RELIABILITY AND FACTORAL VALIDITY OF A NOVEL SPORT-SPECIFIC TEST IN WELL TRAINED ARCHERS

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Abstract: The aim of this work is to validate one specific archery test and to give new light on implementation of this test onto archers and their training. The study involved a total of forty-three archers of both sexes and varying age groups. Testing was conducted over two consecutive days, following clearly defined criteria and a standardized procedure. Each participant performed the tasks using their own personal bow, which they regularly use during training and competition. The factor analysis showed that the results of the first trial described the highest common variability for man juniors 0.963, while for man seniors this happened in second trial 0.975. In the case of girls, an extremely small difference in the value of the common variance between the first two attempts was determined, 0.870 and 0.869. General validity of the test was very high in each group, 71.07% for girls to 91.01% for male senior of valid variance, which means that test with applied measuring procedure was highly reliable in measuring variables. The results of this research should help coaches to improve the applicability of this specific test, enabling them to independently conduct periodic testing, based on which they can monitor the individual changes in the preparedness of each athlete, as well as to control the effectiveness of the applied training concepts and methods.

Keywords: Archery test; measurement; monitoring; specific preparedness of archers; strength

INTRODUCTION

At the first glance, archery does look like stationary activity, but that end's there. Even archer stand still during shooting process, it's action require power, strength, endurance, fine motor skill, focus and balance through whole body. In order to perform a correct archery technique, an athlete must be able to feel and control his/her technique well (Humaid, 2014).

If we have a clear understanding of what competitive activity entails and its components, it will be easier for us to design training sessions and prepare athletes for competitions. This is a crucial step in athlete preparation, as coaches are expected to create and design training sessions that closely resemble the actual competition environment, enabling athletes to adapt more easily to the familiar setting and conditions during the competition itself.

The various elements that make up performance have been extensively explored in sports and sports sciences. Broadly speaking, performance results from the interaction of physical, mechanical, physiological, and psychological factors, with the specific components and subcomponents of these factors differing depending on the nature of the event (Kim et al., 2015).

Same authors were identified performance factors contributing to success in archery and categorized them into three groups: mental, skill, and fitness. The fitness-related factors that influence performance included "drawing a bow without an arrow," "lower-body weight training," and "upper-body weight training".

In order to successfully manage the training process and bring these factors to a level that provides the conditions for success in archery, one of the basic prerequisites is the application of diagnosing the initial condition of athletes, that is, assessing the preparedness of athletes in a certain cycle of preparation. To effectively and efficiently manage the training process, it is crucial to collect information about the current state of the athlete or group of athletes being trained, including their health status, current level of fitness, performance results, and other relevant factors. Additionally, it is necessary to collect data on the abilities that determine success and the achievement of top-level results in archery. It is also important to understand the model characteristics of elite athletes, as this provides a clear target to strive for and a specific goal for what one aims to achieve with the athlete. Furthermore, for quality management of the training process, it is crucial to document and monitor the training sessions, progress, and results of the athletes. All of this, along with many other aspects, forms part of, or should form part of, the management of the training process, as it is an ongoing activity that follows specific steps, phases of development, and implementation.

Unfortunately, in archery there are almost no direct tests for assessing the state of training or certain physical abilities, but rather general tests are used on the basis of which assessments and conclusions are made. In addition, among archery coaches and experts, there is a small number of specific bow tests that can be performed and the training process managed based on the results obtained. Although it is obvious that in sports, the dosage of volume and intensity of exercise and training must be clearly defined and precisely determined, unfortunately, in archery such tests are very few, almost non-existent.

However, one test, often used as a training exercise, stands out as such and is an exception. It is the specific archery test 7+2 (7 plus 2), which is the most specific of its type, and was first performed, described and published in detail by (Redža et al., 2021). The test is primarily intended to measure and assess repetitive upper limb strength under specific conditions, i.e. to assess the archer's capacity to draw and hold their bow for seven seconds, pause for two seconds (hence the name 7+2), and repeat this action until the first signs of fatigue.

Kim and colleagues (2015) conducted a study on a large number of respondents, 463 archers and 36 archery experts, including archery professors and national coaches, and through careful selection, came to the conclusion that the "bow draw without an arrow" exercise is the most relevant in terms of archery-related strength. In windy conditions, prolonged expansion time causes even more errors, and practicing drawing the bow without an arrow can help overcome this problem. In this way, weaker archers can strengthen and further improve their weaknesses in the skill by applying this exercise (Kim et al., 2015).

