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Research article

RELIABILITY OF SPECIFIC TESTS OF STRENGTH OF SPORTS ARM WRESTLING

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Abstract. *The goal of the present study was to explore the reliability of a specific strength test of sports arm wrestling. The Maximal muscle force (Fmax) and maximal Rate of the muscle force development (RFDmax) for the right and left arm in a specific arm wrestling supinated and neutral position were analyzed. The sample of variables included the following two variables: Maximal voluntary force (F_{max}) and maximal voluntary explosive force, i.e., maximal Rate of force development (RFD_{max}), measured at the left (L) and right (R) arm (musculus Biceps Brachii), for both sports-specific positions – supination, and the neutral position. The Single variable Inter-test reliability was determined using the Intraclass Correlation Coefficient (ICC) and Cronbach's Alpha based on standardized items. The statistical significance level was determined on the criterion of $p \leq 0.05$. Very high reliability (ICC = 0.916-0.971) exists for maximum muscle force variables, measured for the left and right arm with supinatorial and neutral hand positions. Moderate and high reliability (ICC = 0.681-0.892) was found for explosive muscle force variables, measured with the left and right hand in supinatorial and neutral hand positions. Generally, the highest values of muscle maximal and explosive force were achieved during the first test attempt. By looking at this information, coaches and athletes, may reliably use this specific AW test to create a clearer picture of the athlete's current physical readiness and for making appropriate decisions to guide the training process.*

Key words: *Muscle Strength, Metrological Sensitivity, - Methodological Validity*

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INTRODUCTION

Muscle contractile output in sports theory, known as strength, is often equated with muscle force and can be defined as the ability of a muscle or a group of muscles to produce physical force while contracting against an external resistance (Zatsiorsky, 1995). The isometric dynamometry method is traditionally used to measure the maximal force that can be produced during a maximal voluntary contraction against a supramaximal load or resistance, while tensiometric dynamometry can be used for measuring maximal force, as well as an explosive force too (Mirkov, Nedeljkovic, Milanovic, Jaric, 2004; Marković, Dopsaj, Koprivica, Kasum, 2018). The quantitative measure of arm strength can be obtained using a different type of dynamometer, and the standard dymomometer test is known as – the Hand Grip test (Dopsaj et al., 2018; Zarić, Dopsaj, Marković, 2018; Marković, Dopsaj, Veljković, 2020; Majstorović et al., 2020; Majstorović et al., 2021). However, from the aspect of the Arm Wrestling biomechanical position, the Hand Grip cannot be considered a sports-specific test.

Arm Wrestling (AW) is considering one of the oldest sports. Paintings in an Egyptian tomb testify that this way of competition among people was popular back then in 2000 BC. The first rules and the first organized competition were set up in Petaluma (California) 60 years ago (Usanov & Gugina, 2012). AW starts reaching its glory at the end of the 20^{th} century. AW is an individual sport where sportsmen face one another either in a tournament or a super match. The muscles of the forearm are the most important for AW , primarily wrist flexors, supinators, and pronators, secondarily elbow flexor and extensors, and thirdly shoulders muscles (Pectoralis Major, Pectoralis minor, Subscapularis, Deltoideus) and back muscles (Latissimus dorsi) (Silva et al., 2009).

Like in every other sport, AW has its techniques, the top-roll and hook. In top-rolling, the competitor tries to open the opponent's finger and wrist by pulling his/her hand, arm, and shoulder backward from the center. The main part of the hook is pushing to the center of the table and forcing the opponent's wrist in a supinated position, and one’s own in the wrist flexion position with or without supination (McKay & McKay, 2009).

In AW competition, the referee who will start the match with "Ready...Go" is considered as a head referee, and the referee who watches for elbow fouls after the match starts is considered an assistant referee (World Armwrestling Federation, 2009). People watching an AW match may think that the most crucial factor for the win is maximal muscle strength. However, there are equally important abilities like technical efficiency and Rate of muscle force development, thanks to which we can put an opponent in a challenging position to defend (Song et al., 2007).

