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Corresponding author: milan.markovic@pr.ac.rs

THE INFLUENCE OF A WRESTLER'S PREPARATION ON SUCCESS AND MORPHOLOGICAL COMPOSITION

Milan Marković¹, Milivoj Dopsaj², Mehmet Ismail Tosun³

In wrestling, in addition to technical and tactical training, success largely depends on physical preparedness. The subject of this paper is morphological composition and success in specific wrestling tests. The aim of the paper is to examine the direct influence of the level of preparedness on success and the indirect influence on morphological composition in wrestlers. Success is defined by the total number of throws in both the shorter Specific Wrestling Fitness Test (SWFT) and the longer and more physically demanding Specific Wrestling Performance Test (SWPT). Morphological composition is defined by the percentage values of body fat (PBFM) and muscle mass (PSMM). The sample consists of 26 wrestlers, divided into two groups, in 4 different ways, from the aspect of preparedness. In this regard, preparedness was defined by the movement of lactate values from the 3rd to the 5th minute, in subjects whose lactates increased (La3-5min.↑) and decreased (La3-5min.↓), by the percentage of pulse rate recovery to the 1st ($\Delta\text{HR}_{1\text{min}} \leq 9.99\%$ and $\geq 5.99\%$) and 5th ($\Delta\text{HR}_{5\text{min}} \leq 39.99\%$ and $\geq 40\%$) minute, and the number of throws in the tests (≤ 25 and ≥ 26 on the SWFT; ≤ 34 and ≥ 35 on the SWPT). The applied t test determined the absence of a statistically significant difference between the defined groups of lactate value movements as a function of the number of throws on both the SWFT ($p = 0.867$) and the SWPT ($p = 0.131$). It was also found that there were no statistically significant differences in PBFM ($p = 0.769$) and PSMM ($p = 0.601$) on the SWFT, while the longer SWPT, with its demands, showed a significant difference in PBFM ($p = 0.031$) and PSMM ($p = 0.018$) in favor of the faster metabolic recovery. Further analysis of the difference revealed no statistically significant difference between the groups with different levels of pulse rate recovery both up to the 1st and 5th minute, regardless of the variables and the test ($p = 0.067 - 0.918$). The defined groups of success on the tests as a function of the level of preparedness are statistically significantly different by the nature of the data distribution regardless of the test ($p = 0.000$), while from the morphological aspect they also showed significant differences in the PBFM both on the SWFT ($p = 0.001$) and on the SWPT ($p = 0.000$), and in the PSMM but only on the more demanding test (SWPT, $p = 0.044$).

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¹ PhD Assistant, Professor, Faculty of Sport and Physical Education, University of Priština-Kosovska Mitrovica, 38218 Leposavic; <https://orcid.org/0000-0002-9544-3773>, milan.markovic@pr.ac.rs

² PhD Full Professor, Faculty of Sport and Physical education, University of Belgrade, Belgrade, Serbia; <https://orcid.org/0000-0001-7135-2993>, milivojmdopsaj@fsfv.bg.ac.rs

³ PhD Assistant Professor, Department of Physical Education and Sports, Faculty of Sport Sciences, Hitit University, Çorum, Türkiye, <https://orcid.org/0000-0003-3158-3942>, mehmetismailtosun@hitit.edu.tr



Different types of preparation characterize different sports, but it is often very difficult to define a sport as exclusively aerobic or anaerobic, rather these energy requirements are intertwined, which is supported by the different distribution of wrestlers, in defined groups of type and level of preparation, at different loads. In this regard, in this way, we have determined that the preparedness of a wrestler cannot be viewed only from the aspect of metabolic or cardiovascular components, but as an interweaving of all energy components, and success on tests itself as the most discriminating parameter of preparedness, which entails the best ratio of morphological structure.

Keywords: combat sports, field testing, performance, lactate concentration, heart rate

Introduction

In order to achieve elite sporting performance, it is necessary to ensure an adequate level of athletes' preparedness, which may include physical, technical, tactical, psychological, and theoretical preparation. The importance of different forms of preparedness varies depending on the characteristics of the sport, while in combat sports, physical preparation is given particular emphasis (Mirzaei & Akbarnezhad, 2008).