Test 7+2 was developed by South Korean coaches in the early 1980's and over the time got spread out around the world, and become a tool for many coaches to determine the ability of archers to resist bow poundage, as well as to assess bow poundage change to be adequate and so as not to disturb the archers technique, and shooting form (Redža et al., 2021), but the metrological evaluation of the given test has not been realized so far.

Precisely because of everything previously said, the goal of this paper is to determine the level of reliability and validity of a specific field test for archers 7+2 in function of its practical applicability. Based on the previously analyzed available scientific literature, as well as on the basis of the set problem, subject and goal of the research, it is possible to define a general hypothesis: the 7+2 test is expected to show high reliability and validity in the monitored age and gender groups.

METHODS

Participants

The subject sample included total of 43 well trained male (N=29) and female (N=14) archers, from tree different countries. The study covered different age categories, Male under 18 years of age (N=18), Male seniors above 18 years of age (N=11) and Woman under 18 years of age (N=14). Basic chronological morphological indicators and data on the sport-training experience of the tested sample were as follows for male: body height = 178,09 ± 5,70 cm, body mass = 81,63 ± 9,29 kg, body mass index = 25,76 ± 3,03 kg/m^2, age = 29 ± 6,36 years, training experience = 7,18 ± 4,45 years, for females under 18 years of age: body height = 163,82 ± 4,95 cm, body mass = 66,50 ± 12,66 kg, body mass index = 24,74 ± 4,31 kg/m^2, age = 15,93 ± 1,51 years, training experience = 3,64 ± 2,41 years, and boys under 18 years of age: body height = 170 ± 13,71 cm, body mass = 62,3 ± 22,27 kg, body mass index = 20,9 ± 5,11 kg/m^2, age = 14 ± 2,51 years, training experience = 3,8 ± 1,85 years.

Procedures

In order to define the reliability of the demonstrated performance in the function of assessing readiness on a specific field test, a test-retest procedure was used. Testing the reliability of the tests was carried out over two test days, using two reliability testing modalities: Trial-to-Trial and Day-to-Day. All participants were informed of the potential risk and discomfort associated with the test itself, and measurements were conducted out with their parental willing consent in the line with the Helsinki Declaration. Sampling took place on the field of the Archery Club Kosutnjak from Belgrade, Serbia and on the field of the Archery Club Paradoks from

Crnomelj - Svibnik, Slovenia. The collecting samples were in the period from the spring of 2022 to the summer of 2023. Targeted daily temperatures were in the range from 28°C to 33°C, where high daily temperatures and rainy days were avoided. All participants were informed prior to the test, about test itself, where they done it before or not. Test was explained individually and demonstrated, and designated commands were explained.

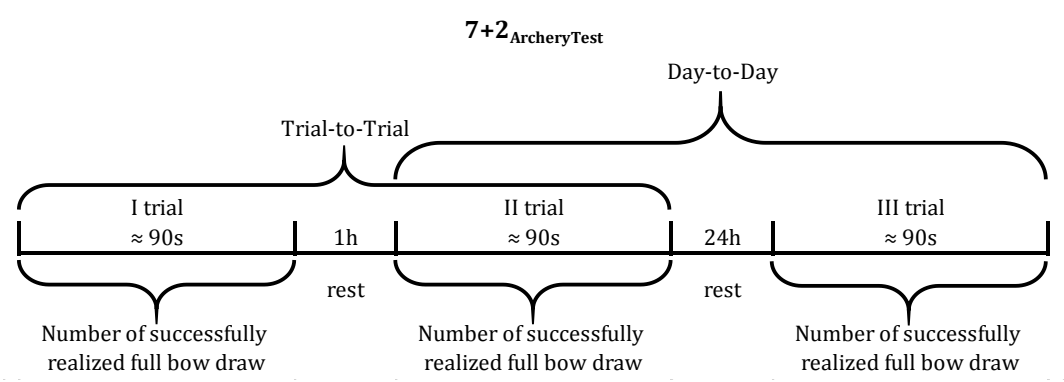

Figure 1. Schematic view of the testing procedure

All participants were advised not to do heavy training for upper body or heavy archery training 48 hours prior to the test. As two days were required for testing, the morning period was chosen for doing tests, between 09:00 am and 11:00 am for the first sampling, follows with one hour of total rest, and then the test is conducted once more. After the test is done on the first day, participants were advised not to have heavy training for upper body or shooting high volume of arrows that day, as the next day test is conducted once more. The test time on the second day was the same as the real test on the first day, or to be precise, 24h is required to pass between first tests of the day. Average time to do one test was 1,5 minutes per person.