AW is a sport that requires muscle strength, predominantly of the upper body. Top-skilled arm wrestlers possess higher maximum muscle strength compared to low-skilled ones. The highest differences in strength tests exist for the forearm supinator (77.9 %), forearm pronator (52.4 %), hand flexors (51.2 %), shoulder pronator (44.3 %), hand abductor (37.3 %), supine forearm flexors (34.0 %), grip (32.1 %), and neutral-point forearm flexors (29.0 %), in favor of top-skilled arm-wrestlers (Matyushenko et al., 2020). Flexing forearm strength is higher in arm-wrestlers compared to students, who do not practice arm-wrestling, where statistically significant differences ($p < 0.05$) were found (Podrigalo et al., 2015). These finds show the importance of including exercises for strengthening (maximum and explosive force) mentioned muscles in AW training. Besides that, those muscles have an essential role in achieving success in an AW competition.

It is important to advance scientific knowledge in performance testing to design specifically adjusted training protocols and periodization models and to increase success in competition (Bridge et al., 2014; Chaabene et al., 2017). The main purposes of sport-specific testing can comprise talent identification and development of young athletes as well as the identification of strengths and weaknesses in young and elite athletes to be used for training purposes (Tabben et al., 2014). Prior to the design of a test protocol for sport-specific performance assessment, it is recommended that a systematic needs analysis be conducted to identify the demands of the specific sport (Kraemer et al., 2012). With the systematically derived information on sport-specific demands from the needs analysis, adequate sport-specific performance tests can be designed and implemented into training practice (Tabben et al., 2014). Even though there is a well-accepted advantage of sport-specific performance testing over the application of general physical fitness tests, there is no study available that systematically reviewed the methodological quality (e.g., sample size, inclusion/exclusion criteria, stability of testing conditions), validation data (i.e., reliability, validity, sensitivity), and feasibility (i.e., practicability) of the existing sport-specific tests related to AW.

Also, there are no defined AW specifics strength tests which can hint at success, and it is a requirement of sports science and methodology of sport to establish a specific test for AW.

The aim of the present study was to establish reliability of two sports specific AW strength tests with which they can be measured the Maximal muscle force (F_{max}) and Rate of the muscle force development (RFD_{max}) for the right and left arm in a supinated and neutral position. The second aim is to establish data for defining the initial quantitative values for the assessment of specific fitness of AW athletes of the national level.

METHODS

The current study was realized by applying the laboratory method of testing using tensiometric dynamometry. Testing is realized by the method of the test-retest using the trial-by-trial technique alternately with the left and right arm, where the choice of arm and pulling position for the start of the testing was randomized relative to the participants.

Participants

Eleven male participants were engaged in the study, active competitors in the sport of Arm Wrestling (AW), with the following basic training and anthropo-morphological characteristics: Age – 26.2±5.3 yrs., BH – 181.4±5.0 cm, BM – 85.5±10.7 kg, BMI – 26.00±3.24 kg/m^2, PBF – 10.84±4.72 %, PSMM – 51.33±2.72 %, and with 3.1±1.2 years of AW training. All of the participants who volunteered for the study were healthy and had no neuromuscular disorders or orthopedic dysfunctions affecting hand strength. The research was conducted according to the postulates of the Declaration of Helsinki and with the permission of the Ethics Committee of the University of Belgrade Faculty of Sport and Physical Education (02 No. 484-2).

Testing equipment

Testing of the AW sport-specific strength (i.e., maximal isometric muscle force – F_{max}, and maximal explosive force – RFD_{max}) was performed using a standardized and evaluated tensiometric probe from the Sport Medical Solution company (SMS) measurement and electronic devices company (All4gym d.o.o.; http://all4gym.rs/). The SMS probe system was used for the acquisition and in-depth analysis of the force signal, i.e., the F-t curve in basic and sports specific testing (Marković, Dopsaj, Koprivica, Kasum, 2018; All4gym d.o.o.; http://all4gym.rs/; Majstorović et al., 2021). The system measuring chain consisted of a standard load cell, an acquisition unit with an integrated 12-bit A/D conversion and signal conditioning, with installed SMS software on a laptop. The load cell (CZL301) was equipped with a full bridge strain gauge sensor located on a steel fixed structure (Figure 1). The load cells had a rated load of 2000 N, a maximum measurement error of 0.03 %, and linear dependence. The frequency of sampling of the system was set at 500 Hz. Before testing, load cell calibration was performed using laboratory weights. All measurement characteristics for the used SMS test system were evaluated as reliable and valid (Marković, Dopsaj, Koprivica, Kasum, 2018; Marković, Dopsaj, Veljković, 2020; Majstorović et al., 2020).

