Original Article

Physical and psychological conditions in kayaking: Strength, flexibility, and motivation

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ABSTRACT

The effect of physical condition factors such as strength and flexibility on kayaking has been widely investigated. However, little information is found regarding psychological factors such as motivation and how they are simultaneously involved. Therefore, this research aims to analyse the elements of physical (arm muscle strength and waist flexibility) and psychological (achievement motivation) conditions on the ability to row a kayak. A total of 17 male athletes in Aceh province, Indonesia, participated in this research voluntarily. Participants were athletes registered with the Indonesian Rowing Association and had participated in championships at the provincial level (22.32 ± 1.02 years, 71.56 ± 3.64 kg, 173.09 ± 2.17 cm, and BMI 23.89 ± 2.88). Each data was collected using push and pull dynamometer tests, sit and reach tests, questionnaires, and ergometer machines. The data were then analysed using descriptive statistics, correlation, and regression analysis. The results showed that arm muscle strength, waist flexibility, and achievement motivation influenced kayak rowing ability ($R = 0.933$; $F = 29.17$; $p < .05$). Partially, the influence value of arm muscle strength was $R = 0.727$; $F = 16.79$; $t = 4.09$; $p < .05$, waist flexibility was $R = 0.695$; $F = 14.04$; $t = 3.74$; $p < .05$, and achievement motivation was $R = 0.817$; $F = 30.13$; $t = 5.48$; $p < .05$. Of these three elements, motivation was reported as the most dominant element, followed by arm muscle strength and waist flexibility. Finally, it is important for coaches, athletes, and practitioners to consider these elements in achieving optimal rowing ability.

Keywords: Performance analysis of sport, Kayaking, Arm muscle strength, Waist flexibility, Motivation, Sports performance.

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INTRODUCTION

The canoeing Olympics have been recognized internationally by the International Canoeing Federation (ICF). This event uses two styles of boats: kayak and canoe (Yasin et al., 2020). The movement of the boat in the water is dominated by the upper limbs, although all propulsion power must be transferred to the boat through the rower's lower limbs (Nilsson & Rosdahl, 2016).

The transformation of the shaft rotation force about the rower's vertical axis is a major technical difficulty (Bonaiuto et al., 2020; Li, 2017), and these combinations of movements are continually repeated over long periods of practice (Abelleira-Lamela et al., 2020). When rowing, the body works as a propulsion machine, applying a load equivalent to 40 to 45 kg on the paddle handle or 220 to 250 strokes during the race (Harfield, 2016). Not surprisingly, this exercise requires a high level of performance by engaging all major muscle groups, including the quads, biceps, triceps, glutes and abs. In addition, components of balance, strength, flexibility and cardiovascular endurance are also needed for this ability (Hosea & Hannafin, 2012; Karaba-Jakovljevic et al., 2016).

Currently, most studies focus on assessing kayak paddler performance from a physiological perspective (Li et al., 2017), biomechanics (Kolumbet, 2017), and physical perspective (Bal & Singh, 2017; López-Plaza et al., 2017; Zharmenov et al., 2019). Additionally, strength and conditioning for competitive rowers have also been investigated (Nugent et al., 2020). They were literature reviews focusing on the areas of biomechanics, physiology, and injury epidemiology in rowing. Another study that can be recognized was the one that examined the ability to adapt to environmental factors in kayaking, such as wind and waves (Hamacher et al., 2018). This study focused on the local dynamic stability of kayak paddling techniques. In addition, scholars also studied the role of land kayaking exercises to improve postural balance, muscle performance, and cognitive function (Choi & Lee, 2018). The study included older adult participants with mild cognitive impairment. Finally, another study examined the effect of training and detraining on rower muscle strength (upper and lower leg muscle strength) (Janjic et al., 2019).

While studies above mainly focus on the physical aspects of the sports, it should be noted that many sports (including kayaking) require psychological elements to determine the final results, especially motivation (Shekhar & Devi, 2012). To the best of our knowledge, only three studies have investigated psychological factors related to motivation in kayakers (Fernández-Río et al., 2018; Ruiz-Juan et al., 2010; Saies et al., 2014). Among them, no study concurrently conducts research and finds the relationship between physical (arm muscle strength and waist flexibility) and psychological (achievement motivation) conditions to the ability to row a kayak.

Therefore, this research aims to analyze the effects of physical (arm muscle strength and waist flexibility) and psychological (achievement motivation) conditions on the ability to row a kayak. This research is significant because rowing ability is an important factor in winning a race, so several of these elements must be analysed and proven.