Assessment of draw capacity and resistance to the bow poundage was conducted using specific archery 7+2 test ($7+2_{ArcheryTest}$). Test is conducted in the way that archer make shooting position with their own bow reaching full draw (anchor position) and hold position for seven seconds, followed by brake of two second in the neutral position by lowering bow and arms down. Test ends when archer could no longer maintain full draw without changing his/hers usual position or when significant collapsing due to tremor occur. The examiner counts number of successful attempts before tremor or changing position at the full draw. The number of successful attempts is also the result of the test.

Figure 2. Exeminees position during measuring procedure

Statistical Analysis

All the variables were subjected to descriptive statistical analysis, correlation, factor and structural equation modeling analysis. Each characteristic obtained during the test trials was represented by one item used in multivariate data analyses (Hair et al., 1998). Raw results were processed by use of descriptive statistical analysis in order to calculate basic descriptive statistical values (MEAN – mean value, SD – standard deviation, Min – minimal variable value, Max – maximum variable value, cV% – variable coefficient of variation). General statistical validity of results for the observed variables from the aspect of multivariate analysis as well as inter-item correlation, was performed by use of Bartlett's Test of Sphericity. Reliability of the applied test as a measuring instrument was defined by multivariate method for Structural equation modeling, and using the General validity analysis in Krombach's alpha. Reliability was assessed by Spearman-Brown rtt and by factor analysis through communalities extracted on the first characteristic (initial) eigenvalues (H2) (Hair et al., 1998). All statistical operations were carried out by applying the Microsoft ® Office Excel 2010 and the SPSS for Windows, Release 20.0 (Copyright © SPSS Inc., 1989–2002).

RESULTS

Table 1 shows descriptive statistics of observed characteristics according to trials (Mean, SD, cV%, Min, Max) (Table 1). Based on the established level of result variability as an indicator of homogeneity, the coefficients of variation (cV%) ranged from 12.67% to 29.58%, suggesting that the tested groups, within the framework of the test-retest method, demonstrated a sufficient degree of homogeneity in terms of

training status. This implies that all measured variables belonged to a set of homogeneous values (Table 1).

Table 1. Basic Item Descriptive Characteristics according to trials (N=43) in examinees

The results of descriptive statistics for the sample (N=43)						
		Mean	**SD**	**cV%**	**Min**	**Max**
Males <18 years (N=18)	Test 1	7.33	2.17	29.58	4	11
	Test 2	7.06	2.04	28.95	3	10
	Test 3	7.33	2	27.27	4	11
Males >18 years (N=11)	Test 1	8.45	1.69	20.05	7	11
	Test 2	8.55	2.16	25.3	6	12
	Test 3	8.55	2.07	24.19	6	13
Females <18 years (N=14)	Test 1	6.36	1.22	19.12	4	8
	Test 2	6.36	0.93	14.61	5	8
	Test 3	6.64	0.84	12.67	5	8

Table 2 shows results of correlation and structural equation modeling analysis. The average inter-item correlation in all variables described mutual correlation within a correlation matrix at a statistically significant level at $p<0.001$ (Bartlett`s test of Sphericity) and ranged between 0.788 for girls and 0.947 for man senior. The representability rate (KMO-MSA) ranged between 0.686 for girls and 0.738 for man juniors, the generalizability rate (Cronbach alpha) ranged between 0.788 for girls and 0.947 for man senior, while the reliability rate (Spearman-Brown rtt) ranged between 0.719 for girls and 0.954 for man senior (Table 2). Based on the obtained data, it can be claimed that the research established excellent reliability in the sample of male participants, both younger and older ($\alpha > 0.9$), and acceptable reliability in the sample of girls ($\alpha > 0.7$) (Vaske et al., 2016). The KMO (Kaiser-Meyer-Olkin) measure indicates a high and statistically significant level of multivariate adequacy of the given variables ($p = 0.000$), with values of 72.3% for the senior male group, 73.8% for the younger male group, and 68.6% for the female group. This essentially means that the collected data can be validly used in multivariate analysis to a degree ranging from 68.6% (females) to 73.8% (younger males). This further implies that the remaining portion of the variability lacks measurement adequacy and represents a source of noise—variability attributable to factors not directly related to the intended measurement. Such factors may include various systematic or random errors during measurement, differences in participant motivation during testing, or differing levels of training among participants, among others.

