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Development of an Archery Technique Test Instrument: Objective Evaluation to Improve Athlete Performance

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Abstract

This study aims to develop a valid and reliable archery technique test instrument for recurve bow athletes to address the limitations of existing instruments, which tend to be subjective and focus solely on accuracy. The research and development (R&D) method, adapted from the steps of Borg and Gall, involved 14 athletes at the National Potential Young Athlete Training Center (SLOMPN) as the total sample. The developed test instrument not only measures accuracy (through qualification and elimination scores), but also specifically and objectively measures speed, strength, and endurance specific to the sport of archery. The seven main test components produced include: qualification score, elimination score, shooting speed, bow draw maximum quantity, bow training, battery test archery, and maximum shooting. The trial results showed that all seven test items were internally valid, with a correlation coefficient (r) higher than (rtable = 0.532). Furthermore, this instrument has a very high level of reliability (stability across testing sessions), with a test-retest correlation coefficient of 0.893. This study concludes that the developed archery technique test instrument is proven to be feasible, valid, and highly reliable for use. This instrument provides a comprehensive, objective evaluation tool, enabling coaches to profile athletes and design more effective and specific training programs, considering aspects of strength, speed, and endurance, in addition to shooting accuracy.

How to Cite

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INTRODUCTION

Archery is a demanding sport that requires a high level of technical mastery, focus, and seamless coordination between the body and mind. An archer's success primarily hinges on their technical execution, which includes their stance, aiming precision, bow control, and shot consistency (Lee & Kim, 2017). This highlights the urgent need for valid and reliable technical test tools that can evaluate an athlete's performance in an objective and measurable way (Smith, Brown, & Thompson, 2019). Currently, most existing technical assessments in archery are subjective, often relying on the judgment of coaches or referees, which makes them vulnerable to personal bias (Johnson, 2020). Studies have clearly shown that incorporating objective, data-driven tests can significantly help coaches design more effective training routines (Anderson & Carter, 2018; Zhang et al., 2021). Therefore, creating standardized measurement tools is a vital step toward improving the quality of athlete development in archery (Taylor & Roberts, 2020).

Beyond just being objective, any new archery technique test must carefully consider the content and construct validity of its components (Miller, 2016). Validity ensures the instrument accurately measures the specific technical skills it targets, such as the body position during the draw, arm stability, and shot consistency (Jackson & Green, 2019). For instance, research by Park and Lee (2017) stressed that this kind of validity is crucial for confirming that the instrument genuinely reflects the intended skill. Reliability is another essential factor; high reliability means the instrument will produce consistent results when used repeatedly under different circumstances and at various times (Williams, 2018). Carter and Davis (2020) demonstrated that testing tools lacking reliability can actually hinder performance evaluation by generating confusing and inconsistent data.

Effective technique tests must also be mindful of their sensitivity and specificity (Nelson, 2019). Sensitivity refers to the instrument's power to spot even tiny changes in an athlete's performance, whereas specificity measures how well it assesses a particular technical aspect without being influenced by other factors (Harris & Johnson, 2021). Consequently, developing these instruments requires a rigorous testing phase. As technology evolves, we've seen several innovations in measuring archery performance. The adoption of motion sensors and video analysis software, for example, has proven highly effective in boosting the accuracy of technique assessments (Chen et al., 2018). Liu and Zhang (2020) found that leveraging this technology aids coaches in pinpointing subtle technical flaws that are difficult to spot with the naked eye.

Meanwhile, research focused on developing archery technique tests is still relatively sparse in Indonesia. Some local studies, like Santoso's (2019), emphasize the need to create tools specifically adapted to the local context and the unique traits of Indonesian athletes. This current study, therefore, aims to close that gap by developing an instrument tailored to local needs. In a training setting, a well-designed technique test can function as a powerful evaluation tool for crafting personalized training plans (Thompson, 2017). For example, if the test reveals that an athlete has weak arm stability, the coach can immediately design targeted drills to fix that specific issue (Roberts, 2018), which can dramatically increase the overall effectiveness of the training.

