Nofriyandi Nofriyandi

8 Desember 2025 JSA Asmuddin 399_409

Artikel Gunadi

Document Details

Submission ID

trn:oid:::3618:124453529

Submission Date

Dec 14, 2025, 8:50 PM GMT+7

Download Date

Dec 14, 2025, 9:00 PM GMT+7

File Name

8 Desember 2025 JSA Asmuddin 399_409.pdf

File Size

812.3 KB

11 Pages

6,340 Words

38,244 Characters

9% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography

Exclusions

- 8 Excluded Sources

Match Groups

35 Not Cited or Quoted 7%
Matches with neither in-text citation nor quotation marks

13 Missing Quotations 3%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

7% Internet sources
4% Publications
6% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **35** Not Cited or Quoted 7%
  Matches with neither in-text citation nor quotation marks
- **13** Missing Quotations 3%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

7% Internet sources
4% Publications
6% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Student papers	Tarleton State University on 2025-06-06	<1%
2	Student papers	University of Michigan Flint on 2025-12-06	<1%
3	Internet	repositorio.ucam.edu	<1%
4	Internet	mdpi-res.com	<1%
5	Internet	www.frontiersin.org	<1%
6	Student papers	Universitas Islam Riau on 2025-08-05	<1%
7	Internet	www.mdpi.com	<1%
8	Internet	louisdl.louislibraries.org	<1%
9	Internet	doaj.org	<1%
10	Student papers	STKIP PGRI Sumenep on 2025-11-17	<1%

11 Student papers
bayreuth on 2025-06-03 <1%

12 Internet
www.scirp.org <1%

13 Student papers
St. Mary's College Twickenham on 2017-04-07 <1%

14 Internet
brieflands.com <1%

15 Internet
link.springer.com <1%

16 Internet
pdfs.semanticscholar.org <1%

17 Internet
pmc.ncbi.nlm.nih.gov <1%

18 Internet
research.vu.nl <1%

19 Internet
researchonline.jcu.edu.au <1%

20 Student papers
University of Edinburgh on 2023-04-27 <1%

21 Internet
gala.gre.ac.uk <1%

22 Internet
jurnal.sainsglobal.com <1%

23 Internet
sportedu.org.ua <1%

24 Internet
www.siz-au.com <1%

25 Student papers

Buckinghamshire Chilterns University College on 2023-06-29 <1%

26 Student papers

Chapman University on 2021-10-14 <1%

27 Publication

Hisashi Ukawa, Ryo Horie, Kai Ataka, Yuki Matsumoto. "Genetic testing drives a d... <1%

28 Publication

Wang Xiangyu, Wu Hao. "Data-augmented machine learning for personalized car... <1%

29 Internet

id.scribd.com <1%

30 Internet

kipdf.com <1%

31 Internet

ludum.com <1%

32 Internet

pea.lib.pte.hu <1%

33 Internet

verjournal.com <1%

34 Internet

www.scahperd.org <1%

35 Publication

Zoltan Alfőldi, Krzysztof Borysławski, Ferenc Ihasz, Imre Soós, Robert Podstawski.... <1%

Journal Sport Area
http://journal.uir.ac.id/index.php/JSP
Vol. 10. No. 3. December, (2025)

Physical fitness and anthropometric correlates of 500 m rowing performance in Indonesian athletes

Asmuddin[1abcd,*], La Ode Maklum Sabrin[2bcd], Bogy Restu Ilahi[3cde], Doni Pranata[4ab], & Amran[5abc]

Universitas Halu Oleo, Indonesia[1]
Universitas Sembilanbelas November, Indonesia[2]
Universitas Bengkulu, Indonesia[3]
Universitas Tanjungpura, Indonesia[4]
Universitas Negeri Yogyakarta, Indonesia[5]

Received 13 May 2025; Accepted 09 December 2025; Published 14 December 2025
Ed 2025; *10*(3): 412-422

ABSTRACT

Background: Rowing performance is shaped by athletes' physical fitness and anthropometric characteristics, yet evidence from Indonesian rowing populations remains scarce. This gap is critical as declining performance in Kendari highlights the need to identify key predictors of 500 m rowing performance to inform more targeted, evidence-based training programs. **Objectives**: This study aimed to examine the relationship between physical ability, anthropometric characteristics, and 500 m rowing performance among male national rowing athletes at PPLP Kendari. **Methods**: A correlational quantitative design with a cross-sectional approach was employed. Thirty-nine male athletes aged 15-25 years were purposively selected from a total population of 60 based on inclusion criteria, including active participation in centralized training for at least six months, injury-free status, and official registration during the 2024 training season. Data were collected using standardized anthropometric and physical ability tests. Statistical analyses were conducted using descriptive statistics and multiple regression, with model assumptions confirmed (Kolmogorov-Smirnov, $p > 0.05$; VIF = 1.12; condition index = 8.5). **Findings/Results**: The regression analysis revealed a significant model ($F(2,36) = 6.619$, $p = 0.004$), explaining 51.9% of the variance in 500 m rowing performance ($R^2 = 0.519$, SEE = 4.4 s). Anthropometric variables contributed 17.7% ($R^2 = 0.177$) and physical ability variables 16.2% ($R^2 = 0.162$), indicating that the combined model provided stronger explanatory power. **Conclusion**: Both anthropometric and physical ability factors demonstrated a moderate positive correlation with rowing performance. The findings emphasize the combined influence of physique and conditioning in achieving optimal rowing outcomes. This study contributes empirical evidence on the determinants of rowing success among Indonesian athletes and offers practical insights for designing targeted and evidence-based training programs.

