-repetition maximum deadlift performance (ICC = 0.98; r = 0.88, $p \leq 0.05$; De Witt et al., 2018). Participants stood on a leg and back strength dynamometer (T.K.K.5401; Takei) with their feet parallel and hip-width apart, and with slight knee flexion. The metallic dynamometer bar, which was held using a mixed grip, was aligned to the mid-thigh. The participants received verbal encouragement during three 5-second trials, each of which were separated by two minutes of rest (Balogun et al., 1991; Coldwells et al., 1994). For both strength tests, the highest readings across trials were recorded. Data in this study showed high test-retest reliability (handgrip left ICC = 0.95, CV = 0.22; handgrip right ICC = 0.81, CV = 0.18; IMTP ICC = 0.92; CV = 0.22).

Upper body power was determined by the overhead medicine ball throw (OMBT; test-retest reliability ICC = 0.96, Gabbett & Georgieff, 2007). Participants were requested to overhead throw a 3-kg medicine ball as far forward as possible, from a standing arm-relaxed position. Three attempts were performed, recorded to the nearest centimetre and the highest value was recorded as the representative value (Gabbett & Georgieff, 2007; López-Plaza et al., 2019). Values in this study showed an ICC of 0.91 for retest reliability and CV of 0.21.

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics (Version 28). All data was normally distributed (Shapiro-Wilk, $p > 0.05$). Within and between-sex comparisons were explored using paired and independent samples t-tests respectively, and Hedges' g effect sizes were calculated to determine the magnitude of difference between conditions (where < 0.20 was trivial; 0.20 – 0.59 small; 0.60 – 1.19 moderate; 1.20 – 1.99 large; and ≥ 2.00 very large) (Hopkins et al., 2009). Z-Scores for all parameters were individually calculated to assess each participant in relation to their group mean. For all statistical tests, data was reported as means ± SDs with $\alpha = 0.05$.

RESULTS

Anthropometrically, the male paddlers were taller and had greater sitting height and arm span than the female paddlers (each $p < 0.05$; each g > 1.89; Table 1). For males, arm span was more than double the sitting height whereas this was not the case for females (M, 202 ± 7% v F, 190 ± 7%; $p < 0.01$, g = 2.41; Table 1). Mass did not significantly differ between sexes despite a moderate effect size ($p = 0.07$; g = 1.03), and Body Mass Index (BMI)

Table 1. Physical Parameters of elite freestyle paddlers.

	Male (n = 8)	Female (n = 7)	Hedges' g
Age (years)	20.0 ± 4.6	21.3 ± 7.5	0.75
Body Mass (kg)	70.76 ± 9.28	61.27 ± 9.20	1.03
Standing Height (m)	1.78 ± 0.06	1.63 ± 0.05*	2.58
Sitting Height (m)	0.93 ± 0.03	0.87 ± 0.02*	1.89
Arm Span (m)	1.87 ± 0.07	1.65 ± 0.06*	3.47
Arm Span (% Sitting Height)	202 ± 7	190 ± 7*	2.41
BMI (kg/m²)	22.23 ± 1.65	22.86 ± 2.94	0.27
Sit-&-Reach (cm)	26.7 ± 6.7	32.1 ± 5.5	0.87
IMTP (kg)	151.80 ± 17.27	110.25 ± 23.12*	2.06
OMBT (m)	6.50 ± 0.89	4.61 ± 0.37*	2.71
Handgrip Right (kg)	45.08 ± 5.67	35.17 ± 5.27*	1.81
Handgrip Left (kg)	45.45 ± 7.48	34.21 ± 5.73*	1.67

*Notes: BMI = Body mass index; IMTP = Isometric mid-thigh pull; OMBT = Overhead medicine ball throw; * = significant between-sex difference (p < 0.05); † = significant within-sex bilateral difference (p < 0.05); g < 0.20 trivial, 0.20–0.59 small, 0.60–1.19 moderate, 1.20–1.99 large, and ≥ 2.00 very large* was similarly comparable (M, 22.23 ± 1.65 kg/m^2 v F, 22.86 ± 2.94 kg/m^2; p = 0.61, g = 0.27; Table 1). Additionally, sit-&-reach flexibility was consistent (M, 26.7 ± 6.7 cm v F, 32.1 ± 5.5 cm; p = 0.12, g = 0.87; Table 1), yet the male paddlers were stronger and more powerful (IMTP: p < 0.01, g = 2.06; OMBT: p < 0.01, g = 2.71; Table 1). Males also had greater absolute hand-grip strength than females on both the right (p < 0.01, g = 1.81) and left sides (p = 0.01, g = 1.67), however within-sex comparisons revealed no statistically significant bilateral differences, and effect sizes were small and trivial in magnitude (M, p = 0.79, g = 0.55; F, p = 0.13, g = 0.17; Table 1). Figures 1 and 2 show Z-score values for each measured parameter for male and female paddlers respectively.

