ORIGINAL ARTICLE

Reliability of the two new specific wrestling tests: performance, metabolic and cardiac indicators

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background and Study Aim: Wrestling belongs to the group of multidisciplinary acyclic sports which require well-trained physical, technical, tactical and psychological abilities. Based on the former result analysis, it can be noticed that there is a need for designing tests for evaluation of wrestlers' specific performance abilities. The aim of the research is the reliability and usefulness quantitative descriptive indicators of given properties of wrestler's based on results two innovative specific tests.

Material and Methods: The test-retest procedure was used to define the reliability: Specific Wrestling Fitness Test (SWFT); Specific Wrestling Performance Test (SWPT). The sample consisted of 8 male wrestlers who compete at national level, aged 20.43 ±2.06 years. A dummy was used as a prop, and the "suplex" technique as a standard throw; the load was relativised by using three different weight dummies. In relation to the test and the attempts, the total number of throws, metabolic and cardiac indicators, as well as the derived criterion variables of specific performance were observed.

Results: The reliability indicators and applied tests and abilities measured were determined as reliable (Cronbach's Alpha: 0.798 to 0.953; IIC: 0.664 to 0.910; ICC: 0.674 to 0.957), and quite sensitive to the change of results achieved. Describing the same characteristic of applied variables for specific wrestling performance evaluation was determined by the factor analysis. Therefore all variables could be successfully implemented in the wrestling practice.

Conclusions: These tests provide the possibility to wrestling coaches to individually realise testing during a season, and to use certain performance evaluation models, depending on the informational needs and available equipment in the function of better performance description, in order to improve the sports training methodology and to increase the knowledge fundus.

Keywords: field tests • lactates • load • tactic • technique • training zone

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INTRODUCTION

Wrestling belongs to the group of multidisciplinary acyclic sports which require well-trained physical, technical, tactical and psychological abilities [1]. The exceptional dynamic of the activity of both competitors with the prominent change of tempo and rhythm in the fight is present in wrestling. In variable situational conditions, constant change of offence and defence activities and other forms of motor execution mainly happens in the zones of maximal and submaximal load (training zone) of a wrestler [2, 3]. Generally, all energy systems work simultaneously (aerobic and anaerobic), but in the different degree of representation which always depends on the current technical and tactical situation of the fight [4, 5].

It has been determined that, from the aspect of energy, mainly anaerobic glycolytic pathways prevail in a fight [1]. The anaerobic system provides metabolic conditions for short and quick execution of maximum strength during a fight, for sudden and explosive throws and lifts, but also for leading a fight with submaximal and maximal intensity [5].

Special attention in wrestler's performance diagnostics should be paid to anaerobic lactate energy systems. Moderate to the high concentration of lactate (10-20 mmol/L) accumulates after the competition as well [6, 7] which can disrupt acid-base balance and thus cause poor performance [8]. By observing these variables during intensive training or competition of athletes, the levels of acidosis and muscle fatigue, as well as the indicator of athlete's general preparedness can be evaluated [2, 9-11].

Diagnostics of physical characteristics is an important part of the control process of being well-trained and well-taught as it provides information on the ability which needs to be improved, but on the efficiency of training process applied as well [12]. Although the laboratory tests provide scientifically valid and reliable results, they mainly insufficiently reproduce realistic competitive loads, i.e. the level of development of specific performances for each sport individually. From the aspect of methodology, there has been a greater need for sports specific tests in sports science [10, 13-15]. Specific tests present the approximation of sports activity to controlled conditions, which is possible to observe and measure, and which simulates the time structure of competition, i.e. fight, as well as load, metabolic and cardiac exertion that are manifested during competition conditions [16-18]. In relation to these aspects, it is possible to find a vast number of research that deal with the innovation of specific tests in different sports which can evaluate the development of conditional, anaerobic, aerobic and other abilities [11, 14, 19-28].

When searching formed to research, a significant number of works that dealt with this subject has not been found in wrestling. A specific test for wrestlers was mentioned in just one research, constructed under the name of "The Pittsburgh Wrestling Performance Test" (PWPT) and which was related to freestyle wrestlers. In this research, moderate connection with anaerobic power has been determined, but with an exceptionally high level of reliability of the created specific test in wrestling [20]. Another work that aimed to create reliable field tests for evaluation of wrestler's preparedness was conducted, but the aspect of specificity was omitted [11]. It should be noted that more research relating to wrestling sport is mentioned, but those dealt with tests used for tracking the coordination as a motor ability or other isolated abilities [25, 27]. Also, some specific tests that were used to analyse physical performances, metabolic and functional responses in combat sports have been created by judoka [24]. The metabolic reaction of the organism after the realisation of the Special Judo Fitness Test (SJFT) is quite similar in relation to the lactate concentration, in relation to the judo fight [13]. Based on the former result analysis, it can be noticed that there is a need for designing tests for evaluation of wrestlers' specific performance abilities.

The aim of the research is the reliability and usefulness quantitative descriptive indicators of given properties of wrestler's based on results two innovative specific tests.

MATERIAL AND METHODS

The combination of laboratory and field testing was used as the main method of the research. The analytic and statistical method, as well as the method of induction, were applied. Compared to the analytic methods, the method of functional analysis was applied in order to discover mutual relations and connections between the parts of the examined phenomenon.

Multidisciplinary – *adjective* studying or using several specialised subjects or skills [39].

Field testing – *noun* testing for something such as biomechanical analysis, carried out at the athlete's usual training ground, for the maximum authenticity of results. Compare **lab testing** [39].

Lab testing – *noun* testing for something such as a biomechanical analysis that is carried out in a controlled private environment. Compare **field testing** [39].

Training zone – *noun* the heart rate range within which a person should aim to exercise for maximum effect [39].