Keywords: Physical ability; body anatomy; strength; rowing

https://doi.org/10.25299/sportarea.2025.vol10(3).22416

Corresponding Author: Asmuddin, Department of Physical Education, Faculty of Teacher Training and Education, Universitas Halu Oleo, Kendari, Indonesia
asmuddin@uho.ac.id

How to Cite: Asmuddin, Sabrin, L. O. M., Ilahi, B. R., Pranata, D., & Amran. (2025). Physical fitness and anthropometric correlates of 500 m rowing performance in Indonesian athletes. *Journal Sport Area*, *10*(3), 412-422. https://doi.org/10.25299/sportarea.2025.vol10(3).22416

Authors' Contribution: a – Study Design; b – Data Collection; c – Statistical Analysis; d – Manuscript Preparation; e – Funds Collection

INTRODUCTION

Rowing is a power endurance sport performed across rivers, lakes, and open waters, requiring athletes to generate coordinated propulsive forces through the use of oars and a sliding seat system (Agius et al., 2023; Sebastia-Amat et al., 2020; Stadler et al., 2020). Internationally, the sport is categorized into canoeing, rowing, and dragon boat racing governed by the ICF, FISA, and IDBF respectively while in Indonesia these disciplines are jointly overseen by the Indonesian Rowing and Canoeing Association (PODSI). Within performance analysis, the 500 m rowing test is frequently used as an indicator of sprint capability and power endurance output; however, classifying this measure as "strength" is inaccurate unless accompanied by direct strength assessments such as 1RM leg press or bench pull.

Competitive rowing consists mainly of sculling and sweep rowing (Wychowański & Baca, 2018). In sculling, athletes use two oars and apply bilateral propulsive forces, whereas sweep rowing requires a single oar with asymmetric loading patterns supported by a fixed oar rig system (Yuliawati et al., 2022). Across both modalities, performance relies heavily on effective coordination of the legs, trunk, and upper limbs, making anthropometric attributes and physical fitness critical components of success (López-Plaza et al., 2017; Penichet-Tomás et al., 2019). Rowing is widely recognized as a technically demanding power-endurance discipline in which optimal boat speed depends on the harmonization of posture, equipment mechanics, rhythm, and physiological output (Grima et al., 2023; Mpimis et al., 2023). Athletes with advantageous morphology particularly greater body height, arm span, limb length, and fat-free mass demonstrate more efficient stroke mechanics and higher propulsive force generation (Campa et al., 2023; Piqueras et al., 2021). Rowing performance is further challenged by environmental instability, such as waves and wind, and is strongly influenced by leg-driven power from the foot-stretcher, which serves as the primary source of propulsion (Busta et al., 2023; Engstrom et al., 2023). These biomechanical and environmental demands require rowers to develop superior muscular strength, aerobic capacity, neuromuscular coordination, and technical consistency.

The sport of rowing can be understood as embodying an artistic quality, primarily due to the harmonious interplay between human kinetic expression and the functionality of the rowing apparatus. Balance with rhythmic movements is also very important to train, because in the condition of a speeding boat the limbs must also balance the boat so that it cannot capsize. As noted in previous studies, rowing movements are performed rhythmically and continuously, with an optimal ratio between the work and recovery phases (Agius et al., 2023; Grima et al., 2023). The rower's body weight also greatly affects the stability of the boat, so the boat is adjusted to the characteristics of the rowers.

The inherent instability of the rowing shell, acting as the rower's fulcrum, is significantly influenced by environmental factors such as waves and wind. This environmental dynamic often prolongs the acquisition of proficient sprint rowing skills. Furthermore, footstool force has been demonstrably associated with rowing speed. Given that rowing propulsion is critically reliant on leg-driven repulsion, robust lower limb muscular strength is therefore a fundamental physiological prerequisite for competitive rowing athletes. Rowing sports use repulsion or encouragement by using the feet, muscle or leg strength is very guided in this rowing sport itself, therefore rowing athletes must have strong and sturdy legs (Busta et al., 2023; Engstrom et al., 2023; Podstawski et al., 2023).

Kendari has long been regarded as one of Indonesia's rowing development hubs, having produced multiple nationally recognized athletes. The construction of the Kendari Bay rowing facility in 1993, and its history of national team selections, illustrates its strategic importance for athlete development. However, recent evaluations reveal a decline in performance attributed to reduced athlete regeneration, limited conditioning programs, insufficient equipment, and outdated training methodologies (Asmuddin et al., 2020; Agustan et al., 2022). These challenges underscore the urgent need for evidence-based profiling of athletes' physical capacities and anthropometric characteristics to support talent identification and training optimization.

Rowing sports demand optimal physical condition from athletes, as they co ntend with multifarious challenges in every race. In addition to physical and mental fortitude, they are required to overcome the inherent challenges posed by the natural environment, equipment, and rowing infrastructure, which act as impediments during competitive events (Alföldi et al., 2021; Daley et al., 2023; Hohmuth et al., 2023). The decline in achievements of Kendari rowing athletes since 1995/1996 is visibly manifested, whereas Lasmin and his team are still leading in sports at ASIAN GAMES level in 1998.