DISCUSSION

This is the first study to establish the kinanthropometric and physical characteristics of

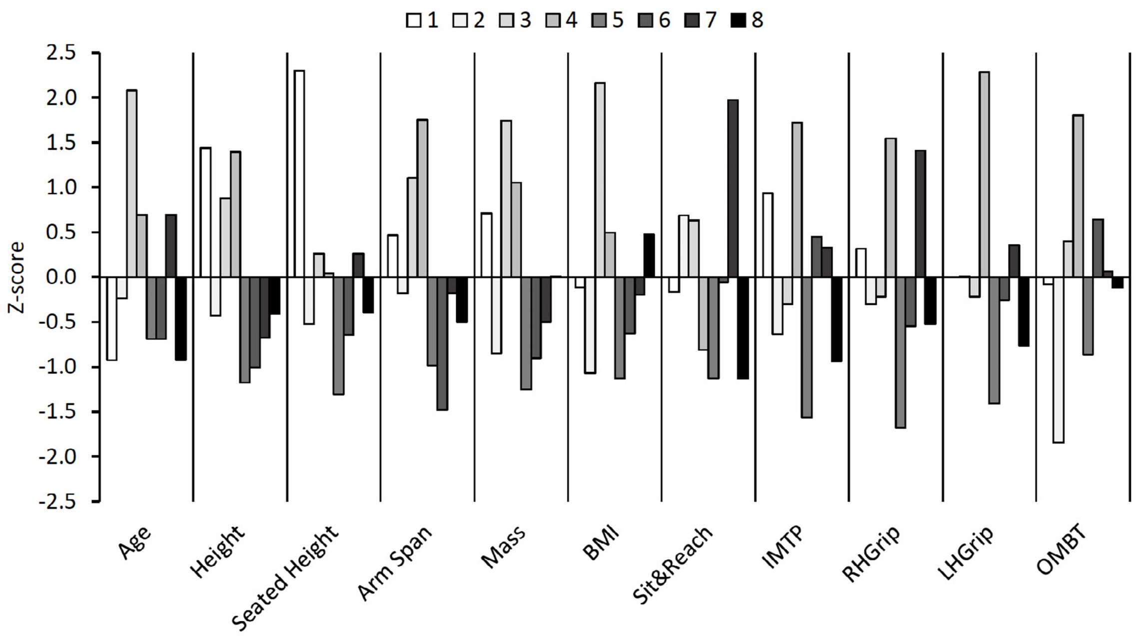

Figure 1. Z-scores for the measured parameters of male freestyle paddlers.
Note: BMI = Body mass index; IMTP = Isometric mid-thigh pull; RH = Right hand; LH = Left hand; OMBT = Overhead medicine ball throw