Acidosis – *noun 1.* a medical condition in which there are more acid waste products than usual in the blood because of a lack of alkali **2.** same as **acidity** [39].

Load – *noun* **1.** a weight or mass which is supported **2.** the force that a body part or structure is subjected to when it resists externally applied forces **3.** the amount of something, usually weight, that a body part can deal with at one time [39].

Technique– *noun* a way of performing an action [39].

Technique – specific procedures to move one's body to perform the task that needs to be accomplished [40].

Tactics – decisions and actions of players in the contest to gain an advantage over the opposing players [40].

Suplex – is an offensive move used in both professional and amateur wrestling. It is a throw that involves lifting the opponent and bridging or rolling to slam the opponent on their back [38].

Specific Wrestling Fitness Test (SWFT) – the test consists of three 30-second segments of throws, between which there is a 20-second rest. After the commencement of the test is signalled, the examinee throws the wrestling dummy with maximum intensity, i.e. as many time as possible during the

Participants

The sample consists of 8 male wrestlers aged 20.43 ±2.06 years, body height 180.86 ±4.45 cm, body weight 85.28 ±8.14 kg, body mass index 26.10 ±2.64 kg/m², percentage of body fat 14.80 ±5.48 %, the percentage of skeletal muscle mass 49.04 ±3.25 %. The examinees were highly trained national-level Greco-Roman wrestlers, with the training experience of 5.56 ±2.56 years, and a weekly number of training 7.00 ±2.00. All examinees voluntarily participated in the research.

The research was carried out according to the conditions of "Declaration of Helsinki for recommendations guiding physicians in biomedical research involving human subjects", with the approval and consent of the Faculty of Sport and Physical Education University of Belgrade's Ethics Committee.

Procedures

In order to define the reliability of executed performance, as well as metabolic and functional indicators, the test-retest procedure, where the tests were carried out two times with 72-hour break between the testing, was applied. The body composition measuring, which was carried out by bioelectrical impedance (InBody 720, Cerritos, USA) was realised the first day, as well as the field testing which consisted of two examined specific wrestling tests. The measuring of the body composition was realised in the morning, between 8 and 9 a.m. in accordance with the standardised recommendation of the manufacturer. A light meal ensued afterwards (fruit or a smaller sandwich, along with rehydration), as well as the 1-hour break, after which the examinees were tested in the wrestling gym. In the second term of the testing, the specific field testing was realised after 3 days. The beginning of both terms of measuring the specific wrestling field tests was at 10 o'clock a.m. All tests were carried out at the Faculty of Sport and Physical Education in Belgrade.

Before every testing, wrestlers did a general 15-minute warm-up individually, followed by additional 5 minutes of specific warm-up in the form of throwing a partner or a wrestling dummy. Afterwards, all examinees went through the 20-minute process of theoretical and practical familiarisation with the procedure of tested tasks, after which a 10-minute break ensued.

A wrestling dummy was used as a prop in both specific wrestling tests and the suplex technique as the standard throw for all examinees. In order to relativise the load, three dummies with different weights were used as follows: ≤74.9 kg body weight, a 22 kg dummy was thrown, from 75.0 to 89.9 kg, a 27 kg dummy was thrown, and ≥90.0 kg, a 32 kg dummy was thrown. Both tests were time coordinated with a special software which was programmed according to the task's time structure of both tests, and which, apart from the visual display of the time, provides a display of every segment of the test, as well as sound signals which denote preparation, beginning and end of the test. Time intervals of work and rest, as well as the intensity of work according to the scheme presented with the Figure 1. and 2., constructed the time and motoric structure of the tests as follows:

Specific Wrestling Fitness Test (SWFT)

The test consists of three 30-second segments of throws, between which there is a 20-second rest. After the commencement of the test is signalled, the examinee throws the wrestling dummy with maximum intensity, i.e. as many time as possible during the timeframe. The general task of the examinee was to realise the as larger number of throws in all three parts of the test as possible, i.e. the result of the test was the total number of throws realised on the overall test (Figure 1).

Specific Wrestling Performance Test (SWPT)

The test consists of two 3-minute segments, which simulate a round in a fight timewise, with timeframe. The general task of the examinee is to realise the as larger number of throws in all three parts of the test as possible, i.e. the result of the test was the total number of throws realised on overall test.

Specific Wrestling Performance Test (SWPT) – the test consists of two 3-minute segments, which simulate around in a fight timewise, with a 30-second rest between each segment. After the commencement of the test is signalled, the examinee throws the dummy, then lifts the dummy into the initial position and rests up to 10 seconds, then realises the throw again, lifts the dummy and rests up to 20 seconds, and ultimately, realises the throw and rests up to 30 seconds. Once the stopwatch ticks the 30th second, the intensive part of the test ensues – a part where the examinee's task is to realise the as larger number of throws as possible in the next 20 seconds; from the 50th to the 60th second. In addition to performing the given throws in 10-second intervals, the general task of the examinee is also to realise the largest number of throws possible in the phases defined for the maximum number of throws.

Pittsburgh Wrestling Performance Test (PWPT) – incorporates various wrestling moves common to the sport. This study evaluates the reliability of the test and compares it to measures of anaerobic power (AP), muscular strength and the Cleveland State University (CSU) Wrestling Performance [39].