Recent investigations reveal decreased performance of Kendari rowers, directly related to an old athlete regeneration, lack of physical conditions, insufficient training and competition equipment, and facilities. The trend of decline is quite evident across competition events. Thus, this community partnership programme has been launched to address the physical condition of athletes as a key issue behind the recent performance decline (Agustan et al., 2022; Asmuddin et al., 2020). Furthermore, there is still insufficient adherence to the principles of training consistent with the primary physical components, the use of physical conditioning methods appropriate to the energy aspects of rowing, and the carrying out of tests and measurements that are not sufficiently performed. These elements lead to a deterioration in performance (Alföldi et al., 2021; Asmuddin et al., 2020).

Regular exercise can influence an individual's physical and mental health (Asmuddin et al., 2020; Penichet-Tomas et al., 2023). Physical fitness refers to an individual's capacity to execute actions that necessitate exertion in daily life effectively, without encountering considerable exhaustion. An athlete's performance is evident in the tournaments they partake in, mostly through the assessment of physical performance. The study conducted by (Hamano et al., 2015), examines the correlation between physical attributes and fitness levels among two contestants. Fitness considerations influence an athlete's performance, particularly in rowing, which necessitates a high level of fitness for optimal match completion (Penichet-Tomas et al., 2021).

Rowing performance necessitates age during races, since more mature rowers often exhibit greater body size, superior physical fitness, and enhanced rowing capabilities (Alföldi et al., 2021; Penichet-Tomas et al., 2021). Furthermore, the primary characteristics that forecast performance time in rowing are maturity status and chronological age. This sport closely resembles physical strength training and cardiovascular endurance, similar to swimming (Chen et al., 2024; Penichet-Tomas et al., 2023; Rodríguez González et al., 2023; Yang et al., 2025). The athlete's fitness level can influence their endurance, speed, and strength during competition.

Although international research has widely documented the influence of anthropometry and physical fitness on sprint and endurance rowing performance (Harun et al., 2022; Penichet-Tomás et al., 2019), such findings may not directly translate to Indonesian rowers due to differences in genetics, environmental conditions, nutritional patterns, and training systems. Research within Southeast Asia remains limited, and studies in Indonesia have largely focused on psychological or general performance aspects, rather than biomechanical or physiological determinants. Consequently, coaches lack localized benchmarks that reflect the unique demographic and developmental characteristics of Indonesian athletes. To address this gap, the present study provides the first focused analysis of anthropometric and physical fitness correlates of 500 m rowing performance among youth athletes enrolled in the *Pusat Pendidikan dan Latihan Olahraga Pelajar* (PPLP) Kendari national training pathway. By establishing population-specific performance indicators, this research aims to contribute actionable evidence for athlete selection, program design, and long-term athlete development within the Indonesian rowing system.

METHOD

Type of Research

This study employed a correlational-descriptive design to examine the associations between physical abilities, anthropometric characteristics, and rowing strength among athletes of PPLP Kendari. The design was chosen to identify relationships between variables without implying causality.

Participants

The population of interest comprised 60 rowing athletes registered at PPLP Kendari, consisting of 39 male and 21 female athletes. For the purposes of this study, only the data from the 39 male athletes were included in the final analysis. The exclusion of female athletes was based on methodological considerations, particularly the very limited number of female rowers available and the substantial differences in biological characteristics, training load, and periodization patterns between male and female athletes. The exclusion of female athletes in this study was based on methodological considerations, particularly the very limited number of female rowers available and the substantial differences in biological characteristics, training load, and periodization patterns between male and female athletes (Nurjaya et al., 2020; Schweinbenz, 2007).

Accordingly, a purposive sampling strategy was applied using the following criteria: athletes had to be male, aged 15-25 years, actively engaged in centralized training for at least six months, injury-free, and officially registered in the 2024 training season. Based on these criteria, 39 male athletes were included in the final sample. However, the absence of female athletes remains a limitation, as the findings cannot be generalized to female rowing populations.

Instrument

Data were collected using standardized protocols administered by trained assessors. Physical testing followed the American College of Sports Medicine (ACSM) guidelines, anthropometric assessments adhered to International Society for the Advancement of Kinanthropometry (ISAK) standards, and rowing evaluations were adapted from World Rowing recommendations. To ensure reliability, assessors underwent calibration, equipment was verified prior to each session, and standardized warm-ups and instructions were applied. Two trials were recorded for each test, with additional attempts performed when results exceeded error thresholds.

a. Physical Ability Tests. Performance was measured through established field tests: 30 m sprint (acceleration), one-minute sit-up (trunk endurance), countermovement vertical jump (lower-limb power), pull-ups/flexed-arm hang (upper-body strength), wall-sit (leg endurance), modified sit-and-reach (flexibility), and 20 m shuttle run (aerobic capacity, VO_2 max estimated using the Léger equation).
b. Anthropometrics. Body height, weight, chest circumference, arm girths (flexed and extended), and arm length were assessed with a stadiometer, digital scale, and anthropometric tape in line with ISAK Level-1 procedures. Duplicate measures were taken, with means used for analysis.
c. Sprint performance was measured using a 500 m rowing time trial at the PPLP Kendari rowing facility. All athletes used the same type of single sculling boat to keep equipment consistent. Because the test was conducted on outdoor water, the trials were scheduled in the early morning when wind and water conditions were most stable. Basic environmental checks (wind and water surface) were performed before testing to ensure the conditions were suitable. Timing was recorded to the nearest 0.1 s, providing a reliable indicator of rowing-specific sprint capacity.