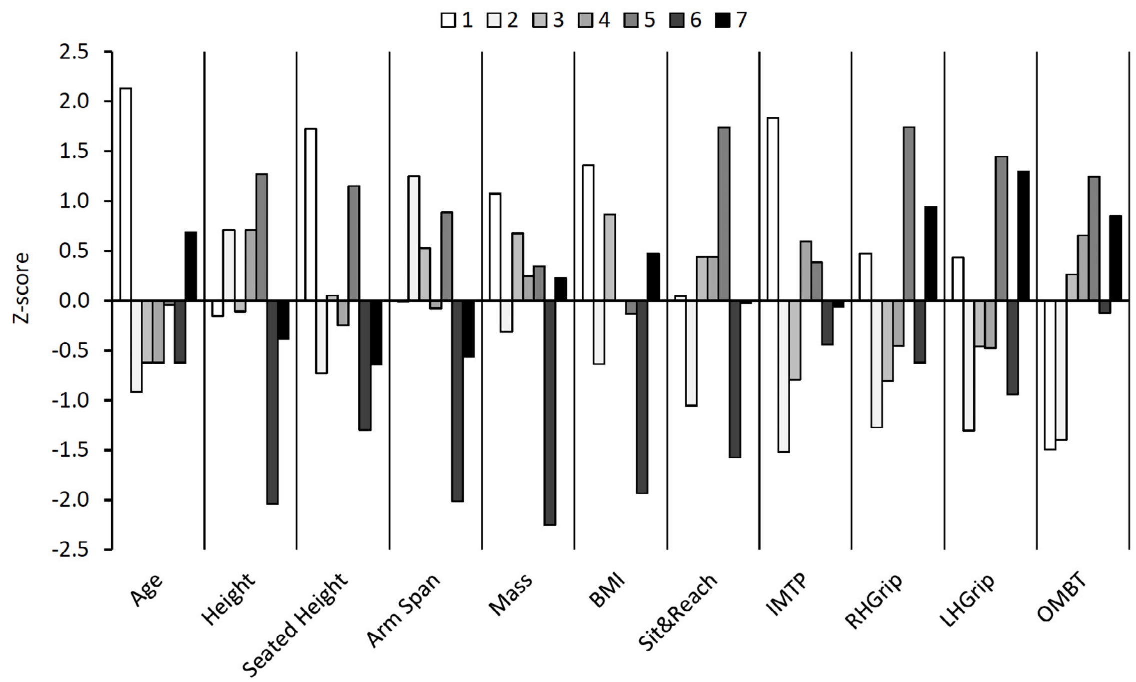

Figure 2. Z-scores for the measured parameters of female freestyle paddlers.
Note: BMI = Body mass index; IMTP = Isometric mid-thigh pull; RH = Right hand; LH = Left hand; OMBT = Overhead medicine ball throw

freestyle paddlers. As common anthropometric attributes are important for the identification of talented flatwater paddlers (Ackland et al., 2003; Alacid et al., 2011; Ridge et al., 2007; López-Plaza et al., 2017b), the results presented here provide normative data that could be used as the basis for determining an optimal freestyle paddling profile.

Compared to other paddle sports, results of this study indicated that freestyle paddlers are anthropometrically smaller and lighter than heavyweight elite rowers (Busta et al., 2023), outrigger canoeists (Humphries et al., 2000), and both flatwater sprint kayakers and canoeists (Ackland et al., 2003). Both male and female heavyweight rowers are comparably taller (M rowers, 1.90 ± 0.07 m v freestylers 1.78 ± 0.06 m; F rowers, 1.78 ± 0.05 m v freestylers, 1.63 ± 0.05 m), and have greater mass (M rowers, 91 ± 8.8 kg v freestylers 70.76 ± 9.28 kg; F rowers, 76.4 ± 5.5 kg v freestylers, 61.27 ± 9.20 kg) and BMI (M rowers, 25 ± 2 kg/m^2 v freestylers 22.23 ± 1.65 kg/m^2; F rowers, 24.1 ± 1.7 kg/m^2 v freestylers, 22.86 ± 2.94 kg/m^2) than freestyle paddlers (Busta et al., 2023). Similarly, Ackland et al. (2003) reported Olympic sprint canoeists and kayakers to have heights (M, 1.84 ± 0.06 m; F, 1.70 ± 0.06 m) and masses (M, 85.2 ± 6.2 kg; F, 67.7 ± 5.7 kg) that were each greater than those of these elite freestyle paddlers (Table 1). Compared to freestyle paddlers, male outrigger canoeists are similar in standing height (1.75 ± 0.05 m) and have a similar arm span (1.78 ± 0.07 m), however male outrigger canoeists appear to have greater seated height (1.00 ± 0.02 m) and greater mass (80 ± 5 kg) than male freestyle paddlers (Humphries et al., 2000). Following a similar trend, female outrigger canoeists' standing height and arm span were comparable to freestyle paddlers (1.68 ± 0.05 m; 1.70 ± 0.05 m, respectively) yet the outrigger canoeists had both greater seated height and mass (0.97 ± 0.03 m; 70 ± 8 kg, respectively; Humphries et al., 2000) (Table 1).

The kinanthropometric characteristics of freestyle paddlers are more aligned to the body size data of slalom kayakers and canoeists (Ridge et al., 2007; Coufalová et al., 2021), possibly due to the similar upper-body agility requirements of slalom paddle sports to freestyle paddling in comparison to rowing. Anthropometrically, both these male and female freestyle paddlers (Table 1) had arm spans and seated heights comparable to slalom kayak and canoe paddlers (M, 1.85 ± 0.06 m; 0.95 ± 0.04 m; F, 1.65 ± 0.07 m; 0.88 ± 0.03 m, respectively; Coufalová et al., 2021) and similar BMI (M, 23.1 ± 1.5 kg/m^2 v 22.2 ± 1.6 kg/m^2; F, 21.8 ± 1.4 kg/m^2 v 22.9 ± 2.9 kg/m^2; Coufalová et al., 2021). Additionally, both the standing height and mass of these elite male and female freestyle paddlers more closely resemble those of slalom canoeists and kayakers competing at Olympic (Ridge et al., 2007) rather than European level (Coufalová et al., 2021). While this could possibly be a level-defining attribute, it would require further investigation.