METHODS

Study design and participants

This research employed an associative quantitative method to analyse and prove the relationship between two or more variables. A total of 17 male athletes in Aceh province, Indonesia, participated in this research voluntarily. Participants were athletes registered with the Indonesian Rowing Association and had

participated in championships at the provincial level (22.32 ± 1.02 years, 71.56 ± 3.64 kg, 173.09 ± 2.17 cm, and BMI 23.89 ± 2.88).

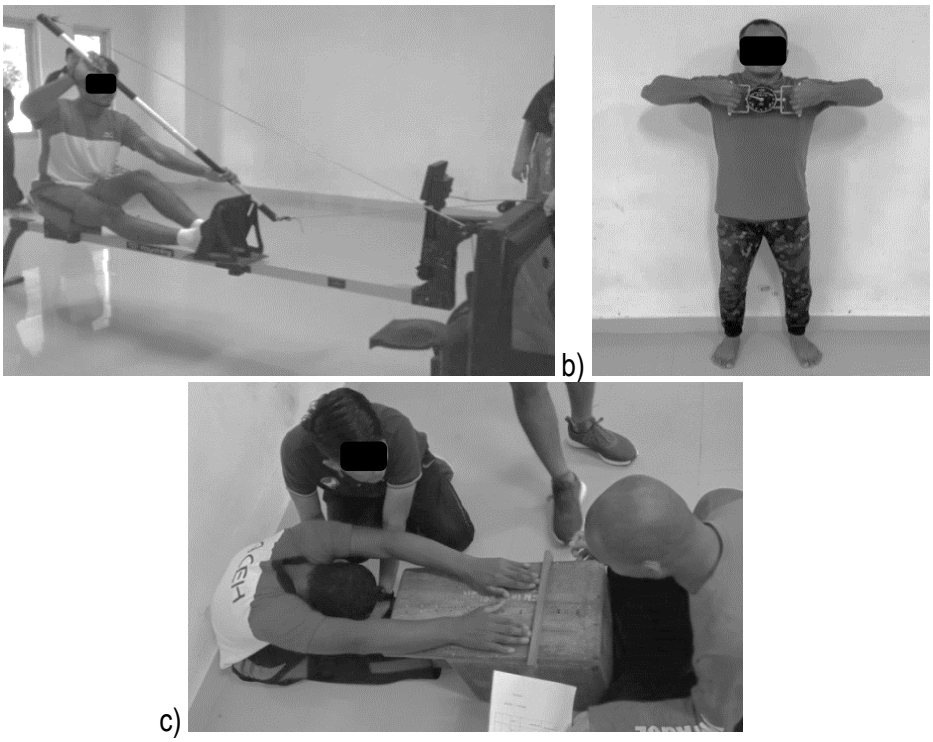

Figure 1. a) Kayaking ability test, b) arm muscle strength test, and (c) waist flexibility test.

Instruments and procedures

Kayaking ability

In this research, the ability to row a kayak was obtained from an ergometer machine (1.000 meters) (Begon et al., 2009) (Figure 1.a). The test was performed similarly to the rowing movement in the water. The rower's sitting position on the ergometer machine was also made the same as sitting on a kayak, such as looking straight ahead, one leg pressing with the knee bent ± 120°, and the back and legs forming an angle of ± 90°. In addition, the rower's body was upright (no leaning too far forward), while the arms were parallel to the shoulders and extended forward. The assessment classification for this test is presented in Table 2.

Arm muscle strength

Furthermore, arm muscle strength was obtained from the push and pull dynamometer test (Nasuka et al., 2020) (Figure 1.b). The test was implemented by having participants (a) stand with their feet shoulder-width apart, (b) look straight ahead, (c) hold the dynamometer with both hands straight in front of their chest, (d) straighten their arms and hands parallel to their shoulders, and (e) pull the tool as strong as they can. When pulling, the tool should not rest against the chest but against the hands (elbows remain parallel to the shoulders). The assessment classification for this test is presented in Table 2.

Waist flexibility

Waist flexibility was obtained from the sit and reach test *(López-Miñarro et al., 2009) (Figure 1.c)*. The test was conducted by asking participants to (a) face the measuring instrument in a sitting position, (b) straighten both their legs and attach them to the end of the plexus, (c) put both tips of the thumbs parallel to the

measuring instrument, (d) straighten the position of the hands, and (e) reach for the measuring instrument using both hands and push as far as possible (hold the final position for three seconds) (Antara et al., 2023). The assessment classification for this test is presented in Table 2.