Furthermore, prior research indicates that using structured technical testing tools can also serve to boost athlete motivation (White & Black, 2020). Athletes who can objectively track their progress in technical skill development are often more driven to improve their performance (Green, 2021). Thus, these instruments offer significant psychological benefits in addition to their function as mere evaluation tools. Standardized instruments are also key for creating an objective and fair selection process for athletes at regional and national levels (Hernandez & Lopez, 2019). They help minimize the subjectivity that often complicates selections based purely on direct observation (Miller, 2020).

The development of any new archery technique test must necessarily involve coaches and athletes in the testing process (Walker & Harris, 2017). Their input is essential to guarantee the instrument is practical for real-world scenarios and user-friendly (Nelson et al., 2019). This research will therefore include close collaboration with professional coaches and seasoned athletes. Statistical analysis is also a core element of the development process. Techniques like factor analysis and Cronbach's alpha reliability testing will be employed to ensure the instrument achieves high validity and reliability standards (Johnson & Brown, 2018), with appropriate statistical rigor strengthening the final quality of the tool.

This research is expected to make a valuable contribution to sports science, specifically by introducing a more effective way to evaluate archery technique (Carter, 2020). With a robustly valid and reliable instrument, the training process can become much more focused and quantifiable (Taylor & Smith, 2021). Finally, the findings from

this study are intended to serve as a template for developing technical test instruments in other sports. The experience gained from building the archery tool can be adapted for any sport with similar needs for technical evaluation (Jackson & Lee, 2019).

METHODS

This study employed a research and development (R&D) method. The research took place at the National Potential Young Athlete Training Center (SLOMPN), involving 14 participating athletes selected via total sampling—meaning the entire population was included. By adhering to the developmental stages established by Borg and Gall, we aim for this technical test instrument to become a reliable and valid asset. It's expected to significantly boost the quality of training and athlete selection, while also streamlining the process of profiling in archery. Furthermore, this test should empower coaches to create more impactful training programs informed by precise evaluation data (Borg & Gall, 1983). We adapted the standard Borg and Gall model to fit the on-the-ground circumstances, focusing on six adjusted steps: identifying needs, analyzing product development, writing performance goals, developing the test instrument, designing and evaluating the product, and finally, product revision.

Needs Identification

The initial step in crafting a skill test for novice archers is identifying specific needs by uncovering the difficulties and obstacles athletes face while mastering fundamental skills. Researchers achieved this clarity by interviewing coaches, observing training sessions, and analyzing existing skill tests. This process allowed the team to precisely define the instrument's focus and objectives. The goal was to gather in-depth information on the techniques and skills that coaches prioritize, ensuring the resulting test is appropriate and truly relevant to real-world training environments (Taber et al., 2024). Furthermore, this step actively encouraged stakeholder involvement to provide essential feedback, which ultimately helps ensure that the final instrument is widely accepted and used.

Product Development Analysis

Following the needs identification, the next phase was product development analysis to design the assessment instrument's core framework. This analysis established the test's purpose and the necessary validity and reliability criteria, grounded in a review of relevant theories and prior research on archery skill measurement. The researchers then crafted a detailed development blueprint, specifying the measurement method, test format, and assessment approach. By incorporating archery expert input, the team ensured the instrument would be both scientifically sound and highly practical for coaches and athletes (Rizal et al., 2019).

Writing Performance Objectives

The subsequent step is formulating the performance objectives, which are central to the assessment tool's development. These objectives must be clearly defined to guide both coaches and athletes throughout training. This research highlights the need for goals to be specific, measurable, and suitable for diverse skill levels. Clear performance objectives provide direction for the training program itself, allowing coaches to easily track and evaluate progress over time, which studies show boosts motivation and performance (Kusuma et al., 2023). Therefore, establishing appropriate performance objectives is a fundamental cornerstone for this instrument's development.

Developing the Assessment Instrument

The next stage was developing the assessment instrument, transforming planned ideas into a concrete evaluation tool. Researchers created an initial draft featuring tests to gauge beginners' fundamental archery skills, incorporating competition-relevant scenarios to measure accuracy and arm strength. The team also considered external factors (like weather and psychological state) that might sway outcomes. A pilot test was then conducted to check practicality, with feedback from coaches and athletes used to refine the tool, ensuring it was both theoretically sound (valid) and practical for real-world use (Hartigh et al., 2018). Through a series of necessary revisions based on this feedback, the goal is for the final instrument to be a highly effective tool for evaluating athlete skills.