This is the first study to measure leg and back flexibility in male and female freestyle paddlers and no previous studies have assessed this parameter in similar age group or elite slalom paddling populations. However, male freestyle padders are notably less flexible than male National canoe polo players, who have increased sit-&-reach values of 35.9 ± 5.9 cm (Alves et al., 2013). The handgrip strength of both male heavyweight and lightweight rowers is greater in magnitude than that of male freestyle paddlers, however, all are bilaterally similar (Table 1; Busta et al., 2023). In contrast, handgrip strength of female freestyle paddlers for both hands was found to be less than that of heavyweight elite female rowers but greater than that of lightweight elite female rowers (Busta et al., 2023). There is a current paucity of literature reporting the IMTP across paddle-sports. For male freestyle paddlers, isometric leg and back strength was comparably lower than that of surf boat rowers (151.80 ± 17.27 kg v 196.43 ± 15.63 kg; Fell & Gaffney, 2001). Strength values from the IMTP test for female paddlers remains unreported except for the current study. As a predictor of upper limb power, the OMBT test was employed in compliance with earlier research findings (e.g., López-Plaza et al., 2019). However, previous studies that have adopted this test have evaluated this physical characteristic only in juvenile paddlers (~13 years; López-Plaza et al., 2017; 2017b; 2019). Interestingly, values for measures of upper body power from both young males and young females were comparable to the adult paddlers of this study, each attaining similar 3-kg OMBT displacements (Table 1), however, comparisons between juveniles and adults should be made with caution given maturation status.

The nature of freestyle paddling and the provision of on-water facilities means that athletes must travel to various dedicated locations to access different river features on which they can develop their on-water skills. As such, they are generally without access to specialised sports science and clinical equipment to regularly assess kinanthropometric and strength-based metrics as markers of performance. Thus, for

Table 2. Reference values for anthropometric parameters from comparable male samples.

Study	Sample Characteristics	Parameter	Mean ± SD
Busta et al., 2023	Elite Heavyweight Male Rowers (n = 31)	Age (years)	25.6 ± 5.5
		Body Mass (kg)	91.0 ± 8.8
		Height (m)	1.90 ± 0.06
		BMI (kg/m^2)	25 ± 2
		Sitting Height (m)	0.90 ± 0.04
		Arm Span (m)	1.93 ± 0.07
	Elite Lightweight Male Rowers (n = 15)	Age (years)	28.8 ± 6.5
		Body Mass (kg)	72.3 ± 1.2
		Height (m)	1.81 ± 0.04
		BMI (kg/m^2)	22.1 ± 1.1
		Sitting Height (m)	0.87 ± 0.03
		Arm Span (m)	1.83 ± 0.06
Coufalová et al., 2021	European Slalom Canoe and Kayak Male Paddlers (n = 48)	Age (years)	24.3 ± 4.8
		Body Mass (kg)	74.8 ± 6.2
		Height (m)	1.80 ± 0.05
		BMI (kg/m^2)	23.1 ± 1.5
		Sitting Height (m)	0.95 ± 0.04
		Arm Span (m)	1.85 ± 0.06

Table 3. Reference values for anthropometric parameters from comparable female samples.

Study	Sample Characteristics	Parameter	Mean ± SD
Busta et al., 2023	Elite Heavyweight Female Rowers (n = 16)	Age (years)	23.6 ± 3
		Body Mass (kg)	76.4 ± 5.5
		Height (m)	1.78 ± 0.05
		BMI (kg/m^2)	24.1 ± 1.7
		Sitting Height (m)	0.85 ± 0.03
		Arm Span (m)	1.79 ± 0.05
	Elite Lightweight Female Rowers (n = 6)	Age (years)	22.5 ± 1.4
		Body Mass (kg)	59 ± 3.1
		Height (m)	1.70 ± 0.04
		BMI (kg/m^2)	19.9 ± 0.4
		Sitting Height (m)	0.82 ± 0.3
		Arm Span (m)	1.72 ± 0.03
Coufalová et al., 2021	European Slalom Canoe and Kayak Female Paddlers (n = 26)	Age (years)	23.7 ± 6.9
		Body Mass (kg)	58.8 ± 4.6
		Height (m)	1.64 ± 0.05
		BMI (kg/m^2)	21.8 ± 1.4
		Sitting Height (m)	0.88 ± 0.03
		Arm Span (m)	1.65 ± 0.07