Table 1. Standardized Physical Ability, Anthropometric, and Rowing Performance Test Protocols

Domain	Test/Measure	Variable Measured	Unit of Measurement	Protocol/ Standard
Physical Ability Tests	30-metre run	Acceleration / speed	Seconds (s)	ACSM (2018)
	Sit-ups (1 min)	Trunk muscular endurance	Repetitions (n)	ACSM (2018)
	Vertical jump	Explosive leg power	Centimetres (cm)	ACSM (2018)
	Pull-ups (male athletes)	Upper-body strength	Repetitions (n)	ACSM (2018)
	Hanging elbow bend (female athletes)	Upper-body endurance	Seconds (s)	ACSM (2018)
	Wall-sit test	Isometric leg endurance	Seconds (s)	ACSM (2018)
	Modified sit-and-reach	Flexibility (hamstring/lumbar)	Centimetres (cm)	ACSM (2018)
	20-m shuttle run (bleep test)	Aerobic capacity (VO_2 max est.)	$ml·kg^{-1}·min^{-1}$	Léger & Lambert (1982)
Anthropometrics	Height	Stature	Centimetres (cm)	ISAK (2019)
	Weight	Body mass	Kilograms (kg)	ISAK (2019)
	Chest circumference	Thoracic girth	Centimetres (cm)	ISAK (2019)
	Upper arm girth (flexed 90°)	Muscle circumference	Centimetres (cm)	ISAK (2019)
	Upper arm girth (extended)	Muscle circumference	Centimetres (cm)	ISAK (2019)
	Arm length	Limb length	Centimetres (cm)	ISAK (2019)
Rowing-Specific Test	500-m rowing time trial	Sprint rowing performance	Seconds (s)	World Rowing (2017)

Research Procedures

The study was conducted at the PPLP Kendari beach rowing facility under standardized conditions to minimize environmental variability. Prior to data collection, athletes were briefed on objectives, procedures, and safety, and a uniform warm-up was administered. Testing followed a sequential structure. Physical ability tests were conducted first, followed by anthropometric assessments, and finally the rowing-specific performance test. All sessions were carried out by trained assessors who had undergone calibration, with equipment verified before each session. Standardized instructions and start procedures were used to ensure consistency across participants. This structured sequence and quality control measures were implemented to enhance the reliability and validity of the data collection process.

Data Analysis

All statistical analyses were conducted using SPSS (version 26.0). Descriptive statistics (mean, standard deviation, minimum, and maximum values) were first computed to summarize the characteristics of the data. Prior to inferential testing, assumptions of normality and homogeneity were verified. Normality was assessed using the Kolmogorov–Smirnov test, supported by visual inspection of distribution plots, while Homogeneity of variances was not tested, as this study only involved correlational-descriptive analysis focusing on the relationships among variables, rather than group comparisons that require equal variances (Nimon, 2012).

Since all variables met the assumption of normality ($p > 0.05$), Pearson's product–moment correlation was used to examine associations between physical abilities, anthropometric measures, and rowing performance. Multiple regression analysis was then employed to determine the extent to which anthropometric and physical ability variables predicted 500-m rowing performance. The coefficient of determination (R^2), adjusted R^2, standard error of estimate (SEE), unstandardized coefficients (B), standardized coefficients (β), and 95% confidence intervals were reported to evaluate the strength and precision of these predictive models. All analyses applied a significance threshold of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Assumption checking for parametric analysis in this study was conducted using the Kolmogorov-Smirnov normality test, as presented in Table 1. The results show that all variables strength ($p = 0.173$), anthropometry ($p = 0.298$), and physical ability ($p = 0.646$) had p-values above 0.05. These findings indicate that the data did not significantly deviate from a normal distribution. The confirmation of normality through this formal statistical test provides a sufficient basis for applying Pearson correlation and linear regression.

The descriptive findings confirmed that the athletes' anthropometric characteristics and physical abilities were within the expected range for competitive rowing populations. Prior to conducting the inferential analysis, the dataset was examined for compliance with the normality assumption, which is essential for the appropriate use of parametric statistical techniques. Normality was assessed using the Kolmogorov-Smirnov (K-S) test, and the results are presented in Table 2. All variables demonstrated p-values greater than 0.05, namely strength ($p = 0.17$), anthropometry ($p = 0.29$), and physical ability ($p = 0.64$). Because none of the p-values fell below the alpha threshold ($\alpha = 0.05$), the test results indicate that there is no statistically significant deviation from a normal distribution for any of the variables.

Table 2. Results of Normality Testing of Strength Data for Male Rowing Athletes, Physical Ability and Anthropometry

Variable	N	KS-Z	p	Explanation
Strength	39	1.10	0.17	Normal
Anthropometry	39	0.97	0.29	Normal
Physical Abilities	39	0.73	0.64	Normal

The confirmation of normality (**Table 2**) ensured that the dataset met the assumptions for parametric statistical tests. Before conducting further correlation and regression analyses, multicollinearity among predictor variables was also examined. The variance inflation factor (VIF) and condition index results (**Table 3**) demonstrated that both anthropometry and physical ability variables showed no signs of multicollinearity, indicating their suitability for inclusion in regression modeling.

