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Development of Test Instruments for Measuring Physical Condition in Rowing Sports

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ABSTRACT

Background: Accurate and standardized physical fitness assessment is essential for optimizing athletic performance in rowing. However, the lack of valid and reliable testing instruments remains a major limitation in addressing this need. This study aimed to develop and validate a physical fitness test instrument tailored to the specific characteristics of rowing, providing practical and standardized measurement guidelines.

Methods: The development process involved three main stages: analysis, design, and evaluation. The analysis stage included needs identification, theoretical review, and literature analysis. The design stage reconstructed test components based on relevant theories and validation by seven experts (four academics and three practitioners). The evaluation stage involved external validation and testing on 48 rowing athletes in Jambi Province.

Results: The findings indicate that the developed instrument has strong validity and reliability. Aiken's V analysis yielded a value of 0.77 (above the minimum threshold of 0.75), and inter-rater reliability using the Intraclass Correlation Coefficient (ICC) showed a significant value of 0.000. The final instrument consists of nine items: 30-Meter Sprint, Push-Up, Sit-Up, Standing Broad Jump, Beep Test, V Sit and Reach, Medicine Ball Throw, Stork Stand, and Hand-Eye Coordination Test.

Conclusion: The instrument is proven valid, reliable, and effective for assessing the physical condition of rowing athletes, and can be used for training and performance evaluation. This study contributes a standardized testing tool in rowing and suggests further research on broader populations to improve generalizability and flexibility.

KEYWORDS: Measurement Test; Physical Condition; Rowing

I. INTRODUCTION

Rowing is a sport that demands complex biomotor combinations such as strength, endurance, flexibility, balance, and coordination (Ihsan et al., 2023; Volianitis et al., 2020). The performance of rowing athletes is highly dependent on optimal physical condition to maintain rhythm and movement efficiency during races (Syafitri et al., 2025; Legge et al., 2023; Worsey et al., 2019). As a result, a key component of athlete coaching programs focused on long-term success is precise physical condition evaluation (Martens & Vealey, 2023; Bompa & Buzzichelli, 2019).

However, the physical test tools that are currently in widespread use are primarily focused on broad metrics and do not yet accurately capture the features of rowing performance (Thomas et al., 2023). According to the findings of tests conducted by the Indonesian Ministry of Youth and Sports from May 2–5, 2024, certain strengths, like arm power or dynamic coordination in rowing, cannot yet be fully described by tests like 30-meter running, push-ups, sit-ups, standing broad jumps, and VO_2Max (Foster et al., 2020; Gualdi-Russo et al., 2022).

This issue is significant because improper test instrumentation may lead to less reliable results during the athlete selection and assessment process. (Firmansyah et al., 2023; Rozali et al., 2022). When it comes to athlete coaching, using tools that aren't pertinent to the demands of sports can actually lead to poor training decisions (Kittel et al., 2021)

Strong arms and back muscles, a strong heart, and excellent upper- and lower-extremity coordination are necessary for rowing. (Kleshnev, 2020). Athletes' true physical characteristics will not be captured by tests that do not expressly evaluate these skills, making the coaching program less than ideal (Pasaribu, 2020).

However, in line with the specificity principle in sports training, there is an urgent need to create a sport-specific physical condition evaluation tool (sport-specific test) (Trecroci et al., 2021). Training efficacy and measurement accuracy can be increased with equipment made especially for a given sport (Hasibuan et al., 2024)

The contemporary sport science paradigm, which highlights the significance of creating tools based on real performance needs in the field, is likewise consistent with this urgency (Thomas et al., 2023). To be employed as a reliable and valid measuring tool in this situation, the designed instrument needs to pass a rigorous validation and dependability process (Sürücü & Maslakçi, 2020)

Previous research has shown that the development of certain tools can help significantly the prediction of athletes performance (Exel & Dabnichki, 2024). Thus, developing equipment in accordance with the features of rowing sports should be the proper method to contribute to the overall development of rowing athletes in science and in practice especially in Jambi Province.

The aim of the present study was to offer a physical testing tool that is specific for rowing. This calculator is meant to be a tool for coaches and other sport professionals as a basic starting point for developing a more specific plan to target the athletes VO2max. If this tool has been adopted, measurement of physical condition of the athletes could more correctly, validly, and reliably be performed. The concordance of the instrument with rowing characteristics as a sport into account will be the main goal, in order to enable the developed test of physical condition represent the necessities of athletes in the practiced sport.

This research is relevant for the development of evidence-based sports development policies as the test tools developed are contextually constructed based on the local needs and the nature and type of sports in rowing (Tomoliyus & Sunardianta, 2020). Consequently, this tool is not only theoretically applicable but also very active in the actual field conditions. This should be considered in the national and the regional level to, for example, the choice of athletes, the normal athletes' EM evaluation and evaluating of the training programs achieving. Therefore, with the availability of this instrument, it is a strategic measure in the enhancement of coaching and success in the rowing sports in general.