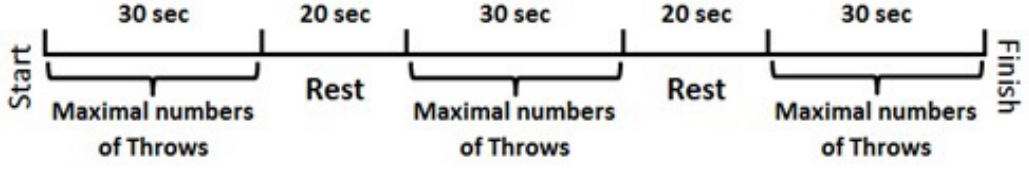

Figure 1. Structure of the Specific Wrestling Fitness Test (SWFT).

a 30-second rest between each segment. The task was as follows: after the commencement of the test is signalled, the examinee throws the dummy, then lifts the dummy into the initial position and rests up to 10 seconds, then realizes the throw again, lifts the dummy and rests up to 20 seconds, and ultimately, realizes the throw and rests up to 30 seconds. Once the stopwatch ticks the 30th second, the intensive part of the test ensues – a part where the examinee's task is to realize as larger number of throws as possible in the next 20 seconds; from the 50th to the 60th second, the examinee rests and prepares for the second minute of the test which is completely the same as the first one; in the third minute of the test, up until the 30th second, everything is the same, and afterwards, the examinee realizes as larger number of throws as possible in the 30-second timeframe, i.e. up until the third minute of the fight simulation elapses; then the 30-second rest ensues; the second round of the test is completely the same as the first. In addition to performing the given throws in 10-second intervals, the general task of the examinee was also to realise the largest number of throws possible in the phases defined for the maximum number of throws. The total number of throws realised in the phases for performing the maximum number of throws achieved during the entire test, i.e. both rounds, is taken as the final result of the test (Figure 2).

In addition to the variables the total number of throws is defined with (N^{Throws}) in relation to both tests (SWFT; SWPT) and relation to the first (I) and the second (II) attempt of both tests, both metabolic and cardiac indicators were observed as the indicators of the total physiological straining achieved on the tests [29] as follows: (a) the lactate concentration in capillary blood as a means of achieved metabolic acidosis, in the third ($La^{3min.}$) and the fifth ($La^{5min.}$) minute of the recovery, expressed in mmol/L; (b) the frequency of the pulse as a functional measurement of achieved load of the cardiovascular system, right after the test is finished ($HR^{0min.}$) and after the first minute of recovery ($HR^{1min.}$), expressed in beats per minute (bpm).

M400 Polar Heart Rate Monitor (Polar, Inc., Lake Success, NY, USA) which was placed around the chest of the examinee before the test, was used to measure the frequency of the pulse. The lactate concentration was analysed using a portable new generation lactate analyser (Lactate Plus-NOVA biomedical, USA), using a lactate biosensor based on lactate oxidisation (Lactate Methodology – Lactate oxidase biosensor) [30, 31]. All samples were drawn from the capillary blood, from the finger by an experienced medical technician [15]. The samples were collected each time from a different finger. For collecting a blood sample, a disposable blood lancet Unistik 3 Comfort (Owen Mumford Ltd. UK) was used.

Based on the obtained results, the indexes of success were calculated as a criterion specific performance variable, i.e. specific wrestling performance abilities was quantified in two ways for both test variant (SWFT and SWPT) as follows: (c) performance index as a measure of the specific wrestling performance ($_{SJF}^{INDEX}$) achieved on the SWFT and the SWPT where the calculation was taken from the SJFT, expressed in index values ($_{SJF}^{INDEX} = (HR^{0min.}+HR^{1min.})/N^{Throws}$) [13]; (d) the novel performance index as a measurement of the specific wrestling performance ($_{NEW}^{INDEX}$) achieved on the SWFT and the SWPT where metabolic component ($La^{3min.}$, $La^{5min.}$) was incorporated as the new model of calculation, expressed in index values ($_{NEW}^{INDEX}=((HR^{0min.}+HR^{1min.})/(La^{3min.}+La^{5min.}))\cdot N^{Throws}$).

Statistical analysis

All results were analysed by applying the basic descriptive statistics where the following was calculated: mean value of variables, standard

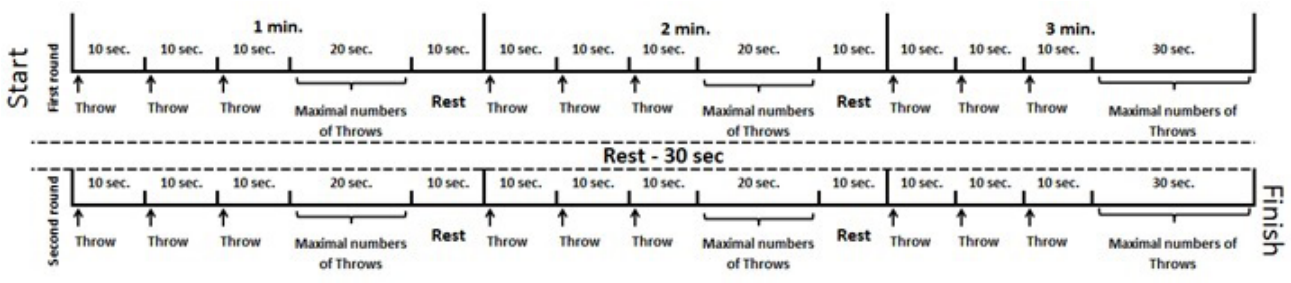

Figure 2. Structure of the Specific Wrestling Performance Test (SWPT).

deviation, standard error (abs. and rel.), lower and higher 95% interval of confidence, minimum, maximum, and coefficient of variation. Reliability indicators were calculated as well – Cronbach's Alpha, Inter-Item Correlation (IIC) and Intra Class Correlation (ICC). The results then underwent the analysis of determining the differences by applying the Student t-test for dependent samples. The factor analysis was used to determine the structure and the set of relations between original metabolic, cardiac, as well as the test results with the defined indexes of wrestling performance as proof of belonging to the commonly measured variance. All statistical analysis was carried out by the software package SPSS 19.0, whereas the value $p<0.05$ was used for the level of statistical significance [32].