Testing protocol

All measurements were performed in the specific standing position using two specific arm positions (neutral and supinated) for both the left and right hand (Figure 1). The elbow is planted on the pad of the AW table; at the start, the angle in the elbow was 90 degrees or less, with a hand in a closed and neutral position, and mid-way in the fully pronated and supinated position. Figure 1 shows a neutral, while Figure 2 shows a supinated start position. Each participant had an individual 10-minute warm-up and two submaximal testing attempts with the left and right arm for familiarisation with equipment and measurement procedures. After the familiarisation procedure, each participant had a minimum of 5 minutes of rest after the experimental testing was carried out using a randomized trial-to-trial method with a pause duration of 3 minutes between the trials (Tanner and Gore, 2012). For each of the AW testing positions and arms, the participants had three test trials (Test 1, Test 2 and Test 3) and all result was taken for statistical analysis. Before the experimental measurement, all participants had light training 48 hours before, i.e., a complete rest of 24 hours before testing. All tests were performed in the Methodological Research Laboratory (MIL) at the University of Belgrade Faculty of Sport and Physical Education, between 11:00 AM and 14:00 PM on the same day.

Fig. 1 Neutral arm AW testing position

Fig. 2 Supination AW testing position

Variables

The following variables were used in the research:

Maximal voluntary force (F_{max}), measured for the left (L) and right (R) arm (*musculus* Biceps Brachii), for both sports-specific positions – supination (S) and the neutral (N) position -

1. BBS_F_{max}_L, maximal voluntary force of the biceps brachii in left hand supination, expressed in Newtons (N);
2. BBS_F_{max}_R, maximal voluntary force of the biceps brachii in right hand supination, expressed in Newtons (N);
3. BBN_F_{max}_L, maximal voluntary force of the biceps brachii in the neutral position of the left hand, expressed in Newtons (N);
4. BBN_F_{max}_R, maximal voluntary force of the biceps brachii in the neutral position of the right hand, expressed in Newtons (N).

Maximal voluntary explosive force, i.e., Rate of force development (RFD_{max}), measured for the left (L) and right (R) arm (*musculus* Biceps Brachii), for both sports-specific positions – supination (S) and the neutral (N) position -

5. BBS_RFD_{max}_L, maximal voluntary explosive force of the biceps brachii in left hand supination, expressed in Newton per second (N/s);
6. BBS_RFD_{max}_R, maximal voluntary explosive force of the biceps brachii in right hand supination, expressed in Newton per second (N/s);
7. BBN_RFD_{max}_L, maximal voluntary explosive force of the biceps brachii in neutral position of the left hand, expressed in Newton per second (N/s);
8. BBN_RFD_{max}_R, maximal voluntary explosive force of the biceps brachii in neutral position of the right hand, expressed in Newton per second (N/s).

Statistical methods

All raw data were analyzed by descriptive statistical procedures in order to define the basic results of central tendency (Mean) and data variability (standard deviation – SD, coefficient of variation – cV%, minimal or maximal data value – Min, Max., and 95% range of confidence interval of mean value – Lower and Upper Bound). Differences between test trial mean values of variables were established using the GLM Repeated Measures procedures by multiple analyses of variance. The differences of the variables between the individual attempts were determined using Post Hoc Tests multiple comparisons for observed means with Bonferroni criteria. Single variable Inter-test reliability was determined using the Intraclass Correlation Coefficient (ICC) and Cronbach's Alpha based on standardized items. ICC values from 0.50 to 0.69 are defined as moderate, from 0.70 to 0.89 as high from 0.90, and higher as very high reliability (Munro et al., 1986; Sole et al., 2007). The statistical significance level was determined on the criterion of $p \leq 0.05$ (Hair, Anderson, Tatham, Black, 1998). Statistical analyses were conducted using IBM© SPSS© Statistics Version 23.0.