II. METHODS

a. Research Design and Sample

Research Type The type of research is development research (Research and Development/R&D) which is used to develop a tool that gives an accurate and reliable physical condition for rowing athletes. R&D approach focuses on systematic steps in development, designing, testing and refinement of product (Okpatrioka, 2023). This research was conducted through several systematic stages, namely needs analysis, design, evaluation, and revision, involving the participation of experts in the field. To ensure that the measurement instruments developed truly meet the physical demands of rowing sports, this stage must be carried out. As stated by Clark et al., (2019), research and development are crucial for creating accurate and relevant measurement instruments that align with the unique characteristics of each sport. The products developed are designed, tested, and refined through R&D. R&D also ensures high validity and reliability. This method combines theoretical ideas with examples in sports science.

Experts and all rowing athletes were engaged as the primary subjects of this study. Three practitioners and four academics who are involved in rowing coaching in Jambi Province, and at four higher education institutions in Indonesia serve as the participants of this study. Thus, seven experts oversaw the development of this tool. This approach aims to satisfy a theoretical and an applied standard(Merino-Soto, 2023). Furthermore, the instrument was tried out 48 rowing athletes in Jambi Province. It is important the engagement of these sporting groups in order to determine how feasible, effective and valid the test instrument being developed is.

b. Research Procedure

Between experts and rowers, information was acquired through a questionnaire included in the areas of content related to questionnaires/interviews, addressed to the coaches and academics as experts during competition. Its purpose was to recognize the needs of people engaged in rowing and training. This is consistent with Creswell & Creswell, (2017), claim that data can be collected in different forms and at any time during the research; for example, observation of the participant, where researchers have to engage individual(s) to obtain a deeper understand they really are. By combining data from questionnaires and interviews, the researcher obtained a clearer understanding of the needs of rowing athletes regarding physical condition measurement tools. Therefore, the instruments developed for rowing should be relevant and practical both academically and applicatively.

c. Instrument

There are five types of physical condition tests used in this study, namely speed test, arm muscle endurance, abdominal muscle endurance, leg strength, and cardiovascular endurance (VO_2max). The Deputy for Sports Achievement Development of the Ministry of Youth and Sports applied these five instruments to measure the physical condition of PPLP rowing athletes in 2024,

because these instruments were designed with consideration of the characteristics and specific needs of the rowing sport. According to Oriondo & Dallo-Antonio, (1998), evaluation instruments must be systematically arranged, relevant to the measurement objectives, and possess valid and reliable measures that can be accounted for. The instrument development model in this study is based on this theory. This approach produces instruments that are theoretically robust and applicable for both training and athlete evaluation purposes.

d. Data Analysis

Data analysis in this study was carried out using Aiken's V test, Cronbach's Alpha, and the Intraclass Correlation Coefficient (ICC) involving seven experts, consisting of three practitioners and four academics. For content validity Aiken's V test was applied, with a value greater than or equal to 0.80 indicating high agreement between items and the construct being measured. Internal reliability was tested using Cronbach's Alpha, a value of ≥ 0.70 was considered to represent good consistency. The reliability of physical performance observations was also tested using the ICC in the assessment of inter-rater agreement. As stated, the high reliability means that you can count on the consistency of the instrument (Leyland & Groenewegen (2023). The validity shows how much an instrument actually measures what it claims to measure Black & Babin (2019). The results of the analysis indicated that scale was valid and reliable for use with rowing athletes to assess their physical condition.

III. RESULTS

This research found the results of 12 from an instrument validation study by seven experts (3 practitioners and 4 academics). The assessment was done to estimate the content validity of each item of instrument by applying Aiken's V formula. Experts scored each item in response to its consistency with the dimensions of rowing physical conditioning. In Table 3, the results of the validity of the instrument in general showed that all items had Aiken's V values between 0.75 and 0.93, indicating that they were valid items and can be used to measure. The validation test results are presented in Table 1.