applicability, field-based measures were adopted as part of this study. Furthermore, in addition to analyses of the upper body, with the human-boat interface being predominantly controlled by the lower body, kinanthropometric measures should be extended to the lower body and should include measures of lower limb strength and power to compliment the upper body characteristics described here. As this was a highly specific target population, generalisation of the findings of this paper should be made carefully, however, given the numbers of elite freestyle paddlers this sample is still representative of this population.

CONCLUSION

This study provides a preliminary summary of key kinanthropometric and physical characteristics of freestyle paddlers. Differences are apparent between male and female freestyle paddlers, such that males are taller and functionally stronger than their female counterparts. This should be considered if determining profiles. However, from a general anthropometric viewpoint, body size and proportions of freestyle paddlers are typically like those of slalom paddlers (Ridge et al., 2007; Coufalová et al., 2021), which are smaller and lighter than those of sprint paddlers and rowers. It could be hypothesized therefore, that larger body sizes might be detrimental to freestyle performance due to the manoeuvrability demands of whitewater paddling, yet this assumption would require investigation. Nevertheless, strength and conditioning coaches should carefully examine any changes to the athlete's body size when planning and monitoring interventions. Strength and flexibility are two physical and neuromuscular attributes that appear to be important in paddle sports, especially in freestyle where competitive runs are limited to 45-seconds, and further research should be carried out to confirm the relationship between the anthropometric and strength-based metrics measured here and on-water performance. Additionally, examination of any kinanthropometric differences between elite freestyle kayakers and freestyle canoeists would elucidate further benchmarking and profiling.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ACKNOWLEDGEMENTS

The authors would like to thank Jennifer Horn for helping with data collection and all GB Freestyle staff and athletes for their cooperation in making this possible.

REFERENCES

1. Ackland, T. R., Ong, K. B., Kerr, D. A., & Ridge, B. (2003). Morphological characteristics of Olympic sprint canoe and kayak paddlers. Journal of Science and Medicine in Sport, 6(3), 285-294. https://doi.org/10.1016/s1440-2440(03)80022-1
2. Alacid, F., Marfell-Jones, M., López-Miñarro, P. A., Martínez, I., & Muyor, J. M. (2011). Morphological Characteristics of Elite Young Paddlers. Journal of Human Kinetics, 27, 95-110. https://doi.org/0.2478/v10078-011-0008-y
3. Alves, C. R. R., Pasqua, L., Artioli, G. G., Roschel, H., Solis, M., Tobias, G., Klansener, C., Bertuzzi, R., Franchini, E., Junior, A. H. L., & Gualano, B. (2012). Anthropometric, physiological, performance, and nutritional profile of the Brazil National Canoe Polo Team. Journal of Sports Sciences, 30(3), 305-311. https://doi.org/10.1080/02640414.2011.638086
4. Ayala, F., Sainz de Baranda, P., de Ste Croix, M., & Santonja, F. (2012). Fiabilidad y Validez de las Pruebas sit-and-reach: Revisión Sistemática. Revista Andaluza de Medicina Del Deporte, 5(2), 57–66. https://doi.org/10.1016/s1888-7546(12)70010-2
5. Balogun, J. A., Akomolafe, C. T., & Amusa, L. O. (1991). Grip strength: Effects of testing posture and elbow position. Archives of Physical Medicine and Rehabilitation, 72(5), 280-283. https://doi.org/10.5555/uri:pii:000399939190241A
6. Busta, J., Hellebrand, J., Kinkorová, I., & Macas, T. (2023). Morphological and hand grip strength characteristics and differences between participants of the 2022 World Rowing Championship. Frontiers in Sports and Active Living, 5. https://doi.org/10.3389/fspor.2023.1115336
7. Coldwells, A., Atkinson, G., & Reilly, T. (1994). Sources of variation in back and leg dynamometry. Ergonomics, 37(1), 79-86. https://doi.org/10.1080/00140139408963625
8. Coufalová, K., Busta, J., Cochrane, D. J., & Bíly, M. (2021). Morphological characteristics of European slalom canoe and kayak paddlers. International Journal of Morphology, 39(3), 896-901. https://doi.org/10.4067/S0717-95022021000300896
9. De Witt J. K., English K. L., Crowell J. B., Kalogera K. L., Guilliams M. E., Nieschwitz B. E., Hanson A.M., Ploutz-Snyder L. L. (2018). Isometric midthigh pull reliability and relationship to deadlift one repetition maximum. Journal of Strength and Conditioning Research, 32(2):528–533. https://doi.org/10.1519/JSC.0000000000001605