In combat sports such as wrestling, boxing, judo, and karate, in which weight categories are strictly defined by the rules, morphological characteristics, i.e., body composition, represent one of the key determinants of sporting success (Dopsaj et al., 2013). Of particular importance in this context is the relationship between muscle and fat components of body composition, which directly affects the expression of specific motor and energy-related performances in wrestling. A greater proportion of muscle mass enables more efficient development of maximal and explosive strength, as well as a higher capacity for repeated execution of high-intensity activities during a bout, whereas an increased amount of adipose tissue represents functionally inactive mass that may negatively affect movement speed, agility, and work economy (Mirzaei & Akbarnezhad, 2008; Kim et al., 2011). In addition, an unfavorable muscle-to-fat ratio may lead to faster fatigue and delayed recovery, which is particularly evident under conditions of multiple matches during competitions (Horswill, 2012; Reale et al., 2017).

Another central issue in wrestling training and competitive practice is body mass control. In practice, rapid weight-loss methods are often applied, which may impair athletes' health and reduce their functional and competitive capacities, ultimately negatively affecting performance outcomes (Ćirković et al., 2011).

The somatotype of elite wrestlers is characterized by dominant mesomorphic traits, reflected in pronounced muscularity and a low percentage of body fat. It is generally

considered that the optimal level of body fat in wrestlers ranges between 7% and 10%, achieved through a properly balanced combination of training and nutrition, with exceptions most commonly observed in wrestlers competing in the highest weight categories (Kasum & Dopsaj, 2012).

The subject of this study is body composition and performance in specific wrestling tests (Specific Wrestling Fitness Test - SWFT and Specific Wrestling Performance Test - SWPT). The aim of the study was to examine the direct effect of the level of preparedness on performance, as well as its indirect effect on body composition, in wrestlers.

Methods

Sample

The sample consisted of 26 wrestlers, aged 20.2 ± 1.7 years, with a training experience of 6.7 ± 3.2 years, 7.8 ± 1.9 training sessions per week, body height of 178.9 ± 5.6 cm, body mass of 82.9 ± 7.4 kg, and body mass index of 25.9 ± 2.0 kg/m². In accordance with the aim of the study, the participants were divided into two groups in four different ways (Table 1). All participants were informed about the testing procedures. They participated voluntarily in the study and provided written informed consent. The study was conducted in accordance with the Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects (World Medical Association, 2013), and was approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Belgrade (No. 02-484-2).

Table 1. - Structure of the distribution of respondents according to defined groups

Type	Groups	N	
		SWFT	SWPT
LA 3-5min	La increase ↑	17	10
	La decrease ↓	9	16
ΔHR1min	HR recovery ≤9.99%	15	21
	HR recovery ≥10%	11	5
ΔHR5min	HR recovery ≤39.99%	13	14
	HR recovery ≥40%	13	12
Total number of throws	≤25 throws	14	13
	≥26 throws	12	13

Testing procedure

The data collection process was conducted using previously standardized measurement procedures, both with respect to the analysis of morphological body struc-

ture (Gibson et al., 2008; Sillanpää et al., 2014) and field-based tests (Marković et al., 2017; Marković et al., 2018; Marković et al., 2021; Marković et al., 2022). Body composition measurements were performed using the InBody 270 analyzer during the morning hours. Participants were instructed not to consume food prior to testing; after the measurement, they were provided with a meal and allowed a minimum of two hours before further testing. Subsequently, all participants underwent a final theoretical and practical familiarization with the testing procedures. Prior to testing, a general warm-up lasting 10 minutes was performed, followed by an additional 5 minutes of specific warm-up consisting of partner throws or throws with a wrestling dummy, after which a 5-minute rest period was provided. During testing, participants used a wrestling dummy (Suples, Ltd., ID, USA) and performed the "front suplex" technique. The order of test administration was randomized. Participants with body mass below 74.99 kg used a 22 kg dummy; those with body mass between 75.00 and 89.99 kg used a 27 kg dummy; and participants weighing over 90.00 kg used a 32 kg dummy (Marković et al., 2017). In this way, the relative load of the dummy was standardized according to the athletes' weight categories.

Before testing, a Polar H7 heart rate sensor (Polar, Inc., Lake Success, NY, USA) was placed around the participants' chest to continuously record heart rate. At the end of each test, the wrestlers performed one minute of active recovery, followed by a seated position to enable the assessment of blood lactate concentration, while heart rate monitoring continued according to a standardized protocol. Heart rate was sampled immediately after completion of the test, as well as during the first and fifth minute of recovery (HR1min and HR5min), and expressed in beats per minute (bpm). Lactate concentration was sampled during the third (La3min) and fifth (La5min) minute of recovery and expressed in $\text{mmol}\cdot\text{L}^{-1}$. Blood lactate concentration was analyzed using a new-generation portable lactate analyzer (Lactate Plus, Nova Biomedical, USA), based on lactate oxidation (lactate oxidase biosensor methodology) (Kulandaivelan et al., 2009; Hart et al., 2013). All samples were obtained from capillary blood collected from the fingertip by an experienced medical technician (Dopsaj & Janković, 2014), with a different finger used for each sampling. For the invasive part of the testing, a single-use lancet (Unistik 3 Comfort, Owen Mumford Ltd., UK) was applied. A 30-minute period of combined rest was provided between the tests.