RESULTS

Table 1 shows the results of the descriptive statistical analysis of the tested variables.

Variable	Test Trials	Mean	SD	cV%	Min	Max	95% Confidence Interval for Mean	
							Lower Bound	Upper Bound
BBS_F_{max} (N)	L_1	425.4	49.4	11.61	363.0	537.0	392.2	458.6
	L_2	402.7	49.8	12.37	339.0	515.0	369.3	436.1
	L_3	387.7	45.3	11.68	333.0	491.0	357.2	418.2
	R_1	401.9	39.0	9.70	342.0	457.0	375.7	428.1
	R_2	410.8	66.1	16.09	310.0	551.0	366.4	455.2
	R_3	384.8	84.7	22.01	223.0	564.0	327.9	441.7
BBS_RFD_{max} (N/s)	L_1	1743.1	264.0	15.15	1261.0	2179.0	1565.7	1920.4
	L_2	1904.1	545.5	28.65	1182.0	3043.0	1537.7	2270.5
	L_3	1489.7	467.4	31.38	1151.0	2807.0	1175.7	1803.7
	R_1	1680.0	453.4	26.99	894.0	2581.0	1375.3	1984.7
	R_2	1694.5	480.2	28.34	903.0	2777.0	1371.9	2017.1
	R_3	1586.9	420.2	26.48	828.0	2187.0	1304.6	1869.2
BBN_F_{max} (N)	L_1	378.3	51.5	13.61	274.0	491.0	343.7	412.9
	L_2	359.4	54.8	15.25	279.0	484.0	322.6	396.2
	L_3	334.8	61.3	18.31	202.0	448.0	293.6	376.0
	R_1	377.7	51.2	13.56	291.0	468.0	343.3	412.1
	R_2	351.8	52.2	14.84	255.0	421.0	316.7	386.9
	R_3	333.9	58.1	17.40	211.0	408.0	294.9	372.9
BBN_RFD_{max} (N/s)	L_1	1968.0	490.3	24.91	1306.0	2843.0	1638.6	2297.4
	L_2	1568.7	327.5	20.88	1173.0	2289.0	1348.7	1788.7
	L_3	1429.1	475.6	33.28	844.0	2638.0	1109.5	1748.7
	R_1	2063.4	577.6	27.99	1110.0	3195.0	1675.4	2451.4
	R_2	1677.4	376.9	22.47	1118.0	2262.0	1424.2	1930.6
	R_3	1527.9	477.5	31.25	783.0	2145.0	1207.1	1848.7

Table 1 shows the maximal and explosive muscle force mean values for three left-hand and right-hand attempts. It can be seen that the values of maximum muscle force for the left arm in supination was in the range from 387.7 N to 425.4 N, and for the right arm from 384.8 N to 410.8 N. Then, the maximal muscle force values for the left arm with the fist in neutral position ranges from 334.8 N to 378.3 N, while for the right hand, the range is from 333.9 N to 377.7 N. Also, the values of explosive muscle force for the left hand with the hand in supination range from 1489.7 N / s to 1904.1 N / s, and for the right hand from 1586.9 N / s to 1694.5 N / s. Then, the values of explosive muscle force for the left arm with the fist in neutral position range from 1429.1 N / s to 1968.0 N / s, while for the right, from 1527.9 N / s to 2063.4 N / s.

Based on the relative indicators of variability, it can be argued that the results for all variables are very homogeneous because the values of the coefficient of variation (cV%) range from 9.70% to 33.28% (Table 1 BBS_F_{max}_R_1 and BBN_RFD_{max}_L_3, respectively). This indicates that despite the relatively small number of participants in the sample (N = 11), the obtained descriptive and other data can be considered homogeneous in relation to the population of AW senior male athletes from the Republic of Serbia.