Designing and Evaluating the Product

Once the assessment instrument was fully developed, the next critical step was thorough product design and evaluation. This phase involved a pilot test on various athletes during training and competitions to ensure the tool functioned effectively and accurately measured the intended skills. The evaluation results highlighted the instrument's strengths and weaknesses. By analyzing the pilot test data, researchers assessed whether the instrument met the required validity and reliability standards. User feedback was vital for

further refinement, ensuring the final tool provides tangible benefits for improving athlete skills (Kaldau et al., 2021).

Revising the Product

Based on the evaluation results, researchers made all necessary adjustments to refine the instrument's quality. Revisions included format adjustments, instructions for use, and assessment criteria to ensure they were easily understood by coaches and athletes. This stage was crucial to ensure the tool could be effectively implemented in training programs. Expert input was also incorporated to ensure the final tool met all necessary criteria before it was ready for widespread use (Wang et al., 2023).

The data analysis in this study employed both quantitative and qualitative descriptive analysis. Specifically, qualitative descriptive analysis was used on the findings from the initial needs observations. This helped clarify the specific challenges encountered by athletes and provided the necessary foundation to strengthen the research background. This technique was also used to analyze data on improvement suggestions provided by validators and observers, which were then summarized as the basis for revision. Meanwhile, quantitative descriptive analysis techniques were applied to (1) the validation assessment results from subject matter experts using a rating scale on the draft athlete skills test before the trial; (2) data from observer observations related to the test implementation after the trial; and (3) the results of the archery test designed by the researcher and the qualification scores for the two sessions. The rating scale for the validation questionnaire and product observations consisted of five levels: (1) a score of 1 for a very inappropriate assessment, (2) a score of 2 for an inappropriate assessment, (3) a score of 3 for a fairly appropriate assessment, (4) a score of 4 for an appropriate assessment, and (5) a score of 5 for a very appropriate assessment.

The developed skills test was deemed suitable for testing on both a small and large scale if it quantitatively met the established criteria. Product validity was determined through construct validity and criterion validity tests. Construct validity was assessed by analyzing the results from the large-scale trial of the skills test. This involved using inter-item correlation, where individual test results were correlated with one another, and each test item was correlated against the total qualification score across the two sessions. The specific statistical method utilized for this analysis was Pearson's product-moment correlation. Criterion validity was established by correlating the outcomes of the archery skills test from the large-scale trial directly with the official qualification scores achieved over the two sessions.

To establish the reliability of the newly designed product, a test-retest method was employed. Researchers administered the developed test to the same group of participants on two separate occasions, with a one-day interval between the first and second testing sessions. The test reliability coefficient was then determined by correlating the results from the first test with those from the second. This statistical analysis used Pearson's product-moment correlation technique and was performed using SPSS software to guarantee the accuracy and precision of the resulting data. The test was then deemed appropriate and feasible for use using classifications adopted from (Chaabene et al., 2018), (Burnstein et al., 2011), and (Khairurraziqin & Handoko, 2020).

RESULTS AND DISCUSSION

The results of this research on archery test instruments are based on the needs of archers in the field. Currently, archery coaches only use one test instrument: accuracy, also known as the Total Score, and distance, which is adjusted for each athlete's age.

Based on these field findings, this instrument was developed to assess the improvement in an archer's arm muscle strength. If the training program is effective, results will improve. However, if the test results do not improve, an evaluation of the athlete's training program is necessary.

The types of test instruments are:

Table 1. Types of Archery Athlete Test Instruments

Test Type	Test Name
Scoring	Qualification Score
	Elimination Score
Specific Speed	Speed Shooting
Specific Strength	Bow Draw Max Quantity
	Bow Training
	Battery Test Archery
	Maximal Shooting

The steps or standard operating procedures (SOPs) for administering the test instrument are:

Qualification Score

An archer's qualification score is calculated as follows: 1) Shoot 6 arrows, then calculate the total accuracy of the 6 arrows (this can be called

a series/rambahan). 2) One session consists of 6 series/rambahans, and the total series are added together. 3) The archer shoots 2 sessions and adds up the total accuracy scores. 4) The qualification score is the total score of the 2 sessions.