10. Esparza-Ros, F., Vaquero-Cristobal, R., Marfell-Jones, M., & International Society for Advancement of Kinanthropometry (2019). International standards for anthropometric assessment (2019 ed.). International Society of Advancement of Kinanthropometry (ISAK).
11. Fell, J. W., & Gaffney, P. T. (2001). Physiological profiles of Australian surf boat rowers. Journal of Science and Medicine in Sport, 4(2), 188-195. https://doi.org/10.1016/S1440-2440(01)80029-3
12. Gabbett, T., & Georgieff, B. (2007). Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. The Journal of Strength and Conditioning Research, 21(3), 902-908. https://doi.org/10.1519/R-20616.1
13. Hamano, S., Ochi, E., Tsuchiya, Y., Muramatsu, E., Suzukawa, K., & Igawa, S. (2015). Relationship between performance test and body composition/ physical strength characteristic in sprint canoe and kayak paddlers. Open Access Journal of Sports Medicine, 6, 191-199. https://doi.org/10.2147/OAJSM.S82295
14. Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. Medicine and Science in Sports & Exercise, 41(1), 3-12. https://doi.org/10.1249/MSS.0b013e31818cb278
15. Humphries, B., Abt, G. A., Stanton, R., & Sly, N. (2000). Kinanthropometric and physiological characteristics of outrigger canoe paddlers. Journal of Sports Sciences, 18(6), 395–399. https://doi.org/10.1080/02640410050074322
16. Jeffreys, I. (2015). Evidence-based practice in strength and conditioning: reality or fantasy. Professional Strength & Conditioning, 39, 7-14.
17. López-Miñarro, P. A, Vaquero-Cristóbal, R., Muyor, J. M., Alacid, F., & Isorna, M. (2012). Validez de criterio del test sit-and-reach como medida de la extensibilidad isquiosural en piragüistas. (Criterion-related validity of the sit-and-reach test as a measure of hamstring extensibility in paddlers). Cultura, Ciencia y Deporte, 7(20), 95-101. https://doi.org/10.12800/ccd.v7i20.55
18. López-Plaza, D., Alacid, F., Muyor, J. M., & López-Miñarro, P. Á. (2017). Differences in anthropometry, biological age and physical fitness between young elite kayakers and canoeists. Journal of Human Kinetics, 57, 181–190. https://doi.org/10.1515/hukin-2017-0059
19. López-Plaza, D., Alacid, F., Muyor, J. M., & López-Miñarro, P. Á. (2017b). 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
20. López-Plaza, D., Alacid, F., Rubio-Arias, J. Á., López-Miñarro, P. Á., Muyor, J. M., & Manonelles, P. (2019). Morphological and physical fitness profile of young female sprint kayakers. Journal of Strength and Conditioning Research, 33(7), 1963–1970. https://doi.org/10.1519/JSC.0000000000002511
21. McKenzie D., & Berglund, B. (2019). Handbook of Sports Medicine and Science: Canoeing. Wiley Blackwell. https://doi.org/10.1002/9781119097198
22. Ridge, B. R., Broad, E. M., Kerr, D. A., & Ackland, T. (2007). Morphological characteristics of Olympic slalom canoe and kayak paddlers. European Journal of Sport Science, 7(2), 107-113. https://doi.org/10.1080/17461390701478357
23. Thompson, S.W., Rogerson, D., Bell, L., & Hembrough, D. (2020). The challenges of collaborative working: bridging the gap between research and practice. International Universities Strength and Conditioning Association Journal, 1(1). https://doi.org/10.47206/iuscaj.v1i1.8
24. van Someren, K. A., & Howatson, G. (2008). Prediction of flatwater kayaking performance. International Journal of Sports Physiology and Performance, 3(2), 207–218. https://doi.org/10.1123/ijspp.3.2.207
25. van Someren, K. A., & Palmer, G. S. (2003). Prediction of 200-m sprint kayaking performance. Canadian Journal of Applied Physiology, 28(4), 505–517. https://doi.org/10.1139/h03-039