Achievement motivation

While data on the physical condition was collected using a series of tests, the psychological state (motivation) was obtained from a self-report questionnaire consisting of 30 questions. Detailed items for the questionnaire are provided in Table 1. In this research, the questionnaire was prepared following the operationally determined indicators (Mylsidayu, 2014). The steps in preparing the questionnaire include (a) compiling a grid based on indicators of achievement motivation, (b) compiling question items according to a predetermined grid, and (c) validating the items performed by a sports psychologist to determine which items met content validity. The maximum score for the questionnaire was 150, while the minimum score was 30. Each question was rated from very often (score 5), often (score 4), sometimes (score 3), rarely (score 2), and never (score 1). Then, the results were analysed using percentages (achievement score/ideal score*100%). The classification of this assessment is presented in Table 2.

Table 1. Instruments for achievement motivation.

Variable	Sub variables	Indicator	Items
Motivation achievement	Intrinsic	Dreams and hopes	1-4
		Athlete behaviour	5-8
		Persistent	9-12
		Diligent	13-15
		Self-discipline	16-18
	Extrinsic	Coach and coaching environment	19-21
		Facilities and infrastructure	22-24
		Family support	25-27
		Friends support	28-30

Table 2. Assessment classification.

Arm muscle strength	Waist flexibility	Achievement motivation	Kayaking ability	Classification
≥ 44	≥ 14	81-100	≤ 3.26	Very good
34-43	11-14	61-80	3.26-3.63	Good
25-33	7-10	41-60	3.64-4.00	Enough
18-24	4-6	21-40	4.01-4.37	Less
≤ 17	≤ 4	0-20	≥ 4.37	Very less

Note. The test units are kg for arm muscle strength, cm for waist flexibility, percentage for achievement motivation, and minutes/seconds for kayaking ability.

Statistical analysis

Data in this research were analysed using IBM SPSS version 26 statistical software. While data characteristics for each variable were analysed using descriptive statistics, Kolmogorov-Smirnov and regression significance were employed to determine normality and linearity requirements. Then, the research performed correlation and regression analysis to analyse the relationship between variables.

RESULTS

The descriptive statistical analysis and classification results for each data are presented in Table 3 and Figure 2.

Table 3. Descriptive statistics for each variable.

Variable	Min	Max	M ± SD	Classification
Arm muscle strength	27.00	37.50	32.56 ± 3.04	Enough
Waist flexibility	5.00	15.00	10.29 ± 2.82	Enough
Achievement motivation	78.67	86.00	82.16 ± 1.97	Very good
Kayaking	3.21	4.45	3.82 ± 0.37	Enough

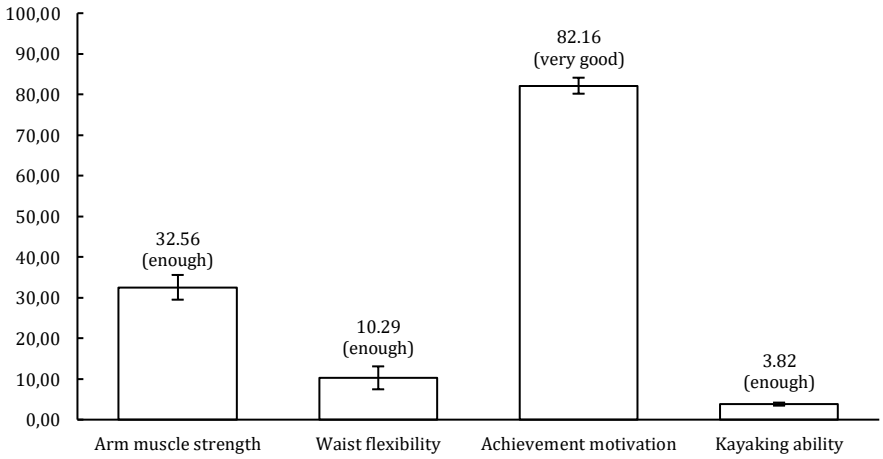

Figure 2. Averages and classification.

Table 4. Summary for testing requirements analysis.

Data	X_1 (*P*)	X_2 (*P*)	X_3 (*P*)
Normality	0.200	0.200	0.147
Linearity	0.986	0.947	0.457

Note. Normal and linear ($p > .05$), Y is the kayaking ability, X_1 is arm muscle strength, X_2 is waist flexibility, and X_3 is achievement motivation.

Table 5. Summary of correlation and regression analysis.