Elimination Score

An archer's elimination score is calculated as follows: 1) Shoot 3 arrows, then add up the accuracy scores (this is called a series/rambahan). 2) The elimination score is the total accuracy score of the 5 series/rambahans.

Speed Shooting

Speed shooting in this test is measured as follows: 1) The archer shoots as many arrows as possible using the technique normally used in training and competition. 2) This test is conducted at a close distance of 5 meters. 3) This test is timed for one minute, and the number of arrows fired is recorded. 4) Once the time runs out, the archer has released an arrow, and the number of arrows fired is counted. If the arrow is not released or is still in the process of being released, it is not counted.

Bow Draw Max Quantity

The Bow Draw Max Quantity test in this test is conducted as follows: 1) The archer draws the bow from the set-up position to the anchor and repeats this for a specified time. 2) This test is performed without nocking an arrow. 3) This test is timed for one minute. 4) Within one minute, the archer can perform the movement from the set-up to the anchor, and the movement is performed without lowering the bow or always maintaining the ready-to-shoot position.

Bow Training

Bow training is conducted as follows: 1) The archer performs movements using an arrow. 2) Perform a movement similar to shooting an arrow, but when you click, hold it for as long as possible until you can't hold it in anymore. 3) Once the forward movement begins, the timing stops.

Battery Test Archery

This test is conducted as follows: 1) The archer performs a movement similar to a bow draw with maximum quantity. 2) However, the time is divided into specific levels. 3) The levels are as follows:

a) Level 1 = Bow Draw with a maximum quantity of 5 seconds, then rest for 5 seconds. Level 2 = Bow Draw with a maximum quantity of 10 seconds, then rest for 10 seconds
b) Level 3 = Bow Draw with a maximum quantity of 15 seconds, then rest for 15 seconds
c) Level 4 = Bow Draw with a maximum quantity of 20 seconds, then rest for 20 seconds
d) Level 5 = Bow Draw with a maximum quantity of 25 seconds, then rest for 25 seconds
e) Level 6 = Bow Draw with a maximum quantity of 30 seconds, then rest for 30 seconds
f) Level 7 = Bow Draw with a maximum quantity of 35 seconds, then rest for 35 seconds

4) The movements above continue immediately when changing levels (for example, after resting at Level 1, immediately move on to Level 2), and so on until the athlete is no longer able to perform the movements. 5) An athlete is considered to be no longer strong if the pull is not full to the anchor, and the pulling position is not perfect.

Maximum Shooting

The Maximal Shooting test is carried out by: 1) Archers shoot at a distance of 5 meters. 2) Shoot with a maximum of 12 arrows. 3) The archer shoots as many arrows as possible until he can no longer shoot. 4) Archers cannot rest between rounds, but can drink first before shooting again. 5) If you are no longer strong enough to shoot, the number of shots fired is counted.

The instrument above is the result of developing an archery athlete testing system. Previously, the only instruments used were the Qualification Score and Elimination Score tests. Therefore, the researcher created this instrument to assess training progress when the score test was not optimal. Using only the score test would significantly impact results, including equipment, mood, psychological state, weather conditions at the test location, and other external factors. Of the seven tests, the maximum score for each item is derived from the results of Indonesian senior national team athletes who have competed in the Olympics. The scores for each item are not absolute and may change based on the scores or the implementation of the most recent test.

This test instrument will significantly assist coaches in assessing an archer's training progress because it tests Strength, Speed, and Strength Endurance. The results of this test will also facilitate the coach's decision on the next training program, as the athlete's progress can be clearly seen.

Figure 1. The atmosphere of test implementation with the athletes SLOMPN Kemenpora in the Archery Field Cibubur, Jakarta.

During the research process, the validity and reliability of the test items were also assessed. The validity of the test items was calculated using Pearson's Bivariate Correlation (r) between the scores of each item and the Total Score (sum of the 7 items) in Test 1. The validity criterion (rt-able for N = 14 at α = 0.05 was 0.532).

