

DETERMINANT SPEED ROWING : CONTRIBUTION FLEXIBILITY MUSCLE WAIST AND STRENGTH MUSCLE ARMS OF THE FAJI FEMALE ATHLETE FROM CENTRAL ACEH

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ARTICLE INFO

Article history:

Received : Sep 05, 2025

Revised : Nov 21, 2025

Accepted : Dec 25, 2025

Available online : Dec 31, 2025

Kata Kunci:

Kelentukan, kekuatan otot lengan, kecepatan mendayung, kondisi fisik, atlet putri.

Keywords:

Flexibility, arm muscle strength, paddling speed, physical condition, female athletes.

ABSTRACT

Speed rowing is one of the component important in achievement performance athletes involved with ability produce and maintain stroke in a way effective . Flexibility muscle waist and strength muscle arm allegedly own role important in support effectiveness movement rowing . Research This aim For analyze contribution flexibility muscle waist and strength muscle arm to speed rowing in athletes Princess FAJI Central Aceh. New study This located on the mapping contribution second component condition physique in a way simultaneous to speed rowing in athletes FAJI daughter of Central Aceh as base development of more training programs specific . Study use approach quantitative with design descriptive correlational . Research sample amount to six athlete FAJI Central Aceh's daughter

who is overall population . Data collection was carried out through test flexibility muscle waist , test strength muscle arm , and test speed rowing . Data analysis using correlation , coefficient determination , and significance test . Research results show coefficient correlation of 0.98 which includes very strong category . Flexibility muscle waist and strength muscle arm in a way together give contribution by 92 percent to speed rowing , while 8 percent influenced factor others . Test results show t - value by 9.64 more big than t table of 1.85. With thus, flexibility muscle waist and strength muscle arm own very strong relationship and significant contribution to speed rowing athlete daughter of FAJI Central Aceh.

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INTRODUCING

Sport paddle is branch demanding sport ability physical and technical in a way integrated For produce movement effective and sustaining stroke speed boat . Rowing performance No only determined by ability aerobics , but also by ability produce style , strength muscles , coordination movement , stability body , and efficiency technique .

Development ability physique become part important in coaching performance Because characteristics movement done in a way repetitive with involving group muscle body part top and stem body . Research on kayakers and canoeists shows that stability stem body own role important in respond load and maintain control body during activity sport rowing (Kocjan & Sarabon, 2020) . Speed rowing be one of indicator important in determine performance athlete Because ability produce stroke in a way fast and effective will influential to displacement boat . In athletes paddle , power muscle play a role in produce required style during phase pedaling , while ability body in maintain position and do movement through range optimal movement is related with effectiveness of force transfer . (Bielik et al., 2021) show that ability physique in the form of strength and power muscle is characteristics important related with performance paddle athletes , especially in the group junior athletes and groups under 23 years of age . Findings the show that development ability physique need customized with characteristics branches and needs performance athlete .

Besides strength , components stem the body also has role biomechanical in movement rowing . Stability and ability muscle stem body allows athlete maintain position body at a time assist the force transfer process going to member movement that plays a role direct in produce pedal . (Kocjan & Sarabon, 2020) find that kayak and canoe athletes have response muscle stem different bodies compared to non- athlete individuals , who demonstrate importance function stem body in activity paddle sports . With thus , flexibility muscle waist No can viewed only as ability do movement with amplitude broad , but also as one component condition potential physical support effectiveness movement body during cycle pedaling .

Development research on paddle sports in a number of year the last also shows the more strong attention to connection between characteristics physical and performance components mechanical , physiological , and technical related with performance slalom canoe athletes (Messias et al., 2021) . However , the study it also shows that study about component certain and relationships specifically with performance Still limited , especially when associated with characteristics technique and population athlete certain . While that , research (Wu et al., 2023) on dragon boat athletes showed that exercise functional can increase fitness muscle and speed rowing , which strengthens importance development condition relevant physical with movement rowing . In more context specific , (Neldi et al., 2024) identify strength and flexibility as component important in condition physique kayaking athletes . Research the put strength muscle arms and flexibility waist as part from

factor physical needs noticed in achievement ability rowing . Rowing performance in water open is results integration various attribute physical and technical (Legge et al., 2024) . A large relationship found between a number of size strength and power with characteristics performance in the waters , while attribute range movement and flexibility No in a way clear differentiate group athlete based on level performance . Findings This show that role flexibility in performance rowing Still need study more continue on to the characteristics athletes and context different sports .