Table 3. Multicolinierity Analysis Result

Predictor Variable	VIF	Condition Index	Interpretation
Anthropometry	1.12	8.5	No multicollinearity detected
Physical Ability	1.12	8.5	No multicollinearity detected

Descriptive analysis of anthropometric data, physical abilities and strength of Kendari male rowing athletes including gender, over, height, weight, chest circumference, upper arm circumference 900, upper arm circumference extended, arm length, 30 m run, sit-ups, vertical jump, pul-ups, sitting on the wall, lunging and reaching, bleep test, strength of Kendari male rowing athletes.

Table 4. Descriptive Statistics of Anthropometric, Physical Ability, and 500 m Rowing Performance among Male Rowers

Variable	Min	Max	Mean	Std. Deviation	Unit
Age	15.00	25.00	19.00	5.29	Years
Body Height	163.0	188.0	173.26	4.27	cm
Body Weight	60.0	75.0	68.74	3.73	kg
Chest Circumference	85.0	98.0	92.54	2.75	cm
Upper Arm Circ. (90° flexed)	27.0	36.0	32.77	1.77	cm
Upper Arm Circ. (extended)	26.0	35.0	31.41	1.93	cm
Arm Length	75.0	83.0	79.49	2.13	cm
30-Meter Sprint	3.98	4.71	4.48	0.19	seconds
Sit-Ups	38.0	53.0	44.26	4.28	reps per minute
Vertical Jump	65.0	79.0	70.69	5.03	cm
Pull-Ups	13.0	22.0	17.90	2.65	reps
Wall Sit	3.21	4.87	3.83	0.46	minutes
Sit-and-Reach	21.0	29.0	25.36	2.48	cm
Bleep Test (VO_2 max proxy)	39.60	49.00	45.54	2.78	stages
500 m Rowing Performance	198.7	264.9	232	11.0	seconds

Table 4 presents the descriptive statistics for anthropometric measures, physical ability test scores, and 500 m rowing performance among 39 male rowers from PPLP Kendari. Descriptive analysis provided an overview of the athletes' profiles (**Table 4**). The 39 male rowers (M = 25.13, SD = 5.29). Mean body height was 173.26 cm and mean body weight 68.74 kg, values consistent with previous reports of elite rowers. Anthropometric consistency was observed, reflected by low standard deviations for measures such as chest circumference (M = 92.54 cm, SD = 2.75) and arm length (M = 79.49 cm, SD = 2.13). In terms of physical abilities, athletes demonstrated strong muscular endurance (sit-ups: M = 44.26 reps; pull-ups: M = 17.90 reps) and aerobic capacity (bleep test: M = 45.54 stages), reflecting a high level of cardiovascular fitness. However, sprint performance (30 m run: M = 4.48 s) indicated moderate speed relative to endurance. Rowing performance on the 500 m time trial averaged 232.0 seconds (SD = 11.0), with values ranging from 198.7 to 264.9 seconds, indicating meaningful inter-athlete variability likely attributable to differences in technique and physiological conditioning.

Regression Analysis Testing Results

The predictive contribution of physical and anthropometric factors to rowing performance was examined through regression analysis, with the results presented in **Table 5**.

Table 5. Regression Analysis Results

Model	R^2	Adjusted R^2	SEE	Koefisien Regresi (B)	95% CI (Lower)	95% CI (Upper)	SE Koefisien	Beta (β)	p-value
Anthropometry → Rowing Time	0.177	0.155	4.35	0.410	0.072	0.748	0.042	0.393	< 0.05
Physical Ability → Rowing Time	0.162	0.140	4.42	0.338	0.050	0.626	0.045	0.318	< 0.05

Table 5 presents the regression results examining the predictive roles of anthropometric and physical-ability variables on 500-m rowing performance among PPLP Kendari athletes. Anthropometric characteristics accounted for 17.7% of the performance variance ($R^2 = 0.177$, $p < 0.05$), with a standardized coefficient of $\beta = 0.393$ indicating a moderate and meaningful association. Athletes with greater body height, arm length, and upper-arm circumference tended to produce faster completion times. These findings align with a large body of rowing scholarship which emphasizes that longer levers and larger muscle cross-sectional areas facilitate higher stroke efficiency, longer stroke length, and improved force transmission (Bourgois et al., 2000). Although this effect size is moderate, it remains practically relevant because morphological leverage cannot be easily modified through training, making anthropometry a robust factor in early talent identification.

Physical abilities explained slightly less variance ($R^2 = 0.162$, $p < 0.05$) with $\beta = 0.318$, reflecting another moderate association with performance. Muscular endurance (pull-ups, sit-ups), anaerobic power (vertical jump, 30-m sprint), and aerobic capacity (bleep test) emerged as meaningful contributors. International evidence supports this multidimensional profile, noting that rowing performance though predominantly aerobic over long distances also demands substantial anaerobic power, muscular endurance, and neuromuscular coordination (Lawton et al., 2011). The current results reinforce this integrated model: while physical conditioning is modifiable through training, its overall explanatory value (16.2%) is slightly lower than anthropometry, underscoring the structural advantage embedded in athletes' morphological characteristics.