Table 2. The results of Correlation and Structural Equation Modeling

	Average Int-Item correlation	Bartlett`s Test of Sphericity	KMO-MSA	Cronbach alpha	Spearman-Brown reliability	Reliability Analysis ANOVA
Males >18 years	0.947	F=27.467 p=0.000	0.723	0.947	0.954	F=18.968 p=0.000
Males <18 years	0.936	F=43.577 p=0.000	0.738	0.936	0.917	F=15.645 p=0.000
Females <18 years	0.788	F=11.792 p=0.008	0.686	0.788	0.719	F=4.706 p=0.000

Table 3 shows the results of factor analysis (Communalities extracted on initial Eigenvalues First Component)-Component Matrix (H2). The factor analysis showed that the results of the first trial described the highest common variability for girls and man juniors: 0.870 and 0.963, while for man seniors this happened in second trial-0.975. General validity of the test was very high in each group, 71.07% for girls to 91.01% for male senior of valid variance, which means that test with applied measuring procedure was highly reliable in measuring variables (Table 3).

Table 3. The Factor Analysis (Extraction Method: Principal Component Analysis)

Communalities extracted on initial Eigenvalues (First Component) Component Matrix (H^2)

	Item 1	Item 2	Item 3	Total extraction: Sums of Squared Loadings	% of explained Variance
Males >18 years	0.928	0.975	0.959	2.731	91.023
Males <18 years	0.963	0.931	0.931	2.661	88.712
Females <18 years	0.870	0.869	0.788	2.132	71.074

DISCUSSION

The primary findings of this investigation indicate that the reliability level is highly statistically significant for all three groups of participants in relation to repeated measurements (Bartlett's Test of Sphericity p = 0.000 – 0.008, Reliability Analysis ANOVA p = 0.000; Table 2). Additionally, a high statistically significant value of multivariate adequacy for the given variables was established (p = 0.000), demonstrating that the measured data can be validly used on a level ranging from 68.6% (females) to 73.8% (younger males). Besides, results in this investigation indicate that athletes from different age and gender group require a different methodology for measuring the draw capacity and resistance to the bow poundage using specific archery 7+2 test (Table 3).

The results of the study revealed higher values of the monitored parameters in senior male participants, which may suggest that seniors possess a higher level of preparedness and are more resistant to fatigue. Additionally, it can be assumed that experience and training history played a significant role in the observed differences compared to their younger counterparts. Furthermore, there is a high likelihood that seniors had previously been exposed to this test and/or exercises with a bow more frequently and to a greater extent than their younger and less experienced archers.

The results of this study gain even greater significance when considering the fact that the findings of previous research. (Kim et al. 2015; Redža et al., 2021; Decheline et al., 2020; Antonov et al., 2017). Exercises or tests with a bow are highly rated on the importance scale regarding physical preparedness. It is also important to emphasize that bow exercises were selected as a crucial factor and prerequisite for successful engagement in archery, and that they are of decisive importance for archery performance, having a positive impact on the results (Kim et al., 2015). They contribute to strengthening the muscles of the upper extremities, which is directly related to aiming and precision (Kim et al., 2015). Thus, the connection between bow exercises and success in archery becomes clearer and inseparable, considering that no such connection between archery performance and the factors influencing it, as well as the mentioned exercises, has been found in the available literature. Furthermore, one of the previous studies (Redža et al., 2021) identified the factor structure within a battery of tests consisting of 9 tests to assess physical fitness in archers. The results showed that Lateral Core endurance and upper muscular strength as the first factor, which has explained 44.512% of the valid variance, is saturated with 4 variables, from which 2 of them belong to space that defines the values of tests for assessing isometric endurance of the trunk lateral flexor musculature and 2 belong to the space that defines the values of the tests for assessing upper muscular strength one of which is exactly the 7+2 test. The same study identified a connection between the lateral endurance of trunk muscles and the 7+2 test, showing that archers who perform better in the Plank test on the side from which the string is drawn (the weaker side) exhibit slightly weaker results, while the other side is somewhat stronger. This imbalance is particularly important, as archers during this test show signs of tremors in the 'leading arm,' which is the arm that, colloquially, holds the bow. As the test progresses, the muscles in the back and around the scapula, as well as the entire arm, experience fatigue, causing visible movement of the scapula toward the spine and the shoulder moving upward (Redža et al., 2021). Unfortunately, further elaboration of this problem from the aspect of archery is practically impossible. In the available literature, there are no studies dealing with the assessment of physical abilities, especially from the aspect of specific tests for the assessment of preparedness in archery. However, in relation to other sports, a large number of researchs were found with the aim of determining the reliability and validity of specific tests, which speaks in favor of the fact how important this area is in the management of the training process. The results of our research are in full agreement with the results of, for example, field tests and tests for monitoring different motor skills in wrestlers, where the reliability level ranges from 0.53 to 0.98 (Gierczuk & Ljach, 2012; Gierczuk & Bujak, 2014; Wright et al., 2015). By applying a specific test of swimming in place at maximum intensity for 60 seconds to assess the kinematic characteristics of the pull force in swimmers, reliability was determined in the range from 0.782 to 0.979 (Dopsaj et al., 2003). In relation to team sports, for example, in the basketball "line drill" field test, the ICC was determined at the level of 0.91 (Carvalho et al., 2011), in the test of 30 seconds of repetitive jumps of maximum intensity in volleyball players, the ICC level was in the range of 0.87 to 0.98 (Dal Pupo et al., 2014), and the reliability level of the T-test of agility in inactive to moderately active range of ICC from 0.60 to 0.96 (Munro &