Both tests were time-controlled using dedicated software programmed in accordance with the temporal structure of the tasks in both tests (standardized throwing intensity, maximal throwing intensity, and recovery). The software provided visual time display, segment identification, and auditory signals indicating test preparation, start, and completion.

Specific Wrestling Fitness Test (SWFT)

The test consisted of three 30-second throwing bouts, separated by 20-second rest intervals. Upon the signal to start the test, participants performed wrestling dummy throws at maximal intensity, aiming to complete as many throws as possible within the given time (Marković et al., 2017; Marković et al., 2018a). The primary task was to achieve the highest possible number of throws across all three segments; therefore, the total number of throws completed during the entire test (TnT) was used as the main outcome measure, representing the final state of specific work capacity.

Specific Wrestling Performance Test (SWPT)

The test consisted of two 3-minute rounds designed to simulate the duration of wrestling bouts. The rounds were separated by a 30-second rest interval. Briefly, during the first 30 seconds, participants performed one dummy throw every 10 seconds. This was followed by a 20-second period during which the maximal number of throws was performed, after which a 10-second passive rest ensued. The same sequence was repeated during the second minute. In the third minute, instead of a 20-second maximal-effort phase, participants performed the maximal number of throws for 30 seconds. This was followed by 30 seconds of passive rest. The second 3-minute round was identical to the first. The total number of throws performed during the maximal-effort phases across the entire test (i.e., both rounds) was taken as the final test score (Marković et al., 2017; Marković et al., 2018; Marković et al., 2021; Marković et al., 2022).

Variables

In line with the aim of the study, the morphological variables observed included percentage of body fat mass (PBFM, %) and percentage of skeletal muscle mass (PSMM, %) (InBody 720). From the perspective of preparedness, the primary performance variable was the total number of throws (TnT) achieved in the tests. Additional parameters, such as blood lactate concentrations in the 3rd and 5th minute of recovery and heart rate values immediately after the tests and during the 1st and 5th minute of recovery, were used for defining the observed groups.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics 20.0). Results are presented as means (Mean), standard deviations (SD), and standard errors (SE). Student's t-test was used to determine differences between groups. The level of statistical significance was set at $p < 0.05$ (Hair et al., 1998).

Results

Table 2 presents the descriptive statistics and t-test results for the variables PBFM, PSMM, and TnT as a function of the defined groups based on different aspects of preparedness, as assessed by the Specific Wrestling Fitness Test. Preparedness examined through changes in lactate values from the 3rd to the 5th minute of recovery, or through the percentage of heart rate recovery at the 1st and 5th minute, did not demonstrate statistically significant differences between the defined groups for any of the analyzed variables ($p = 0.067\text{--}0.918$). In contrast, the total number of throws achieved during the test, as the simplest indicator of preparedness, showed statistically significant differences in relation to PBFM ($p = 0.001$) and, as expected, TnT itself ($p = 0.000$), whereas differences in the percentage of skeletal muscle mass were not statistically significant ($p = 0.081$).

Table 2. - Descriptive and Difference Results of Specific Wrestling Fitness Test Scores

Type	Variables	Groups	Descriptive statistics			t-test for Equality of Means		
			Mean	Std. Deviation	Std. Error	t	Sig.	Mean Difference
LA 3-5min	PBFM	La↑	13.58	3.87	0.94	-0.298	0.769	-0.540
		La↓	14.12	5.30	1.77			
	PSMM	La↑	49.18	2.29	0.56	0.530	0.601	0.553
		La↓	48.63	2.95	0.98			
	TnT	La↑	24.88	5.02	1.22	-0.169	0.867	-0.340
		La↓	25.22	4.58	1.53			
ΔHR1min	PBFM	≤9.99%	13.85	3.71	0.96	0.105	0.918	0.183
		≥10%	13.66	5.23	1.58			
	PSMM	≤9.99%	48.67	2.00	0.52	-0.746	0.463	-0.746
		≥10%	49.42	3.10	0.94			
	TnT	≤9.99%	26.47	4.39	1.13	1.922	0.067	3.467
		≥10%	23.00	4.75	1.43			
ΔHR5min	PBFM	≤39.99%	14.23	2.89	0.80	0.537	0.596	0.923
		≥40%	13.31	5.48	1.52			
	PSMM	≤39.99%	48.61	1.65	0.46	-0.769	0.450	-0.759
		≥40%	49.37	3.15	0.87			
	TnT	≤39.99%	25.46	5.08	1.41	0.484	0.632	0.923
		≥40%	24.54	4.63	1.28			
Total number of throws	PBFM	≤25	16.24	3.80	1.01	3.983	0.001	5.360
		≥26	10.88	2.91	0.84			
	PSMM	≤25	48.20	2.33	0.62	-1.820	0.081	-1.710
		≥26	49.91	2.45	0.71			
	TnT	≤25	21.00	1.62	0.43	-11.593	0.000	-8.667
		≥26	29.67	2.19	0.63			