Table 1. Expert Validation Assessment

ITEM	Judgment Expert							S1	S2	S3	S4	S5	S6	S7	∑S	n(c-1)	V	Description
	1	2	3	4	5	6	7											
01	3	4	4	5	4	4	4	2	3	3	4	3	3	3	21	28	0,75	Valid
02	4	5	3	5	3	4	5	3	4	2	4	2	3	4	22	28	0,79	Valid
03	5	5	4	5	4	5	5	4	4	3	4	3	4	4	26	28	0,93	Valid
04	4	4	4	5	5	4	5	3	3	3	4	4	3	4	24	28	0,86	Valid
05	5	5	5	4	5	4	5	4	4	4	3	4	3	4	26	28	0,93	Valid
06	4	5	4	5	4	4	5	4	4	3	4	3	3	4	25	28	0,89	Valid
07	4	5	5	4	4	5	5	3	4	4	3	3	4	4	25	28	0,89	Valid
08	4	5	5	5	5	4	5	3	4	4	4	4	3	4	26	28	0,93	Valid
09	5	5	4	5	5	4	5	4	4	3	4	4	3	4	26	28	0,93	Valid
10	5	4	5	4	4	5	5	4	3	4	3	3	4	4	25	28	0,89	Valid
11	4	5	4	4	4	4	5	3	4	3	3	3	3	4	23	28	0,82	Valid
12	4	5	4	4	4	5	5	3	4	3	3	3	4	4	24	28	0,86	Valid
13	5	5	5	4	4	4	5	4	4	4	3	3	3	4	25	28	0,89	Valid
14	5	4	5	5	4	5	4	4	3	4	4	3	4	3	25	28	0,89	Valid
15	5	4	5	4	4	4	3	4	3	4	3	3	3	2	22	28	0,79	Valid
16	4	5	3	5	4	4	4	3	4	2	4	3	3	3	22	28	0,79	Valid
17	5	3	4	4	4	5	5	4	2	3	3	3	4	4	23	28	0,82	Valid
18	4	4	4	5	4	4	4	3	3	3	4	3	3	3	22	28	0,79	Valid
19	3	4	4	4	4	5	4	2	3	3	3	3	4	3	21	28	0,75	Valid
20	4	4	4	4	5	4	5	3	3	3	3	4	3	4	23	28	0,82	Valid

Table 1 presents the results from content validation by seven experts on 20 items of the rowing physical condition measurement tool. The V values of Aiken are ranged from 0.75 to 0.93 which means all instrument items are valid and applicable. The highest value (0.93) is for items 3, 5, 8 and 9 that indicates the best agreement between experts on relevance of these to the measured construct. These results could indicate that the proposed measures are consistent with important aspects of athletes rowers' physical condition, strength, endurance and speed which are fundamental for rovers' performance.

These results are consistent with the theory of content validity from Aiken (1985) which posits that an instrument has validity if expert judgments reveal an alignment between items and construct. Furthermore, Wahyuni (2023), argued that validity refers to the integration of empirical and theoretical arguments in underpinning claims upon which measurement interpretations are

based. Moreover, as suggested by Almanasreh et al. (2019) and Bichi et al. (2019), the participation of altogether experts (out of which were practitioners) from different areas provides more objectivity and accuracy to put the validation overall results when further applying this instrument in measuring rower' physical condition. According to Purnomo et al. (2024), an interdisciplinary role in the process of instrument validation is necessary for developing a theoretical measuring tool that is also practical and efficient. In addition, the validation shows that the 5-point rating scale is sensitive enough to reflect differences in expert opinions. Therefore, the instrument was not only content valid but also now ready to be tested for reliability and field tests in a large sample in order that its consistency and practicality for comprehensive assessment of rowers' physical condition could be ensured.

Table 2. Overall Expert Validity Test Results

ITEM	Judgment Expert							S1	S2	S3	S4	S5	S6	S7	∑S	V	Description
	1	2	3	4	5	6	7										
1-20	86	90	85	90	84	87	93	67	70	65	70	64	67	73	476	ɔ,85	Valid

As shown in Table 2, it can be concluded that the results of the content validity from the assessment as many as 20 items physical condition test instrument for rowing-athlete is Aiken's V, which is worth 0.85 where it was greater than minimum limit point that is equal to 0.75 therefore all items were declared valid (V et al., 2020). Seven academic and sports expert raters performed the evaluation on a 5-level rating scale. Aggregated assessment index score among all experts for all items were 476, theoretic maximum score was 560, of this the V value is more than enough (Napitupulu, 2020). This value represents a high agreement level among the experts in relation to relevance and clarity of each item in representing the components related to physical condition that is essential for rowing. These results are consistent with the views of Taherdoost's, (2016) that a content validity is essential for the development of an instrument as it verifies that what was being measured is in line with its intended theory or construct. In addition, Almanasreh, (2019) also highlight that involving experts in the content validation process will enrich semantic representation and better match items to measurement purposes of critical importance for instrument accuracy and credibility. Moreover, based on the work by Johnston et al. (2019) for the measure of sports performance, it is essential to devise instruments that balance conceptual validity and practical applicability in order to apply the tools efficiently on the field. Thus, the verification results show that this instrument developed can satisfy the requirements of sci31611 ence and practice, render it appropriated to objectively and systematically measure the physical state of rowing athletes.