Herrington, 2011). It is interesting to mention the results of the research by Ivanović and Dopsaj (2013) with the aim of determining the metrological values of the isometric force-time characteristics of the leg extensors in differently trained, healthy male athletes. Similar to this research, although the results showed high statistical significance in terms of representativeness, objectivity and reliability for all observed contractile characteristics, different methodological approaches were needed to obtain the most valid results for differently trained and untrained subjects. Based on the obtained results, and from the aspect of the methodology of testing different isometric force characteristics, it was possible to conclude that the standardization of the isometric leg press test requires two attempts in football, where the most reliable data are from the first attempt (H2 from 0.866 to 0.969). Water polo and basketball require three attempts. The most reliable data are from the third and second attempts in water polo (H2 from 0.909 to 0.986). In basketball, the most reliable data are from the second attempt (H2 from 0.824 to 0.987). An untrained healthy adult population requires four attempts, with the most reliable data coming from the third attempt (H2 from 0.961 to 0.995).

Despite the attention that sports scientists pay to the assessment of physical ability, there is not enough research examining the physical fitness of archery, there is no data on model characteristics, as well as data on the most adequate batteries of tests. The lack of reference to these problems has certainly hindered the elaboration of the mentioned phenomena that are the subject of this research. Also, the research was conducted at different ages and competitive level of participants and a relatively small sample, which must be taken into consideration since the young body is still developing, as well as their shooting and physical abilities. In order to apply the obtained results in general, it is necessary to conduct an extensive research that will include the examination on a larger sample of archers, of different ages, competitive level and both genders.

CONCLUSION

The results yielded highly acceptable rates for the indicators of reliability and validity at the significant level of $p<0.001$. The factor analysis showed that the results of the first trial described the highest common variability for man juniors-0.963, while for man seniors this hapened in second trial-0.975. For girls, the first test is saturated with 0.970, while the second is with 0.969 percent of the common variance, difference of only 0.001, which is the value belonging to the measurement error. General validity of the test was very high in each group, 71.07% for girls to 91.01% for male senior of valid variance, which means that test with applied measuring procedure was highly reliable in measuring variables. The standardization of the specific archery 7+2 test requires one trial for girls and man juniors, while for man seniors and girls require two trials where the results is the better value taken at the first or second trial.

The measure of sample adequacy (KMO-MSA) is highly significant for all observed group. Obtained results showed that the applied measuring procedure and used measuring instruments, are highly statistically reliable and can reliable in the function of testing well and highly trained archers.

One of the best methods for monitoring and controlling the preparedness of elite athletes, aside from competition success, is the simpler and faster alternative of using specific field tests. The main goal of the research aimed at improving these specific tests is to provide coaches with the ability to independently conduct periodic testing, based on which they can monitor the individual changes in the preparedness of each athlete, as well as to control the effectiveness of the applied training concepts and methods. Research of this type represents a constant need for scientific research in sports, primarily with the goal of improving sports training technology and enhancing knowledge.

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