An analysis of Table 2 shows that in almost all observed variables there are statistically significant differences (Wilks' Lambda = 0.142-0.475, p = 0.000-0.035), except for the variable BBS_RFD_{max}_R, where no statistically significant differences were found (Wilks' Lambda = 0.874, p = 0.574). The difference between the attempts in the observed variables varies from 52.5% to 85.8% (Partial Eta^2 = 0.525-0.858), and a significantly lower difference of only 12.6% (Partial Eta^2 = 0.126) exists for the variable BBS_RFD_{max}_R. The observed power for all variables ranges from 65% to 100% (Observed power = 0.658-1.000), except for the variable BBS_RFD_{max}_R, where the observed power is only 12% (Observed power = 0.127).

Table 2 Results of differences of mean values between AW tests

Variable	Wilks' Lambda Value	Wilks' Lambda p sig.	Wilks' Lambda Partial Eta^2	Observed Power	Test 1 vs. Test 2	Test 1 vs. Test 3	Test 2 vs. Test 3
BBS_F_{max}_L	0.406	0.017	0.594	0.784	0.032	0.010	0.123
BBS_F_{max}_R	0.321	0.006	0.679	0.914	ns*	ns*	0.037
BBS_RFD_{max}_L	0.475	0.035	0.525	0.658	ns*	ns*	0.035
BBS_RFD_{max}_R	0.874	0.547	0.126	0.127	ns*	ns*	ns*
BBN_F_{max}_L	0.142	0.000	0.858	1.000	ns*	0.000	0.029
BBN_F_{max}_R	0.186	0.001	0.814	0.998	0.045	0.001	0.005
BBN_RFD_{max}_L	0.260	0.002	0.740	0.972	ns*	0.002	ns*
BBN_RFD_{max}_R	0.355	0.009	0.645	0.867	0.020	0.005	ns*

The results of the reliability analysis showed that the value of standardized Cronbach's alpha and ICC are at the level from 0.662 and 0.681 for BBS_RFD_{max}L to 0.974, and 0.971forBBN_F_{max}_L, and that they are statistically significant (Table 3, from p= 0.014 to p=0.000, respectively). Cronbach's Alpha for the variables: BBS_Fmax L is 0.945, BBS_Fmax R is 0.955, BBN_Fmax L is 0.974, BBN_Fmax R is 0.964. In the Rate of the muscle force development test, Cronbach's Alpha values for the variables are: BBS_RFDmax L is 0.662, BBS_RFDmax R is 0.713, BBN_RFDmax L is 0.846, and for BBN_RFDmax R is 0.913. Variables: BBS_F_{max} R, BBS_F_{max} L, BBN_F_{max} R, and BBN_F_{max} L have very high reliability (ICC = 0.916, 0.944, 0.964, and 0.971, respectively). Then, the variables: BBS_RFD_{max} R, BBN_RFD_{max} L and BBN_RFD_{max} R have high reliability (ICC = 0.710, 0.835, 0.892, respectively). Only the variable BBS_RFD_{max} L has moderate reliability (ICC = 0.681).

Table 3 Results of reliability analyses between observed AW tests

	Cronbach's Alpha Based on Standardized Items	ICC – Interclass Correlation Coefficient			F test	
		Average Measures	95% Confidence Interval			
			Lower Bound	Upper Bound	Value	p sig
BBS_F_{max} L	0.945	0.944	0.845	0.984	17.91	0.000
BBS_F_{max} R	0.955	0.916	0.766	0.975	11.86	0.000
BBS_RFD_{max} L	0.662	0.681	0.115	0.907	3.14	0.014
BBS_RFD_{max} R	0.713	0.710	0.195	0.915	3.45	0.009
BBN_F_{max} L	0.974	0.971	0.920	0.992	35.56	0.000
BBN_F_{max} R	0.964	0.964	0.899	0.989	27.46	0.000
BBN_RFD_{max} L	0.846	0.835	0.543	0.952	6.07	0.000
BBN_RFD_{max} R	0.913	0.892	0.699	0.968	9.23	0.000

Discussion

In this study, ICC values show moderate to very high reliability for considered muscle force variables and applied test variants (Table 3). From the abovementioned, it is evident that higher ICC values were established for the maximum muscle force of the left and right arm measured in supination and the neutral position of the hand compared to explosive muscle force values. Therefore, it can be stated that the performed test can reliably measure, i.e. detect changes of measured maximal muscle force, but less during explosive muscle force. Therefore, its use in practice can be recommended.

