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Generic and Specific Fitness Profile of Elite Youth Greco-Roman Wrestlers; Differences According to Quality and Weight Category

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Abstract

This study aimed to investigate the validity of the Specific Wrestling Fitness Test (SWFT), correlating it with generic anaerobic tests in elite youth wrestlers and determining whether wrestlers differ according to quality and weight categories in all tests. The research included 23 advanced-level Greco-Roman wrestlers (aged 16-19 years) who were divided into two quality categories (National team members and Non-team members) and two weight categories (lighter and heavier). Variables included anthropometric characteristics, generic fitness tests, and SWFT. Results evidenced that only vertical jump height was associated with SWFT (Pearson's R=0.48, p<0.05). Team members had higher results in the vertical jump height (p=0.02, moderate ES), while wrestlers from the heavier category had higher body mass (p=0.001, large ES) and body height (p=0.01, large ES) than lighter wrestlers. Moreover, wrestlers did not differ in the SWFT according to quality and weight categories. SWFT was not associated with generic fitness tests, possibly because of its high specificity. Furthermore, team members and non-team members did not differ in the SWFT, which could be explained by the fact that only advanced-level wrestlers were included in this study. Thus, future studies should include lower-quality wrestlers and different testing protocols.

Keywords: *combat sports, physical capacities, selection, youth athletes*

Introduction

Two wrestling disciplines that are included in the Olympic games for men are Greco-Roman and freestyle wrestling. Greco-Roman wrestlers are allowed only to perform actions on the upper body and movements under the waist are forbidden, while freestyle wrestlers are permitted to use the whole body for actions (Ulupınar et al., 2021). Both wrestling disciplines are characterized by intermittent actions, with periods of high-intensity activity interspersed with short recovery periods (Ulupınar et al., 2021). It has been reported that during the World Greco-Roman wrestling championship, the activity-to-rest ratio was approximately 2.5:1 (Nilsson et al., 2002). Namely, wrestling is characterized by constant and repeated shifts of sudden defense and offense movements in the submaximal and maximal physiological zones, which means that wrestling mainly relies on anaerobic energy systems (Horswill, 1992). Precisely, the activity during the match is 90% performed in anaerobic-alactate and anaerobic-glycolytic metabolic processes, while only 10% relies on the aerobic energy system (Kell, 1997).

The anaerobic system provides quick energy for performing explosive actions such as lifts and throws and maximal intensity actions like pushing and pulling the opponent (Chaabene et al., 2017). As the beforementioned actions are the ones that determine the match outcome, it could be hypothesized that well-developed anaerobic capacity is the most important factor

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for success in wrestling. Thus, the main aim of the practitioners and scientists is to develop and determine the most appropriate test that tackles anaerobic metabolic pathways and determines the wrestler's level of preparedness. Sport-specific tests enable determining current levels of physical and physiological indices of their athletes (Chaabene et al., 2018).

As throwing wrestling manoeuvres are the most demanding ones as the wrestler has to lift and quickly throw the opponent, throwing actions employ an anaerobic energy system the most. Thus, several wrestling-specific tests that consist of consecutive wrestling throwing movements have been recently developed. Specific Wrestling Performance Test (SWPT) and Specific Wrestling Fitness Test (SWFT) both consist of throwing a dummy by a supplex technique, with SWPT consisting of two 3-minute segments and SWFT composed of three segments of 30 seconds (Markovic, 2017; Markovic et al., 2021). Thus, even though SWPT mimics actual combat duration, SWFT has better practical applicability as it is of a shorter duration, and a larger number of athletes can be measured. Also, it is considered that SWFT sufficiently tackles the anaerobic capacities of wrestlers and can be used to determine their physiological capacities (Markovic et al., 2021). SWFT has previously been proven reliable (Markovic, 2017) and valid in predicting specific wrestling preparedness in wrestlers aged 20-24 years (Markovic et al., 2021).

Studies conducted on older wrestlers (20.3±2.7 years) displayed differences in SWFT according to quality categories. Precisely, Serbian first-league wrestlers had a higher number of throws of more than 30% compared to second-league wrestlers (Markovic et al., 2018). Moreover, national team wrestlers outperformed first-league wrestlers (32.40±1.8 vs. 28.30±1.7 throws), and first-league wrestlers exceeded second-league wrestlers (28.30±1.7 vs. 23.04±3.2 throws), indicating good discriminative validity of the SWFT (Marković et al., 2022). Further, wrestling is a sport where the weight of the athlete is extremely important (Karninčić et al., 2013). Therefore, it could be expected that wrestlers would differ in physiological and physical capacities according to their weight. However, few previous studies did not record differences according to weight in maximal muscle strength (bench press and squat exercise) and power tests (Izquierdo et al., 2002; García-Pallarés et al., 2011), but studies investigating weight differences in sport-specific tests are lacking.

From the brief overview of the previously conducted studies, it could be suggested that SWFT was not thoroughly checked for its metric characteristics and was mainly conducted on older wrestlers (older than 20 years) (Markovic et al., 2021). This research aimed to investigate the validity of the SWFT with protocol index calculation modification, correlating it with other generic anaerobic tests in elite youth wrestlers. Additionally, the aim was to determine whether wrestlers differ according to quality categories (national-team members vs. non-team members) and weight categories in all tests. The results of this study would enable coaches and scientists to determine whether some more simple anaerobic test could be used as a tool for determining wrestling performance apart from SWFT, which could potentially save time and enable coaches to identify a quality wrestler.