RESULTS

By observing the total number of throws and in relation to the first variant of the test (SWFT), as well and the first and the second testing, 6.96 % more throws was realized during the second testing (Table 1, SWFT_$N^{Throws}{}_{Trial}$I = 20.93 vs SWFT_$N^{Throws}{}_{Trial}$II = 22.49), whereas the results generally range between 18.0 and 27.5 throws. In relation to the second variant of the test (SWPT), 13.68 % more throws was also realised during the second testing (Table 1, SWPT_$N^{Throws}{}_{Trial}$I = 28.21 vs SWPT_$N^{Throws}{}_{Trial}$II = 32.68), and the results range between 24.0 and 41.0 throws.

On average, the lactate concentration values, measured after the 3-minute recovery upon the finish of both tests (SWFT and SWPT), were on the level from 12.58 for SWFT_$La^{3min.}{}_{Trial}$II to 13.44 for SWFT_$La^{3min.}{}_{Trial}$I mmol/L, i.e. they ranged from 9.4 to 15.9 mmol/L. After the 5-minute recovery, lactate concentration values were on average on the level from 12.50 for SWPT_$La^{5min.}{}_{Trial}$II to 13.59 for SWFT_$La^{5min.}{}_{Trial}$I mmol/L, i.e. after the 5-minute recovery ranged from 8.7 to 16.1 mmol/L (Table 1).

Heart rate response to the given exertion after the end of both tests was on the level from 185.20 for SWFT_$HR^{0min.}{}_{Trial}$II to 188.69 SWPT_$HR^{0min.}{}_{Trial}$II bpm, i.e. it ranged from 175.0 to 198.6 heartbeats per minute. After a minute of rest, the heart rate was on the level from 163.26 for SWFT_$HR^{1min.}{}_{Trial}$II to 174.39 SWPT_$HR^{1min.}{}_{Trial}$II bpm, i.e. it ranged from 137.0 to 184.0 heartbeats per minute (Table 1).

Specific wrestling performance, expressed as index value and created according to the standardised model of SJFT ($_{SJF}^{INDEX}$) was from 11.30 for SWPT$_{-SJF}^{INDEX}{}_{Trial}$II to 17.18 for SWFT_$_{SJF}^{INDEX}{}_{Trial}$I index unit on both tests, ranging from 8.3 to 19.3 index values. Specific wrestling performance, where the index value was created according to the new method of indexing, was on average from 276.96 for SWFT$_{-NEW}^{INDEX}{}_{Trial}$I to 469.80 SWPT$_{-NEW}^{INDEX}{}_{Trial}$II, i.e. it ranged from 192.5 to 530.5 index values, regardless of the variant of the test or attempt (Table 1).

As a measure of homogeneity, the cV% results of a total number of throws achieved on SWFT were 12.67 % of the first attempt and 10.24 % of the second test attempt, and on SWPT, the variation was 18.12 % of the first attempt and 12.45 % of the second. The cV% results for lactate concentration values ranged from 11.7 to 17.3 %, for the heart rate from 2.8 to 8.3 %, whereas the index value results ranged from 8.8 to 19.7 %. These results are the proof that the tested group was an extremely homogenous group of examinees, i.e. that all variables measured belonged to the set of extremely homogenous values, regardless of the test (Table 1).

The determined level of reliability for the N^{Throws} variable in the function of the test is highly statistically significant on the level $p = 0.004$ for SWFT_N^{Throws} I vs II, with the repeatability value on the level from 0.821 for ICC to 0.905 for Cronbach's Alpha, whereas for SWPT_N^{Throws} I vs II on the level $p = 0.003$, with the repeatability value on the level from 0.731 for ICC to 0.922 for Cronbach's Alpha (Table 2). It should be emphasized that statistically significant repeatability has not been determined in only three of the variable pairs, for the level of lactate concentration value in the 5th minute of the recovery for both tests (Table 2, SWFT_$La^{5min.}$I vs II, $p = 0.054$, and SWPT_$La^{5min.}$I vs II, $p = 0.062$), as well as for the first variant of the test's heart rate value (SWFT) right after the testing was finished (Table 2, SWFT_$HR^{0min.}$I vs II, $p = 0.571$). The ICC value range from 0.674 to 0.957, IIC values range from 0.664 to 0.910, while the Cronbach's Alpha coefficient values as a measure of internal consistency range from 0.798 to 0.953 (Table 2) for all the variables in which the statistically significant reliability has been determined.

In relation to the mean value differences, the statistically significant difference of the first and the

Table 1. Descriptive statistics of the tested variables.