Table 3 presents the descriptive statistics and *t*-test results for the previously mentioned variables obtained in the Specific Wrestling Performance Test. Statistically significant differences were identified between the defined groups with different levels of preparedness from the perspective of metabolic recovery (La 3–5 min) for the variables PBFM ($p = 0.031$) and PSMM ($p = 0.018$), whereas no significant differences were observed for TnT ($p > 0.05$). The analysis of the monitored variables from the perspective of preparedness as a function of the rate of cardiovascular recovery ($\Delta HR1min$ and $\Delta HR5min$) did not reveal statistically significant differences between the groups defined according to the percentage decrease in heart rate ($p > 0.05$). When the examined variables were analyzed from the basic aspect of preparedness, i.e., the number of throws performed in the test, highly statistically significant differences were found in relation to PBFM ($p = 0.000$), PSMM ($p = 0.044$), and TnT ($p = 0.000$).

Table 3. - Descriptive and difference results of the results achieved on the Specific Wrestling Performance Test

Type	Variables	Groups	Descriptive statistics			t-test for Equality of Means		
			Mean	Std. Deviation	Std. Error	t	Sig.	Mean Difference
LA 3-5min	PBFM	La↑	16.04	4.35	1.37	2.293	0.031	3.690
		La↓	12.35	3.76	0.94			
	PSMM	La↑	47.56	2.12	0.67	-2.545	0.018	-2.319
		La↓	49.88	2.34	0.59			
	TnT	La↑	32.60	7.55	2.39	-1.565	0.131	-4.713
		La↓	37.31	7.43	1.86			
$\Delta HR1min$	PBFM	≤9.99%	14.06	3.79	0.83	0.701	0.490	1.522
		≥10%	12.54	6.51	2.91			
	PSMM	≤9.99%	48.88	2.21	0.48	-0.432	0.670	-0.545
		≥10%	49.43	3.76	1.68			
	TnT	≤9.99%	34.48	7.31	1.60	-1.420	0.168	-5.324
		≥10%	39.80	8.56	3.83			
$\Delta HR5min$	PBFM	≤39.99%	14.41	2.76	0.74	0.817	0.422	1.398
		≥40%	13.02	5.68	1.64			
	PSMM	≤39.99%	48.80	1.58	0.42	-0.398	0.694	-0.397
		≥40%	49.20	3.33	0.96			
	TnT	≤39.99%	33.57	6.89	1.84	-1.409	0.172	-4.179
		≥40%	37.75	8.24	2.38			
Total number of throws	PBFM	≤34	16.58	3.73	1.03	4.338	0.000	5.615
		≥35	10.96	2.80	0.78			
	PSMM	≤34	48.01	2.32	0.64	-2.130	0.044	-1.951
		≥35	49.96	2.36	0.65			
	TnT	≤34	28.54	2.93	0.81	-11.820	0.000	-13.923
		≥35	42.46	3.07	0.85			

Discussions

The aim of this study was to examine the influence of wrestlers' preparedness on sporting performance and morphological characteristics, with preparedness conceptualized through several interrelated aspects: the dynamics of lactate concentration during recovery, the percentage of heart rate recovery during the first and fifth minute post-exercise, and the effectiveness of performing specific wrestling tasks expressed as the number of throws. The obtained results indicate that the relationship between muscle and fat components of body composition exerts a differentiated influence on these aspects of preparedness and performance, with the most pronounced effects observed in the domains of achieved performance and metabolic response.