Variable		*B*	*R*	*Rsquare*	*F*	*p*	*t*	*p*
Arm muscle strength	*Y*	13.67	0.727	0.528	16.79	.001	4.09	.001
	X_1	0.727						
Waist flexibility	*Y*	15.23	0.695	0.483	14.04	.002	3.74	.002
	X_2	0.695						
Achievement motivation	*Y*	9.14	0.817	0.668	30.13	.000	5.48	.000
	X_3	0.817						
Simultaneous	*Y*	8.73	0.933	0.871	29.17	.000		
	X_1	0.429						
	X_2	0.412						
	X_3	0.333						

Note. The regression and relationship are significant ($p < .05$), and the dependent variable is kayaking ability.

As presented in Table 4, the results showed that the data is normally and linearly distributed ($p > .05$). Following that, Table 5 illustrates that the analysis of the relationship between variables (partial or simultaneous) is significant ($p < .05$). The regression model between variables is $Y = 13.67 + 0.727X_1$; $Y = 15.23 + 0.695X_2$; and $Y = 9.14 + 0.817X_3$. Meanwhile, Figure 3 indicates the simultaneous regression model of $Y = 8.73 + 0.429X_1 + 0.412X_2 + 0.333X_3$.

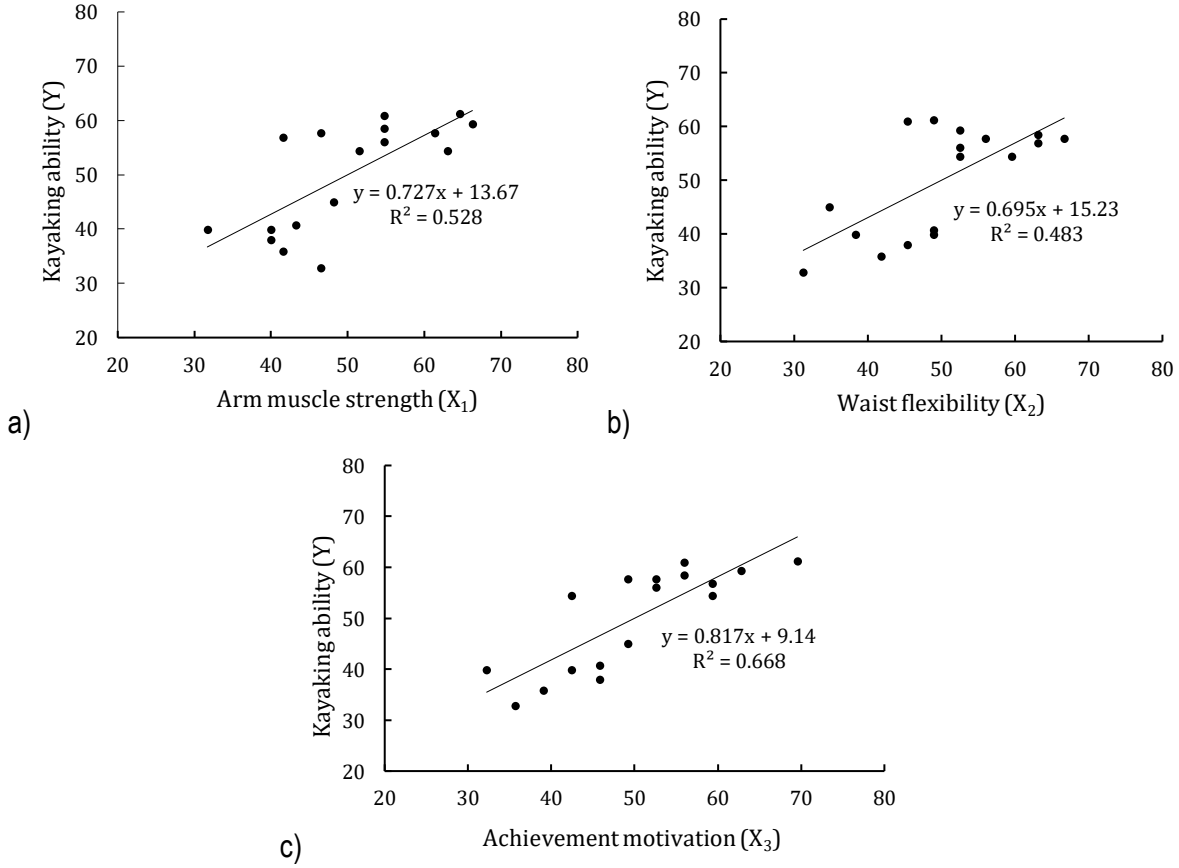

Figure 3. a) Linear curve for arm muscle strength with kayaking ability, b) waist flexibility with kayaking ability, and c) achievement motivation with kayaking ability.