Variables (indicator)	Trial	Mean	SD	cV%	Std Error (Abs)	Std. Error (Rel)	95% Confidence Interval for Mean		Min	Max
							lower	upper		
SWFT_N^{Throws} (n)	I	20.93	2.65	12.67	0.94	4.48	18.71	23.15	18.0	26.0
	II	22.49	2.30	10.24	0.81	3.62	20.57	24.42	20.0	27.5
SWFT_$La^{3min.}$ (mmol/L)	I	13.44	2.32	17.28	0.82	6.11	11.50	15.38	10.3	15.9
	II	12.58	2.06	16.38	0.73	5.79	10.86	14.30	9.4	15.2
SWFT_$La^{5min.}$ (mmol/L)	I	13.59	1.59	11.71	0.56	4.14	12.26	14.92	10.9	16.0
	II	12.77	1.68	13.14	0.59	4.64	11.36	14.17	8.7	14.5
SWFT_$HR^{0min.}$ (bpm)	I	188.66	6.14	3.25	2.17	1.15	183.53	193.79	178.0	198.6
	II	185.20	5.27	2.85	1.86	1.01	180.79	189.60	177.0	191.0
SWFT_$HR^{1min.}$ (bpm)	I	167.14	12.26	7.34	4.34	2.59	156.89	177.40	150.0	182.0
	II	163.26	13.53	8.29	4.79	2.93	151.94	174.57	137.0	179.0
SWFT_$_{SJF}^{INDEX}$ (index unit)	I	17.18	1.51	8.78	0.53	3.11	15.92	18.44	14.5	19.3
	II	15.62	1.47	9.44	0.52	3.34	14.39	16.86	12.5	17.6
SWFT_$_{NEW}^{INDEX}$ (index unit)	I	276.96	41.96	15.15	14.83	5.36	241.88	312.03	192.5	338.8
	II	310.73	33.89	10.91	11.98	3.86	282.40	339.06	263.6	352.0
SWPT_N^{Throws} (n)	I	28.21	5.11	18.12	1.81	6.41	23.94	32.49	24.0	40.0
	II	32.68	4.07	12.45	1.44	4.40	29.28	36.09	28.3	41.0
SWPT_$La^{3min.}$ (mmol/L)	I	13.15	1.89	14.33	0.67	5.07	11.58	14.73	9.8	15.9
	II	13.05	2.04	15.59	0.72	5.51	11.35	14.75	10.1	15.9
SWPT_$La^{5min.}$ (mmol/L)	I	13.15	2.03	15.45	0.72	5.46	11.45	14.84	10.0	16.1
	II	12.50	1.64	13.09	0.58	4.63	11.13	13.87	10.2	15.1
SWPT_$HR^{0min.}$ (bpm)	I	186.11	6.40	3.44	2.26	1.22	180.76	191.45	175.0	195.0
	II	188.69	5.76	3.05	2.04	1.08	183.88	193.51	179.0	196.0
SWPT_$HR^{1min.}$ (bpm)	I	173.55	6.47	3.73	2.29	1.32	168.15	178.96	164.0	183.0
	II	174.39	8.24	4.73	2.91	1.67	167.50	181.28	160.0	184.6
SWPT_$_{SJF}^{INDEX}$ (index unit)	I	13.09	1.94	14.83	0.69	5.24	11.47	14.71	8.9	15.5
	II	11.30	1.58	13.95	0.56	4.93	9.98	12.62	8.3	13.1
SWPT_$_{NEW}^{INDEX}$ (index unit)	I	390.21	76.86	19.70	27.18	6.96	325.95	454.47	266.4	509.4
	II	469.80	57.64	12.27	20.38	4.34	421.61	517.99	371.0	530.5

Legend: SWFT_N^{Throws} total number of throws on the Specific Wrestling Fitness Test; SWFT_$La^{3min.}$the lactate concentration measured in the third minute of the recovery after the SWFT; SWFT_La^{5min} the lactate concentration measured in the fifth minute of the recovery after the SWFT; SWFT_HR^{0min} the heart rate measured immediately upon the end of the SWFT; SWFT_$HR^{1min.}$ the heart rate measured after the first minute of recovery upon the end of the SWFT; SWFT_$_{SJF}^{INDEX}$ performace index achieved on the SWFT where the calculation was taken from the Special Judo Fitness Test [13]; SWFT_$_{NEW}^{INDEX}$ the new performance index achieved on the SWFT where metabolic component was incorporated in the calculation of the index as the new model of calculation; SWPT_N^{Throws} total number of throws on the Specific Wrestling Performance Test; SWPT_La^{3min} the lactate concentration measured in the third minute of the recovery after the SWPT; SWPT_La^{5min} the lactate concentration measured in the fifth minute of the recovery after the SWPT; SWPT_HR^{0min} the heart rate measured immediately upon the end of the SWPT; SWPT_HR^{1min} the heart rate measured after the first minute of recovery upon the end of the SWPT; SWPT_$_{SJF}^{INDEX}$ performance index achieved on the SWPT where the calculation was taken from the Special Judo Fitness Test [13]; SWPT_$_{NEW}^{INDEX}$ the new performance index achieved on the SWPT where metabolic component was incorporated in the calculation of the index as the new model of calculation*

Table 2. Results of the reliability and the analysis of the differences.

Variable pairs	Reliability analyses					Differences analysis	
	Cronbach's Alpha	inter-item correlation	intra class correlation	F test with true value 0			
				value	p	t	p
SWFT_N^{Throws} I vs II	0.905	0.826	0.821	9.98	0.004	–2.95	0.021
SWFT_$La^{3min.}$ I vs II	0.799	0.666	0.780	4.90	0.026	1.34	0.222
SWFT_$La^{5min.}$ I vs II	0.728	0.572	0.695	3.66	0.054	1.53	0.169
SWFT_$HR^{0min.}$ I vs II	–0.152	–0.071	–0.142	0.87	0.571	1.17	0.280
SWFT_$HR^{1min.}$ I vs II	0.914	0.842	0.900	11.34	0.002	1.50	0.179
$SWFT\_{}_{SJF}^{INDEX}$ I vs II	0.871	0.772	0.674	7.75	0.007	4.37	0.003
$SWFT\_{}_{NEW}^{INDEX}$ I vs II	0.891	0.804	0.731	8.35	0.006	–3.83	0.006
SWPT_N^{Throws} I vs II	0.922	0.855	0.731	11.00	0.003	–4.74	0.002
SWPT_$La^{3min.}$ I vs II	0.953	0.910	0.957	20.69	0.000	0.34	0.741
SWPT_$La^{5min.}$ I vs II	0.721	0.563	0.708	3.45	0.062	1.05	0.331
SWPT_$HR^{0min.}$ I vs II	0.865	0.761	0.833	7.24	0.009	–1.73	0.128
SWPT_$HR^{1min.}$ I vs II	0.798	0.664	0.802	4.63	0.030	–0.38	0.716
$SWPT\_{}_{SJF}^{INDEX}$	0.940	0.886	0.734	14.05	0.001	5.55	0.001
$SWPT\_{}_{NEW}^{INDEX}$	0.944	0.895	0.680	13.16	0.002	–6.23	0.000

Table 3. Results of the tested variables for values of communalities of variables (all initial values 1.000).