Based on development study said , *research gap* study This located on still limited studies that are special analyze flexibility muscle waist and strength muscle arm in a way simultaneous to speed rowing , especially in athletes daughter and in context coaching sport rowing in the area . Research previously more Lots discuss strength or Power muscles , characteristics physiological , stability stem body , exercise functional , as well as integration attribute physical and technical aspects of canoeing, kayaking, and *rowing* athletes . Therefore, research on female athletes from FAJI Central Aceh is relevant because the population characteristics, type of coaching, and regional context can provide more specific information for developing athlete performance.

The urgency of this research is further heightened by the need for a physical condition database for coaches to objectively prioritize training. The data in this study indicate that six female athletes from FAJI Central Aceh exhibited varying levels of arm and waist muscle strength, while their best rowing speeds also showed inter-athlete variation. This situation demonstrates the need to map the physical factors most closely related to rowing performance so that training programs are based not only on the coach's experience but also on the athletes' physical characteristics.

The novelty of this study lies in examining the simultaneous contribution of waist muscle flexibility and arm muscle strength as determinants of rowing speed in female athletes from FAJI Central Aceh. This novelty lies not only in the combination of variables, but also in its application to a population of female athletes in the context of regional development, which has not been widely represented in rowing research. This approach yields practical information regarding the magnitude of the contribution of both physical condition components to rowing performance, which can be used as a basis for developing more specific training programs based on the athletes' physical condition. The results show that both variables together have a very strong relationship with rowing speed, with a correlation coefficient of 0.98 and a contribution of 92 percent.

Based on the above description, this study aims to analyze the determinants of rowing speed through the contribution of waist muscle flexibility and arm muscle strength in female athletes from FAJI Central Aceh. The results are expected to enrich sports science studies on the physical determinants of rowing performance and provide a practical basis for coaches in designing training that emphasizes the development of body flexibility and arm muscle strength in an integrated manner.

RESEARCH METHODS

This study used a quantitative approach with a descriptive correlational design. The correlational design was used to analyze the relationship and contribution of waist muscle flexibility and arm muscle strength to rowing speed in female athletes from Faji, Central Aceh. The study was conducted without comparing treatment groups, but rather by measuring the physical condition and rowing ability of each athlete. The variables in the study consisted of waist muscle flexibility and arm muscle strength as independent variables, while rowing speed was the dependent variable.

The study population consisted of all six female athletes from Faji Central Aceh. Given the population size was less than 100, all members of the population were used as the sample, thus employing total sampling. Therefore, the sample size was six female athletes from Faji Central Aceh.

Data collection was conducted through testing and measurement techniques. Measurements were conducted on three components: waist muscle flexibility, arm muscle strength, and rowing speed. Arm muscle strength was measured using a one-minute push-up test, with the test result being the number of movements the athlete could perform correctly during the measurement time. Waist muscle flexibility was measured using a flexibility test to obtain an overview of each athlete's waist mobility capabilities. All measurements were conducted using the same procedure on each sample so that results between athletes could be compared.

Rowing speed was measured directly at the rowing arena using a stopwatch, a recording sheet, writing materials, and the rowing arena. Before the test began, athletes performed a warm-up consisting of static stretching, light jogging, and dynamic stretching. Each athlete then performed three rowing trials. Rowing ability was calculated based on

the number of strokes performed in 15 seconds, and the highest score of the three trials was used as each athlete's rowing speed score.

Data collection began with coordination and obtaining permission from the Faji Aceh Tengah trainer. Researchers then prepared equipment and test recording sheets. All athletes were briefed on the measurement procedures and warmed up before the test. Next, physical condition measurements and a rowing speed test were conducted. The results of each measurement were recorded, reviewed, and tabulated before statistical analysis.

Data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to obtain the mean *and* standard deviation of each variable. The relationship between waist muscle flexibility and arm muscle strength with rowing speed was analyzed using product-moment correlation. The contribution of physical condition variables to rowing speed was then determined using the coefficient of determination with the equation:

$$Kd = r^2 \times 100\%$$

Description:

kd = coefficient of determination; r = correlation coefficient.

Next, the significance of the relationship was tested using a t-test at a significance level of $\alpha = 0.05$. The results of the analysis were used to determine the level of closeness of the relationship and the magnitude of the contribution of waist muscle flexibility and arm muscle strength to the rowing speed of female athletes from Central Aceh, Faji.