DISCUSSION

Based on these findings, arm muscle strength, waist flexibility, and achievement motivation were reported to affect the ability to row a kayak ($p < .05$). The influence values of arm muscle strength were R = 0.727; F = 16.79; t = 4.09; $p < .05$. This finding is in line with previous studies claiming that strength is needed from the start of the race to the final speed to get to the finish line (Kolumbet, 2017; Nugent et al., 2020). Another study argues that canoeing and kayaking are water sports that involve skill and strength (Manna & Adhikari, 2018).

Strength is important in improving performance and reducing injury for competitive rowers (Nugent et al., 2020). Previous studies explain why kayaking requires significant strength of the upper body (Akca & Muniroglu, 2008). They suggest that upper body muscles are needed to produce power to achieve or maintain high speeds. Another study believes that strength training is an integral part of elite rowing, consuming 10-

20% of total training time (Guellich et al., 2009). More recently, scholars have stated that adaptations in strength training should focus on developing and maintaining the neuromuscular units as they are necessary for force production (Janjic et al., 2019).

Repeated manoeuvres are used by elite kayak paddlers to develop their bodies' asymmetrical strength and flexibility. Strikingly, these findings reported that the influence values of waist flexibility were R = 0.695; F = 14.04; t = 3.74; $p < .05$. The degree of lumbar flexion a kayak paddler uses during the rowing motion may influence their flexibility (López-Miñarro & Alacid, 2010). Plenty of research has documented that flexibility is beneficial to improve overall functional ability (Antara et al., 2023; Ihsan et al., 2022; Schenkman et al., 2012). These findings are consistent with earlier research in that it is easier to control speed and power when the hip is flexible (Akınoğlu & Kocahan, 2019).

Moving to the next part, this research believes that psychological factors such as achievement motivation are important to support athlete success. The desire to succeed is a motivating factor for athletes to reach their objectives and a factor that affects their performance in competition. In this research, the influence of achievement motivation was valued of R = 0.817; F = 30.13; t = 5.48; $p < .05$. The findings are consistent with earlier research, showing that several motivational components, such as achievement motivation, goal accomplishment orientation, and self-determination, are essential for the growth of participants' abilities and future success (Forsman et al., 2016; Gillet et al., 2009; MacNamara et al., 2010; Zuber et al., 2015). Sports psychology has extensively explored athletes' motivation. Books and literature that have examined this topic include Duda (2005), Hagger and Chatzisarantis (2008), and Roberts and Treasure (2012). Previous studies focused on theory, such as orientation in goal achievement (Biddle et al., 2003; Harwood et al., 2008) and self-determination theory (Martin & Nikos, 2007; Ntoumanis, 2012). Both have helped structure and guide the current understanding of athlete motivation for achievement. In addition to that, the self-determination theory of motivation is another fundamental paradigm for comprehending motivation in the context of sports and the drivers behind people's pursuit of particular objectives (Gaudreau & Braaten, 2016).

We realize there are several limitations to this study. For instance, the research only used 17 male athletes from Aceh province, Indonesia, as the sample. A wider sample size and other diversity (gender and athlete level) are needed in future research. Then, the physical and psychological conditions investigated in this research were still limited (arm muscle strength, waist flexibility, and achievement motivation). Therefore, it is necessary to involve other elements that might affect the ability to row a kayak.

CONCLUSIONS

These findings conclude that arm muscle strength, waist flexibility, and achievement motivation influence the ability to row a kayak (R = 0.933; F = 29.17; $p < .05$). Partially, the influence values of arm muscle strength was R = 0.727; F = 16.79; t = 4.09; $p < .05$, waist flexibility was R = 0.695; F = 14.04; t = 3.74; $p < .05$, and achievement motivation was R = 0.817; F = 30.13; t = 5.48; $p < .05$. Of these three elements, achievement motivation is the dominant element that influences the ability to row a kayak without ignoring the role of arm muscle strength and waist flexibility. Finally, it is hoped that the results of this research can be used as an evaluation for coaches, athletes, and kayaking practitioners who work on the importance of these elements in obtaining optimal rowing skills. Future research needs to involve other elements with broader characteristics and sample sizes.

AUTHOR CONTRIBUTIONS

Hendri Neldi: study design, data collection, statistical analysis, manuscript preparation, and funds collection. Nasriah: study design, data collection, statistical analysis, and manuscript preparation. Anton Komaini: study design, data collection, statistical analysis, and manuscript preparation. Umar: study design, data collection, and statistical analysis. Willadi Rasyid: study design, data collection, and statistical analysis. Arsil: study design, data collection, and statistical analysis. Deby Tri Mario: study design, data collection, and statistical analysis.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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