Sports AW requires the manifestation of maximum muscle force and explosive muscle force, which can be reliably detected for the mentioned variables by applying the examined specific test. By monitoring the mentioned variables, muscle force values can be identified in specific positions that correspond to positions during competition, primarily in the initial phase of the match. Explosive muscle force is beneficial in the initial phase (start) of the match when a particular advantage can be achieved over the opponent, who has an equal or slightly higher level of maximum muscle force and a lower level of explosive muscle force. By assessing and monitoring the mentioned variables, the identification and selection of talents can be performed, and the direction of the training process determined.

When observing individual variables, the most significant differences in attempts were noticed in the variable BBN_F_{max}_L, then, in the following order: BBN_F_{max}_R, BBN_F_{max}_R, BBN_RFD_{max}_L, BBS_F_{max}_R, BBN_RFD_{max}_R, and finally BBS_RFD_{max}. This implies that regardless of whether the attempt is performed by the left or right hand, the values of muscle forces manifested in almost all the variables are statistically significantly different ($p < 0.05$). Therefore, it is impossible to state that the dominant arm's advantage exists in muscle force values. That shows that in AW training, the training load for both arms is applied and dosed equally. In future and in-depth research, it is necessary to determine the metrological sensitivity and methodological validity of the given tests to know how many attempts and which attempt should be taken as the most representative one for measuring the given specific abilities.

By observing the individual mean values in individual tests for all attempts, the highest values in the maximum muscle force of 425.4 N were achieved with the left hand in supination in the first attempt. All maximum force values are higher for supination regarding the neutral position of the hand. That is not surprising because the m. biceps brachii is most effective when the forearm is in the anatomical position, i.e., when the radius and ulna are parallel (McMilan & Carin-Levin, 2012). The highest value of explosive muscle force of 2063.4 N/s was achieved by placing the hand in the neutral position, also in the first attempt. It seems that the effectiveness rules of m. biceps brachii do not apply to explosive muscle force regarding the position of the hand.

Also, this data indicates that AW athletes are adapted to show maximum values of both strength and explosiveness in the first attempt. The assumption is that this ability is probably very important in relation to the competitive performance in which the athlete who is able to immediately show dominance over the opponent wins, regardless of whether it is a winning strategy due to the maximum level of force achieved to ensure victory, or it is a strategy where the tactics of teasing, i.e., the sudden manifestation of maximum explosiveness achieves the advantage needed to win. Apiknar et al. (2013) point out that strength and a speedy response can enable arm wrestlers to dominate opponents using proper technique.

In order to compare mean values for all three trials of maximum force and explosive force variables from Table 1, raw scores must be converted into standard scores. Conversion can be done using Z scores and percentages. Then, the comparison between the highest values can be made. Therefore, the highest value of explosive muscle force is at 97.00%, while the maximal muscle force is at 94.26%, which is a difference of 2.74%. Thus, observing the calculated standard scores, the participants have higher explosive muscle force values by 2.74% relative to maximum muscle force (regardless of the arm or hand position). It is essential to point out that the highest values of maximum and explosive muscle force are achieved in the first attempt, which should be kept in mind during future testing.