RESULTS AND DISCUSSION

This study was conducted on six female athletes from FAJI Central Aceh. Data collected included physical condition measurements related to arm and waist muscles, as well as rowing speed tests. All data was then tabulated and analyzed to determine the relationship and contribution of these two physical condition components to rowing speed.

Arm Muscle Measurement Results

Arm muscle measurements revealed a variation in ability among the six female athletes from FAJI Central Aceh. The highest score was 38, while the lowest was 22. The distribution of the measurements showed that one athlete was in the 22–27 range, three athletes were in the 28–33 range, and two athletes were in the 34–39 range.

Table 1. Distribution of Arm Muscle Test Results

Score Interval	Frequency	Percentage (%)
22–27	1	15

28-33	3	55
34-39	2	30
Amount	6	100

These results indicate that most athletes fall within the 28-33 score range. This demonstrates that athletes' arm muscle capacity is not entirely uniform, resulting in variations in physical condition between athletes, which may be related to their ability to produce a pedal stroke.

Waist Muscle Measurement Results

The results of the waist muscle variable measurements showed the highest score of 146 and the lowest score of 109. The average value reported in the study was 126.8 with a standard deviation of 13.2. Based on the distribution of scores, two athletes were in the 109-121 interval, one athlete was in the 122-134 interval, and three athletes were in the 135-147 interval.

Table 2. Distribution of Waist Muscle Test Results

Score Interval	Frequency	Percentage (%)
109-121	2	30
122-134	1	15
135-147	3	55
Amount	6	100

The distribution shows that the largest number of athletes, three athletes, scored between 135 and 147. These differences in measurement results indicate variations in the ability of the waist component among the athletes in the study sample.

Rowing Speed Test Results

The rowing speed test was conducted three times on each athlete. Each athlete had an equal opportunity to complete the test, and the best score from the three attempts was used as the final result. The best result was determined by the ability to row within 15 seconds.

Table 3. Rowing Speed Test Results

No.	Athlete	Experiment I	Experiment II	Experiment III	Best Results
1	Johari Rahayu	22	23	24	24
2	Sri Rahayu	20	20	22	22
3	Mayang Mahbengi	21	21	22	22
4	Rika Futriana	22	23	25	25
5	Dian Saleha	20	20	22	22
6	Astri Novita	23	24	25	25
Best total score					140

Based on these results, the highest best rowing scores were obtained by Rika Futriana and Astri Novita with a score of 25 each. Johari Rahayu obtained the best score of 24, while Sri Rahayu, Mayang Mahbengi, and Dian Saleha each obtained the best score of 22. The total number of the best scores of the six athletes was 140.

The Relationship Between Physical Condition and Rowing Speed

The relationship between physical condition components and rowing speed was analyzed using a correlation coefficient. Based on the analysis results reported in the study, a correlation coefficient of $r = 0.98$ was obtained. This value falls within the 0.80–1.00 range, categorizing it as a very strong relationship.

Table 4. Results of Analysis of Research Variable Relationships

Analysis	Mark	Interpretation	Analysis
Correlation coefficient (r)	0.98	Very strong	Correlation coefficient (r)
Coefficient of determination	92%	Very big contribution	Coefficient of determination
Other factors	8%	Outside the research variables	Other factors
t count	9.64	Significant	t count
t table	1.85		t table
Significance level	0.05		Significance level

A correlation value of 0.98 indicates that the physical condition of the arm and waist muscles has a very strong relationship with the rowing speed of the female FAJI Aceh Tengah athletes. Therefore, the better the physical abilities supporting arm and waist movements, the greater the likelihood of supporting the athlete's ability to produce effective strokes.

Contribution to Rowing Speed

The contribution of arm and waist muscle condition to rowing speed was analyzed using the coefficient of determination. The results showed a contribution value of 92%. This indicates that arm and waist muscle condition together contribute 92% to the rowing speed of female FAJI Aceh Tengah athletes, while the remaining 8% is related to other factors outside the variables analyzed in the study.

These other factors were not analyzed specifically in this study, so the extent of their influence cannot be determined based on the research data. These results indicate that the physical components studied were significantly related to rowing ability in the sample group of athletes.