Despite both variables reaching statistical significance, neither predictor set accounted for the majority of the variance. This indicates that rowing performance is shaped by additional determinants that were not measured in this study, including stroke technique, biomechanical efficiency, training exposure, tactical pacing, and psychological readiness. The standard error of estimate values (SEE = 4.35-4.42) reflect moderate predictive precision, while multicollinearity diagnostics (VIF = 1.12; condition index = 8.5) confirm the independence of the composite predictors. These diagnostic indicators support the validity of the regression model but simultaneously highlight that anthropometric and physical capacities capture only a portion of the real-world complexity of rowing performance.

The present findings are also consistent with contemporary analyses of elite and sub-elite rowing populations. Studies show that morphological traits particularly height above 180 cm, long upper limbs, and high lean body mass are common in Olympic-level rowers because they optimize stroke length and force production (Alfőldi et al., 2021). Although the PPLP Kendari athletes exhibited more heterogeneous anthropometric profiles, anthropometry still explained 17.7% of performance variance, demonstrating its robustness even in non-elite contexts. This suggests that structural advantages afforded by body proportions function similarly across competitive tiers, reinforcing the necessity of anthropometric screening during athlete selection.

Physical ability showed a slightly weaker predictive effect, a difference that is understandable when considering the characteristics of the 500-m rowing event. Unlike the standard 2000 m Olympic distance—where maximal aerobic capacity (VO_2 max) is the primary determinant—the 500 m distance emphasizes explosive force generation and high-intensity anaerobic output. Variables such as vertical jump height and sprint acceleration therefore hold greater relevance than general endurance indicators. This interpretation aligns with international findings distinguishing performance determinants between sprint and endurance rowing formats (Harun et al., 2022; Penichet-Tomás et al., 2019). Within this framework, the moderate R^2 for physical abilities reflects the mixed energetic demands of the test: the event requires both repeated force application and sustained drive, but these physiological qualities alone do not fully explain performance without the complementary contribution of anthropometric leverage.

The stronger predictive role of anthropometry in male athletes is also supported by literature showing sex-based differences in muscle mass distribution, leverage ratios, and upper-body strength potential.

Since this study included only male participants, the relatively higher explanatory power of anthropometry may reflect these biological advantages. However, the absence of female athletes limits cross-sex generalizability. Future studies should therefore compare predictive models across sexes to determine whether anthropometry or physical abilities differ in relative influence (Nurjaya et al., 2020). Body composition represents another important dimension in performance profiling. Excess adiposity functions as inert mass, increasing energetic cost and reducing acceleration efficiency (De Larochelambert et al., 2020). Although the present study measured basic anthropometric indicators, it did not include direct assessments of body composition (e.g., skinfolds, segmental lean mass). This omission may partially explain the moderate effect size, as athletes with suboptimal lean-to-fat ratios may compensate through physical conditioning but remain constrained by morphological limits. Integrating nutritional and conditioning interventions could strengthen the predictive value of physical ability variables in future research.

From a practical perspective, these findings provide several actionable implications for athlete development in PPLP Kendari. First, anthropometric characteristics should inform long-term talent identification. Coaches can prioritize athletes whose limb lengths and body proportions offer natural biomechanical advantages. Second, training programs should emphasize targeted strength and power development, particularly in upper-body pulling strength and lower-body explosive force, both of which were strongly associated with rowing performance. Third, aerobic conditioning though secondary in a 500 m race remains essential for overall training capacity and recovery, supporting long-term athlete progression. Fourth, nutritional strategies aimed at optimizing lean body mass should be incorporated into athlete management, given the influence of body composition on rowing efficiency. Finally, regular monitoring of anthropometric and physical indices is crucial for aligning training loads with athlete development trajectories.

Nevertheless, several limitations warrant consideration to avoid overinterpretation of results. The study was conducted with a relatively small, homogeneous sample of male athletes from a single regional training center, limiting generalizability to broader populations. The use of composite indices rather than individual item-level data restricts fine-grained exploration of which specific anthropometric or physical indicators exert the strongest influence. Additionally, this study did not assess rowing technique, which is known to contribute substantially to performance and may interact with anthropometric advantages. Environmental factors such as training history, coaching differences, and psychological variables were also not included. These limitations suggest that the current results should be interpreted as indicative rather than definitive.

Future research should address these gaps by employing longitudinal designs to track changes in morphology, conditioning, and performance over time. Integrating biomechanical assessments such as stroke rate analysis, force curve profiling, and motion-capture technology would allow researchers to quantify how anthropometric and physical traits translate into mechanical efficiency (Mpimis et al., 2023; Penichet-Tomás et al., 2019). The incorporation of psychological constructs such as motivation, resilience, and attentional control may also enhance explanatory models. Advances in sensor-based analytics (e.g., wearable pressure sensors, oar-angle trackers) offer opportunities for high-resolution performance modeling, enabling more accurate mapping of the interaction between physical capacities and technical proficiency.

Overall, the present study provides evidence that anthropometry is the most robust predictor of rowing performance in the PPLP Kendari context, followed by physical ability. While both factors contribute meaningfully, their moderate effect sizes highlight the multifactorial nature of rowing performance, underscoring the need for integrated coaching strategies that combine morphological screening, targeted strength and conditioning, nutritional management, and biomechanical refinement.