Variables	Extraction	Variables	Extraction
SWFT_N^{Throws}	0.970	SWPT_N^{Throws}	0.949
SWFT_$La^{3min.}$	0.914	SWPT_$La^{3min.}$	0.812
SWFT_$La^{5min.}$	0.880	SWPT_$La^{5min.}$	0.864
SWFT_$HR^{0min.}$	0.747	SWPT_$HR^{0min.}$	0.863
SWFT_$HR^{1min.}$	0.771	SWPT_$HR^{1min.}$	0.861
$SWFT\_{}_{SJF}^{INDEX}$	0.948	$SWPT\_{}_{SJF}^{INDEX}$	0.947
$SWFT\_{}_{NEW}^{INDEX}$	0.952	$SWPT\_{}_{NEW}^{INDEX}$	0.965

second measuring was determined, regardless of the test type of the six variable pairs, on the level from t = –2.95 and p = 0.021 for the variable SWFT_N^{Throws} I vs II, to t = –6.23 and p = 0.000 for the variable $SWPT\_{}_{NEW}^{INDEX}$ I vs II (Table 2). In eight variables, the statistically significant difference between achieved average values of the examined variables has not been determined, i.e. the level of the result ranges from t = –1.73 and p = 0.128 for the variable SWPT_$HR^{0min.}$ I vs II, to t = 0.34 and p = 0.741 for the variable SWPT_$La^{3min.}$ I vs II (Table 2).

Based on the measure sampling adequacy (Kaiser-Meyer-Olkin test = 0.419) and the regularity of the multivariate space distribution (Bartlett's Test of Sphericity, p = 0.000), it has been determined that the results of the tested variables and their total variability can be reliably accepted for multivariate statistical analysis.

Based on the calculated values of communalities of variables, it has been determined that all variables are highly extracted into the common measuring space on the level from 0.747 (74.7 %) for $HR^{0min.}$ to 0.970 (97.0 %) for N^{Throws} on SWFT (Table 3).

Three independent factors were extracted by the Factor analysis; the first one explained 38.52 %, the second explained 31.98 %, whereas the third factor explained the 18.38 % of the common variance. The high 88.89 % of the common variance was explained cumulatively, which has proved the high homogeneity of all variables examined in relation to the overall measuring area (wrestling performance) and which has provided the high level of scientific validity of results.

The results of defined factor matrix, as well as individual factor structure, are shown in Table 4.

Table 4. Results of the defined matrix structure – the most significant factors.

Variable	Component		
	1	2	3
SWFT_N^{Throws}	–0.964	0.154	0.048
SWPT_N^{Throws}	–0.959	0.131	–0.107
SWFT_$_{SJF}^{INDEX}$	0.956	0.139	0.197
SWPT_$_{SJF}^{INDEX}$	0.942	–0.107	0.242
SWPT_$_{NEW}^{INDEX}$	–0.803	–0.579	0.026
SWFT_$_{NEW}^{INDEX}$	–0.720	–0.658	0.088
SWFT_$La^{3min.}$	–0.107	0.947	0.035
SWFT_$La^{5min.}$	–0.010	0.933	0.141
SWPT_$La^{5min.}$	0.172	0.915	0.134
SWPT_$La^{3min.}$	0.002	0.889	–0.093
SWFT_$HR^{1min.}$	–0.242	0.647	0.559
SWPT_$HR^{1min.}$	0.270	0.066	0.900
SWPT_$HR^{0min.}$	0.193	–0.257	0.862
SWFT_$HR^{0min.}$	–0.068	0.267	0.829

The first factor was defined based on the 6 variables as follows: N^{Throws}, $_{SJF}^{INDEX}$ and $_{NEW}^{INDEX}$ for both tests, i.e. all variables which were used to define the result and the achieved level of wrestling performance on the tests; the second factor was defined by the metabolic variables (La), whereas the third factor was defined by the cardiac indicators (HR).

DISCUSSION

The improvement of sports specific tests mainly aims towards providing the possibility to all wrestling coaches to individually realise periodic testing, based on which they would be able to track the individual preparedness progress of an athlete and to control the efficiency of applied concepts and training methods as well. Therefore, this type of research represents the permanent need for scientific research in the sport to improve the sports training methodology and to increase the knowledge fundus.

The high level of reliability of the total number of throws (N^{Throws}) for both variants of wrestling tests on the Cronbach's Alpha level from 0.905, IIC from 0.826 and ICC from 0.821 for SWFT, i.e. on the Cronbach's Alpha level from 0.922, IIC from 0.855 and ICC from 0.731 for SWPT were determined in this research (Table 2). That represents somewhat lower value of the reliability results in relation to the former research of this test structure whose level of reliability for PWPT was 0.97 [20], as well as in relation to the research of field test for wrestlers, defined as a motoric task of sandbag throw, where the ICC level was 0.95 [11]. On the other hand, the results of our research are completely in accordance with previously determined standards, in relation to the level of reliability of tests for tracking coordination as a singled out motoric ability of wrestlers, where the level of test reliability ranged from 0.53 to 0.98 [25, 27].