The analysis of lactate concentration during the 3rd to 5th minute of recovery showed that participants with a less favorable morphological profile-i.e., a higher percentage of body fat and a lower proportion of skeletal muscle mass-exhibited higher lactate values, particularly during the Specific Wrestling Performance Test. These findings suggest a greater reliance on anaerobic energy pathways and a reduced capacity for the clearance of metabolic by-products in athletes with less favorable body composition, which is consistent with previous research in combat sports (Horswill, 2012; Mirzaei & Akbarnezhad, 2008). A higher proportion of functionally active muscle mass facilitates more efficient energy resynthesis and faster lactate oxidation, thereby reducing metabolic load during and after high-intensity exercise.

The results related to heart rate recovery during the first and fifth minute after exertion indicate that these indices are not always clearly differentiated with respect to morphological characteristics. Although no statistically significant differences were observed in most of the analyzed variables, a consistent trend toward more favorable recovery was noted in athletes with a lower percentage of body fat. These findings suggest that heart rate recovery is multifactorially determined and, in addition to body composition, depends on aerobic capacity, autonomic regulation, and the overall training status of wrestlers, which is in line with reports in the literature (Sundgot-Borgen & Garthe, 2011).

The clearest and most consistent findings were obtained in the analysis of performance in specific wrestling tasks expressed by the number of throws performed. Results from both tests demonstrated that athletes with a more favorable muscle-to-fat ratio achieved a significantly higher number of throws, directly indicating greater efficiency in the execution of technical and tactical activities. This finding confirms that the muscular component of body mass represents a key basis for force production, explosiveness, and repeated technical efficiency, whereas an increased

percentage of adipose tissue acts as a limiting factor for performance (Kim et al., 2011; Reale et al., 2017).

Overall, the results indicate that wrestlers' preparedness is strongly associated with morphological characteristics, although this relationship is not equally expressed across all analyzed aspects. While metabolic response and final performance outcomes are clearly differentiated with respect to body composition, cardiovascular recovery parameters appear to be less sensitive to morphological differences. These findings have important practical implications for the training process, as they suggest that optimizing body composition primarily affects performance effectiveness in specific wrestling activities, whereas improving recovery requires an integrated approach encompassing both conditioning and functional training components.

The obtained results are consistent with contemporary concepts of long-term body composition management in combat sports, which emphasize the need to avoid rapid and extreme weight-loss methods due to their negative effects on health and performance (Ćirković et al., 2011; Reale et al., 2017). Accordingly, it can be concluded that properly planned preparedness, based on an optimal balance between muscle and fat components, represents a key prerequisite for achieving a high level of sporting success in wrestling.

Conclusion

Based on the obtained results, it can be concluded that wrestlers' preparedness has a significant influence on sporting performance and morphological characteristics, with the strongest effects observed in the domains of achieved performance and metabolic response to specific loads. Preparedness, assessed through the dynamics of lactate concentration, the percentage of heart rate recovery during the first and fifth minute post-exercise, and the effectiveness of executing specific wrestling tasks expressed by the number of throws, proved to be a complex and multidimensional indicator of sporting performance.

The study results indicate that wrestlers with a more favorable morphological profile-characterized by a lower percentage of body fat and a higher proportion of skeletal muscle mass-achieve superior performance, expressed through a greater number of throws and lower lactate concentrations during the recovery period. These findings confirm that an optimal balance between muscle and fat components represents one of the key determinants of success in wrestling, as it enables more efficient force production, improved tolerance to high-intensity loads, and a more favorable metabolic response.

Heart rate recovery parameters during the first and fifth minute after exertion showed a weaker association with morphological characteristics, suggesting that recovery processes are also influenced by other factors, such as aerobic capacity, training status, and individual physiological adaptations. Nevertheless, a trend toward more favorable recovery was observed in athletes with better body composition, further highlighting the importance of systematic and planned management of morphological characteristics within the training process.

Taken together, the results of this study confirm that success in wrestling is largely conditioned by the interrelationship between athletes' morphological composition and preparedness. However, wrestlers' preparedness should not be viewed solely from a metabolic or cardiovascular perspective, but rather as an integration of all energy system components, with performance outcomes in specific tests representing the most discriminative indicator of preparedness. These findings have important practical implications, emphasizing the need for long-term monitoring and optimization of body composition through appropriately structured training and nutrition, while avoiding abrupt and inadequate weight-reduction methods. Such an approach may lead to improved performance, enhanced recovery quality, and overall competitive success in wrestling.

Conflict of interests:

The authors declare no conflict of interest.

Author Contributions:

Resources, M.M. and M.D.; Methodology, M.M. and M.I.T.; Investigation, M.M. and M.D.; Data curation, M.M. and M.I.T.; Formal Analysis, M.D. and M.I.T.; Writing – original draft, M.M. and M.D.; Writing – review & editing, M.M., M.D. and M.I.T.;

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