CONCLUSION

This study is one of the few in Indonesia to systematically analyze the relationship between 500-m rowing performance and the anthropometric as well as physical ability characteristics of male rowing athletes. The findings indicate that rowing performance in the Kendari team is strongly influenced by specific physical ability components, particularly vertical jump (lower-limb power) and sit-up performance (core endurance). Among anthropometric variables, body height and proportional body weight emerged as the most influential indicators associated with better rowing performance. These results suggest that 500 m rowing output is shaped by a combination of explosive power, core endurance, and favorable body dimensions that support mechanical efficiency during rowing strokes. The contribution of this study lies not only in identifying key physical and anthropometric determinants among Indonesian rowers but also in providing evidence-based insights for training and talent identification. Coaches are encouraged to emphasize the development of lower-body power, core stability, aerobic conditioning, and optimal body composition in their training programs, as well as to consider these characteristics when selecting and preparing athletes for short-distance rowing events.

ACKNOWLEDGEMENTS

The author would like to send warm regards and sincere appreciation to the management of the Regional Training Center for Student Athletes (PPLP) Kendari for their kind permission and institutional support that made it possible for this research to be carried out. The author furthermore expresses heartfelt thanks to the athletes of PPLP Kendari, whose energy and dedication have greatly enabled the accomplishment of this study to the fullest extent.

10

CONFLICT OF INTEREST

The author asserts that there are no conflicts of interest pertaining to the publishing of this research. All aspects of the study were conducted independently and without any financial or personal relationships that could inappropriately influence the findings.

REFERENCES

Agius, T. P., Cerasola, D., Gauci, M., Sciriha, A., Sillato, D., Formosa, C., Gatt, A., Xerri de Caro, J., Needham, R., Chockalingam, N., & Grima, J. N. (2023). The Kinematics of Fixed-Seat Rowing: A Structured Synthesis. *Bioengineering*, *10*(7), 774-781. https://doi.org/10.3390/bioengineering10070774

Agustan, B., Muhtarom, D., Hadiana, O., Nurdiansyah, D., & Fauzan, E. (2022). Coaching Clinic Basic Movements and Dominant Physical Conditions for Athletes at Gemilang Raya FC. *ABDIMAS: Jurnal Pengabdian Masyarakat*, *4*(2), 1059–1063. https://doi.org/10.35568/abdimas.v4i2.1301

Alfőldi, Z., Borysławski, K., Ihasz, F., Soós, I., & Podstawski, R. (2021). Differences in the Anthropometric and Physiological Profiles of Hungarian Male Rowers of Various Age Categories, Rankings and Career Lengths: Selection Problems. *Frontiers in Physiology*, *12*(October), 1–11. https://doi.org/10.3389/fphys.2021.747781

Asmuddin, Rusli, M., Saman, A., Suhartiwi, & Salwiah. (2020). The Effect of Physical Training on Rowing Sport Achievement. *3rd International Conference on Education, Science, and Technology (ICEST 2019) 481(Icest 2019)*, 259–262. https://doi.org/10.2991/assehr.k.201027.054

Bourgois, J., Claessens, A. L., Vrijens, J., Philippaerts, R., Van Renterghem, B., Thomis, M., Janssens, M., Loos, R., & Lefevre, J. (2000). Anthropometric Characteristics of Elite Male Junior Rowers. *British journal of sports medicine*, *34*(3), 213–217. https://doi.org/10.1136/bjsm.34.3.213

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*(March), 1–9. https://doi.org/10.3389/fspor.2023.1115336

Campa, F., Matias, C. N., Moro, T., Cerullo, G., Casolo, A., Teixeira, F. J., & Paoli, A. (2023). Methods Over Materials: The Need for Sport-Specific Equations to Accurately Predict Fat Mass using Bioimpedance Analysis or Anthropometry. *Nutrients*, *15*(2), 278-284. https://doi.org/10.3390/nu15020278

Chen, Y., Lan, Y., Zhao, A. H., Wang, Z. C., & Yang, L. J. (2024). High-Intensity Interval Swimming Improves Cardiovascular Endurance, While Aquatic Resistance Training Enhances Muscular Strength in Older Adults. *Scientific Reports*, *14*(1), 25241. https://doi.org/10.1038/s41598-024-75894-0

Daley, M. M., Shoop, J., & Christino, M. A. (2023). Mental Health in the Specialized Athlete. *Current Reviews in Musculoskeletal Medicine*, *16*(9), 410–418. https://doi.org/10.1007/s12178-023-09851-1

De Larochelambert, Q., Del Vecchio, S., Leroy, A., Duncombe, S., Toussaint, J.-F., & Sedeaud, A. (2020). Body and Boat: Significance of Morphology on Elite Rowing Performance. *Frontiers in Sports and Active Living*, *2*, 597676. https://doi.org/10.3389/fspor.2020.597676

Engstrom, I., Anderson, K., Bez, E., Agresta, C., & Telfer, S. (2023). The Effect of Foot-Stretcher Position and Stroke Rate on Ergometer Rowing Kinematics. *PLoS ONE*, *18*(5 May), 1–14. https://doi.org/10.1371/journal.pone.0285676

Grima, J. N., Cerasola, D., Sciriha, A., Sillato, D., Formosa, C., Gatt, A., Gauci, M., Xerri de Caro, J., Needham, R., Chockalingam, N., & Agius, T. P. (2023). On the Kinematics of the Forward-Facing Venetian-Style Rowing Technique. *Bioengineering*, *10*(3), 1–23. https://doi.org/10.3390/bioengineering10030310