Table 3. Results of the Interclass Correlation Coefficient (ICC) Experts.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.581[a]	,406	,764	10,709	19	114	,000
Average Measures	.907[c]	,827	,958	10,709	19	114	,000

Based on the analysis results displayed in Table 3, the Intraclass Correlation Coefficient (ICC) Average Measures value of 0.907 indicates a very high level of reliability in the expert assessment of the physical condition test instrument for rowing athletes. According to . Leyland & Groenewegen, (2023), an ICC value between 0.75 and 0.90 is categorized as good, while a value above 0.90 indicates very high reliability. These results indicate that there is a very strong consistency among the experts in evaluating the items of the developed instrument. Although the ICC Single Measures value of 0.581 falls into the moderate category, this does not diminish the strength of the results because the final reliability value is determined by the Average Measures, which reflects the overall consistency among the raters. The significance value (Sig) of 0.000 indicates that the ICC test results are statistically significant ($p < 0.05$), meaning that the agreement among raters did not occur by chance. In line with this, Rohde et al., (2022) state that ICC is a statistical method commonly used in educational and sports research to measure the consistency or agreement among raters. Therefore, the high ICC value in this study indicates that the instrument used has very good rater reliability and can be applied in various other measurement contexts in the field of sports, particularly in rowing.

Table 4. Reliability Test Retest Results

Reliability Statistics

Cronbach's Alpha	N of Items
.974	2

Based on Table 4 and the results of the test-retest reliability test, a Cronbach's Alpha value of 0.974 indicates a very high level of reliability. According to Wu & Wacharasin (2022), a value of $\alpha > 0.9$ falls into the "very good" or excellent category. These findings indicate that the physical condition assessment instrument for rowing athletes has very high internal consistency and can be relied upon when used repeatedly over different times. The high alpha value indicates that the measurement results are not affected by time variations or other external factors. The test-retest reliability test is a technique to measure the stability of an instrument over time Izah et al. (2023), which means that if the instrument is used again under the same conditions, the results will remain comparable. The high reliability value also indicates that the two items being tested measure consistent and complementary elements, especially when the number of items is only two (N item = 2). Thus, it can be concluded that the tested instrument meets the very good reliability requirements and is suitable for use in research or assessment to measure the physical condition of rowing athletes.

IV. DISCUSSION

After undergoing a development and validation process, a physical condition measurement instrument for rowing athletes has been formulated into nine test items. Each item represents a key component of physical fitness that directly contributes to the performance of rowing athletes. The 30 Metre Sprint speed test is used to measure acceleration ability, which is crucial at the initial stroke phase (start). According to (Bompa & Buzzichelli, 2019), speed is greatly needed in sports that demand quick reactions and responses. The Standing Broad Jump is used to assess leg muscle strength, which plays an important role in the transfer of power from the lower body to the rowing movement. The Beep Test measures cardiovascular endurance, which is crucial for sustaining cycling intensity during races; good endurance allows athletes to maintain a more stable energy output over prolonged durations (Kent et al., 2023). The 1-Minute Sit Up and 1-Minute Push Up are used to measure core and arm muscle strength respectively, both of which are vital for maintaining trunk stability and cycling efficiency. To assess flexibility, the V Sit and Reach Test is employed, as it relates to the range of motion while rowing; optimal flexibility supports technique efficiency and prevents injuries (Legge et al., 2024). The balance test (Stork Stand Test) is extremely important for holding a steady body position on the boat. The Medicine Ball Throw tests upper body power as a predictor for rowing push strength, while the Alternate Hand Wall Toss Test assesses hand eye coordination which is critical in keeping the rhythm of paddle movements. As a stated to by Burhaein, (2024), the choice of nine test instruments is made according to their usefulness for the physiological and technical requirements in rowing, whilst also considering valid and situational relevance as priorities in estimating athlete' s physical condition. Taken together, the study findings suggest that the physical condition test instruments for rowing athletes were valid and reliable enough to use at this stage of measurement. According to scientific measurement standards, this tool is very good, although some minor tweaks would certainly help it work more efficiently and effectively. An immediate need is to administer a ''test-retest'' reliability test and empirical validity with appropriate subject populations (in this case, rowers) on questions in the instrument. The sequential validation procedures, such as cv (18), reliability assessment and empirical assessment, are a significant step in the creation of an applicable and valid measurement instrument. As explained by Clark et al. (2019), such a methodological approach is crucial when practical application of valid and reliable scientific instruments in practice settings are established.

V. CONCLUSION

From the results of this study, it can be concluded that the physical condition test instrument for rowing athletes has been successfully developed systematically, from five to nine items, involving seven experts. Validitas isi dievaluasi menggunakan teknik V Aiken, dilanjutkan dengan uji konsistensi antarpenilai serta uji reliabilitas tes ulang untuk memastikan kestabilan hasil pengukuran dari waktu ke waktu. Setiap tahapan pengujian menunjukkan bahwa instrumen ini memiliki validitas dan reliabilitas yang kuat, sehingga layak digunakan untuk memantau kondisi fisik atlet dayung secara objektif dan konsisten.

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