As for the tests in other fields, it has been determined that the reliability of the specific police polygon test which aimed at surmounting 16 different motoric tasks specific for carrying out the policemen's job in as shortest time interval as possible and where the energy needed for carrying out the job is dominantly gotten from anaerobic glycolysis mechanism, is on the Cronbach's Alpha level of 0.741 and ICC 0.643 [28], whereas the level of *t* test reliability of agility of inactive to moderately active people ICC ranged from 0.60 to 0.96 [23]. As far as the team sports is concerned, the ICC level of the basketball "line drill" field test was on the level of 0.91 [22], the ICC for the test of volleyball players' 30s of maximum intensity repeated jumps ranged from 0.87 to 0.98 [26]. According to the experts' opinion [33, 34], the reliability index above 0.50 is considered to be enough for specific field tests.

In relation to the results obtained in this research, the highly statistically significant result repeatability, as well as the statistically significant difference of average values of N^{Throws} variable for both realized tests, p = 0.021 and t = –2.953 for SWFT and p = 0.002 and t = –4.741 for SWPT have been determined (Table 2). Statistically significant difference between the realised testing attempts on the level p = 0.000 and t = 4.164 has been determined in research which dealt with the specific motor police tests defined by the polygon task [28]. Based on these results, it can be concluded that the effect of learning the task realisation is quite prominent among the highly specifically trained population in the case of the application of testing with the help of complex motor tasks such as a polygon, and especially if they are realised in the anaerobic glycolytic straining regime. In other words, although in our case the tasks on the applied wrestling tests were a part of training content of examinees–wrestlers, which means that they were well-trained and familiar with their performances, it has been shown that the significantly higher number of throws on both tests was achieved only in the second attempt. These results were in accordance with the results from the previous research where it was determined that the total familiarisation with specific wrestling tests be achieved only after the fourth attempt of test realisation [20].

The results have shown that the maximum lactate concentration was reached in the 5th minute of recovery on both tests, even though the statistically significant difference was not determined between repetitions (Table 2). Generally speaking, the achieved average values of lactate concentration were from 12.58 to 13.59 mmol/L with the maximum lactate concentrations measured, which ranged from 14.5 to 16.1 mmol/L for both tests respectively (Table 2). These results indicate the extremely high level of anaerobic acidosis achieved once the applied wrestling tests were realised. It has been previously determined that the Greco-Roman wrestlers' maximum concentrations reach were on the level from 15.8 to 19.1 mmol/L during all (five) matches at the competition [10], i.e. they were on the level between 11.82 and 13.23 mmol/L after a single training control match [9]. By comparing the lactate concentrations with former research of lactate values in wrestling, the identical values of achieved results were determined [9, 11], whereas older research achieved somewhat higher values when the rules required a longer fight duration [2]. In comparison to other combat sports, i.e. lactate values achieved on the SJFT, similar values are also noticeable [35, 36]. These results can serve as a proof of external validation to the results obtained in this study, i.e. as a proof that variants of specific wrestling tests used metabolically provoke almost identical specific competitive load in relation to the wrestling match.

By applying the repeated measuring, i.e. test-retest method, the reliability of measured variables in the function of metabolic test requirements was defined. Significant reliability of measuring lactate concentration of the sample in the 3rd minute of recovery on both tests was on the level p = 0.026 for SWFT_$La^{3min.}$I vs II, and p = 0.000 for SWPT_$La^{3min.}$I vs II (Table 2; Cronbach's Alpha ranging from 0.721 to 0.953; IIC ranging from 0.563 to 0.910; ICC ranging from 0.695 to 0.957), while the lactate values of the sample taken in the 5th minute of recovery were somewhat above the line of measuring reliability significance. This could serve as a proof of individual difference of acute adaptation process of examinee's recovery. However, the results indicate the change of lactate concentration values on SWPT being more reliable compared to the SWFT, because the Cronbach's Alpha, IIC and ICC average sum of values are on the level from 0.837, 0.737 and 0.833, i.e. 0.764, 0.619 and 0.738, respectively, i.e. maximum reliability for the variable SWPT_$La^{3min.}$I vs II on the level from 0.910 for IIC to 0.953 for Cronbach's Alpha was determined (Table 2). In other words, the longer the test load (2x3 minutes) and the earlier the sample of lactate was taken in the phases of recovery (3rd minute), the more reliable the results of the given variable were.

By analysing the functional values, i.e. heart rate directly and in the first minute of recovery, the highly statistically significant reliability was determined in all variables, except in the case of the variable SWFT_$HR^{0min.}$I vs II (Table 2, p = 0.571). Reliability values range from p = 0.002 to p = 0.030 (Table 2; Cronbach's Alpha: 0.798 to 0.914; IIC: 0.664 to 0.842; ICC: 0.802 to 0.900). Upon the action end, the reliability of functional indicators has also been determined in the research of specific police tests, where the ICC was on the somewhat lower level of 0.591 [28]. Compared to other research, the functional reaction of the organism to the load on the tests, i.e. right after the finish of the test

($HR^{0min.}$), is completely in accordance with the values achieved after the specific police polygon [28], where the achieved values of heart rate were 4.8 % higher in relation to the judokas after the realization of the SJFT [37], 3.2 % higher values in relation to the wrestlers after the sandbag throw test [11], and 1.6 % lower values in relation to the wrestlers after the situational fights [10]. These results can also serve as a proof of external validation of applied tests in this research, i.e. as a proof that variants of the specific wrestling tests used, provoke almost identical specific competitive training load in relation to the cardiac reaction of the organism of highly trained wrestlers.