Table 2. Instrument Validity

Test Item	r_{count}	r_{table}	compare
Qualification Score	0.825	0.532	Valid
Elimination Score	0.811	0.532	Valid
Maximal Shooting	0.768	0.532	Valid
Bow Training	0.838	0.532	Valid
Bow Draw Max	0.817	0.532	Valid
Speed Shooting	0.702	0.532	Valid
Battery Test Archery	0.695	0.532	Valid

All seven test items showed a correlation coefficient (r-count) higher than the critical value in the table (r-table = 0.532). Therefore, all items were declared internally valid in measuring the same construct.

The reliability test used Pearson's correlation between the Total Score of Test 1 and the Total Score of Test 2 (Test-Retest Method). The reliability criterion (r-table for N = 14 at α = 0.05 was 0.532).

Table 3. Instrument Reliability

Method	Sig	Result	Status
Test-Retest Correlation	p < 0.01	0.893	Reliabel

The Test-Retest Correlation Coefficient is 0.893, indicating that this test instrument has a very high level of reliability and is stable between testing times.

The importance of testing and measurement as a benchmark for an athlete's development (Boompa & Carrera, 2015), therefore, as a form of researcher innovation, this research produces an archery technique test instrument for recurve bows, which is viewed objectively from various perspectives, including measuring strength, speed, accuracy, and endurance. Before this instrument was created by researchers, archery trainer practitioners in Indonesia conducted athlete tests using only the results of qualification score tests, elimination accumulation score tests and using general physical ability tests, in fact, it is not uncommon for only those who use score tests and when there is a decrease in the score it is immediately considered that the athlete is still lacking in physical condition, with qualification score tests, elimination accumulation score tests and general physical tests, researchers see that the results have many factors including equipment factors, athlete mood conditions, athlete psychological conditions, weather conditions at the test location, and other external factors as well as physical tests that are still not very specific even though in terms of physical there is a special physical test instrument recommended for archery athletes as stated in Permenpora no. 15 of 2024 (Permenpora, 2024), therefore there is a need for a technical test that can be broad and more specific in scope and the level of influence factors is quite low in order to know the progress of arm muscle strength, speed, accuracy and endurance in addition to using general physical ability tests and Qualification score tests and elimination accumulation.

The technique test instrument developed by the researcher is a form of technique test to see how the technique is viewed objectively in accordance with what was stated by (Widoyoko, 2016) namely the test is a form of collecting object information in the form of skills, and this technique test is viewed objectively through a score test for accuracy and specific tests to see the actual condition of an archery athlete, because the more constant the technique the higher the level of accuracy can be, but the influence is quite a lot with the specific tests in this technique test instrument, this specific test will be another consideration in assessing this technique test objectively. If this test is done well with good body condition, the results will be optimal, and also, the external factors that influence the results of this test are very few, so the results are also known to be valid. After this test is carried out, a coach will be able to

determine the next program that will be given to an archery athlete, and if there is an improvement in this test then it can be stated that the training program he is undergoing is successful, this is in line with the opinion of Boompa (2000) that tests and measurements are one of the factors that influence the quality of training. The results of the development of this test instrument can be used for all archery athletes who can already shoot fluently, or in the sense that they are not at the beginner level, who are still learning at the basic level. This research can be right on target for athletes who are ready to compete and for recurve bow athletes.

Table 4. Result of Archery Technique Test

Component	Test Item	Benchmark	Unit	%
Scoring	Qualification Score	679	Score	100%
	Elimination Score	147	Score	100%
Specific Strength	Maximal Shooting	350	Arrow	100%
	Bow Training	75	Second	100%
	Bow Draw Max	37	Repetition	100%
	Battery Test Archery	6	Level	100%
Specific Speed	Speed Shooting	7	Arrow	100%

CONCLUSION

This study concludes that the developed archery technique test instrument is proven to be feasible, valid, and highly reliable for use. This instrument provides a comprehensive, objective evaluation tool, enabling coaches to profile athletes and design more effective and specific training programs, considering aspects of strength, speed, and endurance, in addition to shooting accuracy.

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