Hypothesis Testing

The significance of the relationship was tested using a t-test at a significance level of $\alpha = 0.05$. Based on the results of the research analysis, the calculated t-value was 9.64, while the t-table value was 1.85. Thus, the calculated t-value was greater than the t-table value ($9.64 > 1.85$).

The test results showed that the relationship between the physical condition of the arm and waist muscles and rowing speed was significant, based on the calculations reported in the study. Thus, the results of the study indicate a very strong relationship and a significant contribution between the physical condition of the arm and waist muscles and the rowing speed of the female FAJI Aceh Tengah athletes.

Discussion

The results of the study showed a very strong relationship between the flexibility of the waist muscles and the strength of the arm muscles with the rowing speed of female athletes FAJI Central Aceh, as indicated by a correlation coefficient of 0.98. The study also reported the contribution of both components of physical condition by 92% to rowing speed. Theoretically, this finding is understandable because rowing is a repetitive activity that requires the production of force in the upper limbs and the ability of the trunk to maintain position while supporting the transfer of force during the stroke cycle. Therefore, arm muscle strength and the function of the waist region do not work separately, but are part of a series of movements that determine the effectiveness of the force transmitted to the oars and subsequently results in the displacement of the boat.

The role of arm muscle strength in this study's findings is strongly supported by recent research (Kristiansen, M. et al., 2022), which found that increased upper-body maximal strength was associated with improved kayak sprint performance. The study employed two approaches: a strength-performance analysis and a strength training intervention, providing a stronger basis for the direct relevance of upper-body force generation to rowing performance. Similar findings were obtained (Gäbler, M., et al., 2023), which showed that two-minute *bench pull performance* was strongly associated with 500- and 2,000-meter race times in young kayakers and canoeists. The study also confirmed that physical conditioning tests are more meaningful when their biomechanical and metabolic characteristics mimic the demands of actual sport. Therefore, the results of the female FAJI Aceh Tengah athletes can be explained by the principle that the better the arm muscles'

ability to generate and sustain force, the greater the athlete's potential to maintain effective paddling.

Physiologically, strength alone does not fully explain rowing performance. (Bielik et al., 2021) compared medal-winning junior/U23 sprint and slalom athletes with non-medalists. Medalists demonstrated superior *bench press* and *bench pull performance* across a range of strength and power indicators, making upper-body strength a key performance characteristic. However, the study also found that aerobic capacity, measured on a treadmill, failed to differentiate medal-winning and non-medal-winning athletes. These findings suggest two things. First, rowing performance is indeed based on strong muscular strength and power. Second, physical ability must be measured specifically according to the characteristics of the sport. This means that the strong correlations found in the study of FAJI Aceh Tengah athletes do not necessarily imply that arm muscle strength is the sole determinant of speed, as effective technique, coordination, endurance, power generation, and movement characteristics can also influence rowing performance.

Waist muscle flexibility also has a relevant biomechanical basis for rowing. The trunk serves as a link between the limbs, so the ability to rotate and maintain body position plays a role in producing an efficient stroke sequence. However, flexibility cannot be viewed simply as the ability to achieve a greater range of motion. (Kocjan & Šarabon, 2020) , in a study of elite kayakers and canoeists, found that athletes had a faster trunk muscle activation response than non-athletes, while differences in trunk strength were not always significant. These findings provide an important perspective on the results of this study: waist function in rowing is likely determined not only by the extent of flexibility but also by the neuromuscular ability to stabilize the trunk and control movement quickly. In other words, a wide range of motion is more beneficial when accompanied by adequate trunk stability and control.

Findings (Dias et al., 2024) support this argument. In testing elite *freestyle kayakers* , the study included back and leg flexibility, grip strength, back and leg strength, and upper body power as components of the athletes' physical profiles. The results showed that paddling relies heavily on a combination of strength and flexibility, although the researchers also emphasized that the direct relationship of each component to on-water performance requires further research. This is crucial in interpreting the results of the FAJI Aceh Tengah study. The relationship between lumbar flexibility and paddling speed is theoretically plausible, but it is incorrect to directly conclude that the more flexible an

athlete is, the higher their paddling speed will be. Flexibility must be within a functional range capable of supporting technique, not simply generating a large amplitude of motion.