Derived index values as the means of specific performance of wrestlers have also shown the statistically significantly high level of reliability of both tests applied (SWFT and SWPT) for both variants of indexing: $_{SJF}^{INDEX}$ and $_{NEW}^{INDEX}$ (Table 2; Cronbach's Alpha: 0.871 to 0.944; IIC: 0.772 to 0.895; ICC: 0.674 to 0.734). The statistically significant difference among all derived index values of performance in test attempts was determined, within the range from p = 0.006 to p = 0.000 (Table 2, $SWFT_{-NEW}^{INDEX}$ I vs II and $SWPT_{-NEW}^{INDEX}$ I vs II). It is probable that the cause of these results is the fact that there has been a summarisation of two phenomena of the tested wrestlers as follows: learning factor and factor of positive acute biological adaptation. The statistically significant difference of a total number of throws on both tests applied was determined, where the examinees achieved better results on the second test, and this could be attributed to the learning factor (Table 2, $SWFT\_N^{Throws}$ I vs II, p = 0.021; $SWPT\_N^{Throws}$ I vs II, p = 0.002). Although the lower values during the second test attempt on both tests are not statistically significant when it comes to lactate concentration values and heart rate, they still can be explained by the acute biological adaptation to the defined load (Table 1 and 2). It is because of that that the values of calculated index performances have mathematically summarily shown the existence of statistically significant differences regarding achieving better second attempt result values on both test variants. This way, it has been shown that the used models of calculating the index performance are statistically significant and highly reliable (Table 2, from 0.674 for ICC $SWFT_{-SJF}^{INDEX}$ I vs II and p = 0.007, to 0.891 for Cronbach's Alpha $SWFT\__{NEW}^{INDEX}$ I vs II and p = 0.006; and from 0.680 for ICC $SWPT_{-NEW}^{INDEX}$ I vs II and p = 0.002, to 0.944 for Cronbach's Alpha $SWPT_{-NEW}^{INDEX}$ I vs II and p = 0.002) and rather sensitive to the change of results achieved on the applied tests. By observing the summarized results of the index wrestling performance reliability, it should be emphasized that the higher level of reliability for 7.08 % (summarized reliability of all criteria used – Crombach Alpha, IIC and ICC, for SWFT was 0.791, whereas for SWPT it was 0.847) was determined on the SWPT test variant regardless of the calculating model ($_{SJF}^{INDEX}$ or $_{NEW}^{INDEX}$).

Based on the communality (Table 3), it has been determined that all measured variables are highly extracted into the common measuring area (0.747 to 0.970). By the factor analysis, three factors with cumulatively explained 88.89 % of common variance have been singled out from the set of tested variables. All singled-out factors are extremely precisely structured, so that the first factor consists exclusively of the variables which were used for evaluation of specific wrestling performance and which explained 38.52 %, the second factor exclusively consists of metabolic, i.e. lactate variables which explained 31.98 %, whereas the third factor exclusively consists of functional, i.e. heart rate variables, which explained the remaining 18.38 % of the common variance.

The results have shown that the two most significant variables in the first factor indicate the total number of realised throws for both test variants ($SWFT\_N^{Throws}$ and $SWPT\_N^{Throws}$). Both variants are highly projected onto the first factor: projection of 0.964 and 0.959, and both variants present the simplest one-dimensional model, i.e. an indicator of the level of specific preparedness, the, i.e. analogy of current wrestling performance (Table 4). In the factor structures, index performance variables for both test variants can be found, but they are calculated according to the model of SJFT ($SWFT_{-SJF}^{INDEX}$ and $SWPT_{-SJF}^{INDEX}$) with the high projections of 0.956 and 0.942, respectively. Both the number of throws and heart rate directly achieved after the ending and in the first minute of the recovery are included in the score of these two variables. In other words, performance is calculated based on the two-dimensional model. As the lower values of the given index are a better result on the test, the positive projection is logical about the first two and last two projected variables, where the greater advantage achieved on the test presents a better performance as well. The last two projected variables present

the performance achieved on the applied test variants in the function of the newly projected index ($SWPT_{-NEW}^{INDEX}$ and $SWFT_{-NEW}^{INDEX}$). Both the number of throws and heart rate directly achieved after the ending and in the first minute of the recovery are included in the score of these variables, and the metabolic response of the organism to the given test, i.e. the value of reached lactate concentration in the 3rd and the 5th minute of the recovery is included as well. In other words, performance is calculated based on the three-dimensional model. If we assume that the more different factors are included in some model of calculating the index performance, then the performance alone would be more precise, i.e. better described, and the level of possible difference would be minimised. That is a possible explanation as to why the variables which use only one dimension i.e. N^{Throws} for calculation, variables which use two dimensions, i.e. N^{Throws} and HR, and ultimately variables which use three dimensions, i.e. N^{Throws}, HR and La, are singled out as the most discriminated variables in the first factor which the wrestlers' performance achieved on the applied tests was defined with. One must bear in mind that the examinees were systematically highly trained wrestlers, which means that they were quite a homogenous group in relation to the motoric and physiological characteristics. The multi-dimensional system of performance evaluation in the function of motor and physiologically more homogenous groups may be a possible reason why the most complex performance index had a lower level of sensitivity, i.e. discrimination in the singled-out factor as a result in the factor analysis.

Further research should provide data about the validity of mentioned tests for evaluation of specific wrestling performance in relation to different age and gender of wrestlers, as well as in relation to different competing levels of wrestlers. Also, examination based on larger sample of wrestlers is necessary in order to define the normative which can be used practically in terms of the given wrestling performance.

CONCLUSIONS

Based on all results obtained in this research, it can be stated that the applied tests with the calculated index of specific wrestling performance are reliable, as well as that description of the same characteristic, i.e. wrestlers' performance by applied variables for evaluation of specific wrestling performance, is confirmed.

This way, the obtained results have shown that the new specific wrestling tests, which aim at measuring the specific wrestlers' performance (aerobic, anaerobic, metabolic, functional, as well as coordination abilities), can be applied as the reliable method of evaluating the level of achieved performance in wrestling. Before the final testing, it is necessary to realise the initial familiarisation due to the determined statistically significant difference between test attempts.

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