Harun, M. N., Nasruddin, F. A., & Syahrom, A. (2022). Rowing Biomechanics, Physiology and Hydrodynamic: A Systematic Review. *International Journal of Sports Medicine*, *43*(07), 577–585. https://doi.org/10.1055/a-1231-5268

Hohmuth, R., Schwensow, D., Malberg, H., & Schmidt, M. (2023). A Wireless Rowing Measurement System for Improving the Rowing Performance of Athletes. *Sensors*, *23*(3), 1060-1071. https://doi.org/10.3390/s23031060

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

Lawton, T. W., Cronin, J. B., & McGuigan, M. R. (2011). Strength Testing and Training of Rowers: A Review. *Sports medicine (Auckland, N.Z.)*, *41*(5), 413–432. https://doi.org/10.2165/11588540-000000000-00000

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

Mpimis, T., Gikas, V., & Gourgoulis, V. (2023). A Rigorous and Integrated On-Water Monitoring System for Performance and Technique Improvement in Rowing. *Sensors*, *23*(13), 6150. https://doi.org/10.3390/s23136150

Nimon K. F. (2012). Statistical Assumptions of Substantive Analyses Across the General Linear Model: A Mini-Review. *Frontiers in psychology*, *3*, 322. https://doi.org/10.3389/fpsyg.2012.00322

Nurjaya, D. R., Ma'mun, A., & Rusdiana, A. (2020). Indonesian Women's Rowing from 1986 to 2018: A historical, Social, and Cultural Perspective. *Jurnal Pendidikan Jasmani dan Olahraga*, *5*(2), 218–232. https://doi.org/10.17509/jpjo.v5i2.27256

Penichet-Tomás, A., Pueo, B., & Jiménez-Olmedo, J. M. (2019). Physical Performance Indicators in Traditional Rowing Championships. *The Journal of sports medicine and physical fitness*, *59*(5), 767–773. https://doi.org/10.23736/S0022-4707.18.08524-9

Penichet-Tomas, A., Pueo, B., Selles-Perez, S., & Jimenez-Olmedo, J. M. (2021). Analysis of anthropometric and body composition profile in male and female traditional rowers. *International Journal of Environmental Research and Public Health*, *18*(15), 7826. https://doi.org/10.3390/ijerph18157826

Piqueras, P., Ballester, A., Durá-Gil, J. V, Martinez-Hervas, S., Redón, J., & Real, J. T. (2021). Anthropometric Indicators as a Tool for Diagnosis of Obesity and Other Health Risk Factors: A Literature Review. *Frontiers in Psychology*, *12*, 631179. https://doi.org/10.3389/fpsyg.2021.631179

Penichet-Tomas, A., Jimenez-Olmedo, J. M., Pueo, B., & Olaya-Cuartero, J. (2023). Physiological and Mechanical Responses to a Graded Exercise Test in Traditional Rowing. *International Journal of Environmental Research and Public Health*, *20*(4), 3644. https://doi.org/10.3390/ijerph20043664

Podstawski, R., Borysławski, K., Alföldi, Z., Ferenc, I., & Wąsik, J. (2023). The Effect of Confounding Variables on the Relationship between Anthropometric and Physiological Features in 2000-M Rowing Ergometer Performance. *Frontiers in Physiology*, *14*(May), 1–10. https://doi.org/10.3389/fphys.2023.1195641

Rodríguez González, L., Melguizo-Ibáñez, E., Martín-Moya, R., & González-Valero, G. (2023). Study of Strength Training on Swimming Performance. A Systematic Review. *Science and Sports*, *38*(3), 217–231. https://doi.org/10.1016/j.scispo.2022.09.002

Schweinbenz, A. N. (2007). *Paddling Against the Current: A History of Women's Competitive International Rowing between 1954 And 2003*. University of British Columbia.

Sebastia-Amat, S., Penichet-Tomas, A., Jimenez-Olmedo, J. M., & Pueo, B. (2020). Contributions of Anthropometric and Strength Determinants to Estimate 2000 M Ergometer Performance in Traditional Rowing. *Applied Sciences*, *10*(18), 6562. https://doi.org/10.3390/app10186562

Stadler, A. T., Schönauer, M., Aslani, R., Baumgartner, W., & Philippi, T. (2020). The Impact of a Flexible Stern on Canoe Boat Maneuverability and Speed. *Biomimetics*, *5*(1), 7. https://doi.org/10.3390/biomimetics5010007

Wychowański, M., & Baca, A. (2018). Rowing. In *Modelling and Simulation in Sport and Exercise* (pp. 50–69). Routledge.

Yang, L., Gao, B., Chen, Y., Xu, Q., Zhou, J., & Tang, Q. (2025). Comparing The Effects of Maximal Strength Training, Plyometric Training, and Muscular Endurance Training on Swimming-Specific Performance Measures: A Randomized Parallel Controlled Study in Young Swimmers. *Journal of Sports Science and Medicine*, *24*(1), 128–141. https://doi.org/10.52082/jssm.2025.128

Yuliawati, D., Achmad, I. Z., & Sumarsono, R. N. (2022). Pengaruh Model Latihan Ergometer Terhadap Hasil Mendayung Perahu Rowing. *Jurnal Porkes*, *5*(2), 416–427. https://doi.org/10.29408/porkes.v5i2.6198