Cronbach's alpha values in this study are consistent with Ivanović and Dopsaj's (2013) study, where Cronbach's alpha for F_{max} ranged from 0.964 to 0.989 for leg extensor muscles, measured by a leg extension dynamometer, and for RFD_{max} ranged from 0.739 to 0.945. An exception exists only for BBS_RFD_{max} L, where Cronbach's alpha is 0.662. Participants were tested in a seated position, where their hip angle was at 110°, knee angle 120°, and ankle angle 90°. Furthermore, Majstorović et al. (2021) measured the force of the ankle joint muscles by isometric dynamometry, where Cronbach's alpha ranged from 0.969 to 0.982 for F_{max}, while Cronbach's alpha ranged from 0.916 to 0.933 for RFD_{max}. Furthermore, ICC single measures ranged from 0.785 to 0.949, which is higher than the ICC averaged values range (0.681 – 0.971) for F_{max} and RFD_{max} values in this study. Participants were tested on a chair with knees and ankles bent so that their thighs were parallel to the ground and knees were in line with their toes. Also, Padulo et al. (2020) measured knee flexion and extension isometric peak forces, assessed with a 90° angle with a portable-with-seat dynamometer prototype (ISOM) and found high reliability (ICC 0.879–0.990). Overall, high reliability exists, but it is higher for F_{max} than RFD_{max}.

CONCLUSION

In this study, the maximum and explosive muscle force were tested in a specific arm wrestling test to determine its reliability. Very high reliability (ICC = 0.916-0.971) exists for maximum muscle force variables, measured for the left and right arm in supinatorial and neutral hand positions. Moderate and high reliability (ICC = 0.681-0.892) was found for explosive muscle force variables, measured with the left and right hand with supinatorial and neutral hand positions. Also, Cronbach's Alpha values were higher for maximum muscle force than explosive muscle force. According to the reliability results, the specific arm wrestling test has a more significant advantage in estimating maximum muscle force over explosive muscle force. Based on the established differences from 12.6% to 85.8% (Partial Eta^2 = 0.126-0.858) in the attempts to perform the test, it was concluded that the participants do not have different muscle force levels in the left and right arm. Standardized values, expressed as a percentage, show higher explosive muscle force values by 2.74% than the participants' maximum muscle force. The highest values of muscle force were achieved during the first test attempt. By looking at this information, coaches and athletes, using this specific AW test, can create a clearer picture of the athlete's current physical readiness and make appropriate decisions to guide the training process. For further and in-depth research, it is necessary to determine the metrological sensitivity and methodological validity of the given tests to determine how many attempts and which attempt should be taken as the most representative for measuring specific abilities.

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RELIABILNOST SPECIFIČNIH TESTOVA JAČINE SPORTSKOG OBARANJA RUKU

Cilj ovog rada je bio da se istraži pouzdanost specifičnog testa jačine sportskog obaranja ruku. Analizirana je maksimalna mišićna sila (F_{max}), maksimalna brzina razvoja mišićne sile (RFD_{max}) za desnu i levu ruku u određenom suprinatornom i neutralnom položaju u obaranju ruku. Uzorak varijabli obuhvatio je dve sledeće varijable: maksimalna voljna sila (F_{max}) i maksimalna voljna eksplozivna sila, tj. maksimalna brzina razvoja sile (RFD_{max}), mereno na levoj (L) i desnoj (D) ruci (musculus Biceps Brachii) za specifične položaje za sport - supinacija i neutralni položaj. Pojedinačna međutestovna pouzdanost određena je pomoću koeficijenta interklasne korelacije (ICC) i Cronbach-ove alfe na osnovu standardizovanih stavki. Statistički nivo značajnosti određen je na osnovu kriterijuma $p \leq 0.05$. Postoji vrlo visoka pouzdanost (ICC = 0,916-0,971) za varijable maksimalne mišićne sile, mereno za levu i desnu ruku sa suprinatornim i neutralnim položajima šake. Umerena i visoka pouzdanost (ICC = 0,681-0,892) pronađena je za varijable eksplozivne mišićne sile, mereno levom i desnom rukom sa suprinatornim i neutralnim položajima šake. Generalno, najviše vrednosti mišićne maksimalne i eksplozivne sile postignute su tokom prvog pokušaja testa. Uvidom u ove informacije, treneri i sportisti mogu sa pouzdanošću koristiti specifični AW test kako bi stvorili jasniju sliku o trenutnoj fizičkoj spremnosti sportiste i doneli odgovarajuće odluke za vođenje trenažnog procesa.

Ključne reči: *mišićna jačina, meterološka osetljivost, metodološka validnost*