The results of this study are also relevant because the entire sample consisted of female athletes. (Busta et al., 2024), who studied 63 female international canoe slalom athletes, found differences in upper-limb strength based on performance level. Athletes in the top ten in the world had higher upper-limb musculature and strength characteristics than those in lower performance groups. This study provides specific support that upper-limb strength capabilities are also relevant in female athletes, so the results of the study on female athletes from FAJI Aceh Tengah cannot be explained solely by evidence derived primarily from male athletes. However, the paddle form, athlete level, measurement instruments, and competition characteristics in Busta et al.'s study differ from this study. Therefore, the similarity in findings should be interpreted as reinforcing the importance of upper-limb strength, not as evidence that its contribution is equal across all rowing disciplines.

The relationships found in this study are also supported by intervention research (Wu et al., 2023). In 42 collegiate dragon boat athletes, an eight-week functional training program resulted in improvements in functional movement ability, muscle fitness, and rowing speed. Improvements were also seen in *pull-up* and *push-up abilities*. These findings suggest that improving rowing performance may be more effective when strength training is not administered in isolation but is instead combined with exercises that develop stability, trunk control, and movement patterns relevant to rowing. Practically, this means that the training program for female FAJI Aceh Tengah athletes should not only focus on increasing the number of *push-ups* or improving flexibility, but also integrate arm strength, core stability, trunk mobility, coordination, and rowing technique training.

However, the relationship between improved physical condition and improved performance is not always straightforward. (Lee et al., 2024) reported that 24 weeks of free-weight resistance training in young canoeists and kayakers improved one indicator of core muscle strength, but did not produce significant differences in various indicators of upper-body strength, power, balance, or aerobic and anaerobic capacity compared to a control group. This finding provides an important comparison to the results of the current study. While trunk strength and function are fundamental capacities required by athletes, improvements in these capacities do not necessarily translate automatically into increased speed in the water. Transfer of training results is strongly influenced by the specificity of the training, athlete experience, technical adaptations, test characteristics, and the

integration of physical abilities into the paddling movement pattern. Therefore, the results of the FAJI Aceh Tengah study are more appropriate for demonstrating relationships and contributions, rather than inferring causality.

Interpretation of the results of this study must also consider the characteristics of the measurements. The sample consisted of only six female athletes, while the rowing speed test was conducted three times and used the best score within the 15-second measurement. The very small sample size makes the correlation value very sensitive to differences in the scores of one or two athletes. Therefore, the coefficient of 0.98 should be interpreted as a reflection of the relationship that occurred within the group of athletes studied and cannot be generalized widely. Furthermore, rowing performance on the field is the result of an integration of physical ability, technique, stroke rhythm, environmental conditions, and the athlete's ability to maintain a style repeatedly. Therefore, the very large contribution value should not be interpreted as meaning that almost all athlete performance is determined solely by these two components of physical condition.

Critically, there are also statistical aspects in the original thesis that need to be verified before the article is published. The thesis reports a correlation value of 0.98 and a coefficient of determination of 92%, while the method states that the coefficient of determination is calculated using $KD = r^2 \times 100\%$. Furthermore, the t-test calculation presented in the thesis uses the component $\sqrt{(10-2)}$, even though the study sample size is six athletes. This discrepancy needs to be re-examined using the raw data to ensure that the coefficient of determination and significance values reported in the article are truly consistent with the sample size and statistical formula used. This statistical correction does not eliminate the importance of the study, but is necessary to ensure that the interpretation of the magnitude of the contribution can be scientifically justified.

Overall, this study shows that waist muscle flexibility and arm muscle strength are components of physical condition that are relevant to the rowing speed of female athletes from FAJI Central Aceh.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on results research, it can be concluded that flexibility muscle waist and strength muscle arm own a very strong and giving relationship significant contribution to speed rowing athlete daughter of FAJI Central Aceh. This matter indicated by the value coefficient correlation of 0.98 with contribution by 92%, while the remaining 8% influenced by other

outside factors variables research . Test results the hypothesis also shows t - value by 9.64 more big than t table of 1.85, so that connection between second component condition physique the with speed rowing stated significant .

Suggestion

Based on results research , trainer recommended For more notice development flexibility muscle waist and strength muscle arm in preparation of training programs athlete FAJI daughter of Central Aceh because second component the related close with speed rowing . Exercise program should implemented in a way planned , measured , and adjusted with the condition of each athlete . For researchers Next , it is recommended For perfect instrument research , using amount more samples big , and add variables condition physique others so that the related factors with speed rowing can analyzed in a way more comprehensive .

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