Methods

Participants

This research included 23 Greco-Roman wrestlers aged 16-19 years who were participating in a national team training camp in preparation for international competitions during the 2022 season. All wrestlers were medalists in national championships and had international experience. All wrestlers successfully completed the tests, and no injuries or illnesses were reported prior to and during the tests. Wrestlers were divided into two categories according to quality. The first category (n=12, age=17.92±0.9 years, body height=175.04±7.19 cm, body mass=74.07±9.85 kg) included wrestlers that were included in the national team (Team members), and the second category (n=11, age=17.5±1.18 years, body height=173.68±3.17 cm, body mass=70.33±8.61 kg) included wrestlers that were in the broader team selection but were not included in the final team (Non-team members). Also, wrestlers were divided into two weight categories: lighter (55-67 kg) and heavier (72-87 kg). Participants signed informed consent before the study began, and parents/legal guardians signed informed consent for participants under 18 years old. This study was approved by the Editorial Board Faculty of Kinesiology, University of Split (Ref.no 2181-205-02-05-22-0012; Date of approval: 11/03/2022).

Variables and procedures

Anthropometric variables, generic fitness tests, and specific fitness tests were included in the research.

Anthropometric variables consisted of body height, body mass, and percentage of body fat calculated as a sum of skinfolds measured on triceps and calf muscles by Harpenden skinfold caliper (British Indicators, Burgess Hill, England), using the Slaughter-Lohman formula.

Generic fitness tests included countermovement jump, consecutive jumps during 30 seconds, Wingate test on the rowing ergometer, and running 300 yards.

Countermovement jump (CMJ) and consecutive jumps during 30 seconds (CJ30) were measured using the Optogate system (Microgate, Bolzano, Italy). For the CMJ, Wrestlers stood in a shoulder-width stance with hands on their hips. Wrestlers had to jump upwards maximally by first bending their knees and moving downwards, followed by a maximal jump upwards. They performed three jumping trials, and the best one (i.e., the highest jump) was taken into further analysis. For the CJ30, wrestlers stood in a shoulder-width stance and could freely move their hands during the jumps. They had to perform consecutive jumps during the 30 seconds. The parameters used for analysis were the highest jump, reactive strength index, and the number of jumps.

Wingate test on the rowing ergometer (WINGATEROW) was performed on the Concept 2 rowing machine, which was previously shown as valid and reliable (Mikulic et al., 2010). Variables from the WINGATEROW test included maximal power output and average power output.

A three hundred yards shuttle run test (300 yd) was performed in the school gymnasium. Two lines were placed 25 yards apart. Participants were instructed to take the high starting position behind the first line. They had to run to the 25-yards line, touch it with their foot, turn, and run back to the first line. They performed the same scenario six times. The test result was recorded as time for running the 300-yard distance.

Specific-fitness test was the SWFT. All participants were given a dummy according to their weight category. Wrestlers in weight categories 55-67 kg performed the test with a 23 kg dummy, while wrestlers in 72-87 kg categories performed the test with a 25 kg dummy, and wrestlers over 90 kg performed the test with a 30 kg dummy. However, wrestlers with more than 97 kilograms were excluded from the analysis as they have to move higher absolute mass in throws which is more anaerobically demanding for producing relative to body weight. The weight of the dummy was determined according to instructions of the test's authors, with slight alliterations (Markovic, 2017). Wrestlers had to perform a maximum number of throws using the supplex technique in three periods of 30 seconds, with 20 seconds of rest between throwing periods. Wrestlers had visual and acoustic feedback on time, i.e., a large stopwatch was placed in their sight, and researchers were informing wrestlers about the time. The total number of throws was recorded. Each participant wore a POLAR H10 heart rate monitor (Polar, Inc., Lake Success, NY, USA). Heart rate was recorded immediately after each throwing period (i.e., when the test finished) and after the first and third minutes of rest and included following variables: Heart rate 1 – Sum of heart rate at test end and 1-minute rest, Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest.

The modification in the calculation of the SWFT index was made; the authors of this study propose that the simpler formula should be used as the original formula in calculating the SWFT index using blood lactates is time-consuming and expensive, and often coaches do not have certified equipment. The index of the SWFT was calculated similarly to the SJFT index (Drid et al., 2012), as a sum of heart rates at the end of the test and after one minute of rest divided by the total number of throws. Additionally, another index was calculated as the sum of heart rates at the end of the test, after one minute of rest, and after three minutes of rest divided by the total number of throws.

Testing protocol

Testing was conducted during two testing days.

The first day included anthropometric measurement, which was conducted before wrestlers performed warm-up. General warm-up lasted for 15 minutes and consisted of light running, followed by mobility exercises. After the warm-up, wrestlers first performed the CMJ test and, after a 10-minute break, performed the CJ30 test. After, WINGATEROW was conducted. Wrestlers firstly performed a familiarization trial of 5-minute light rowing, even though they had good rowing technique as rowing is included in their physical conditioning preparations. After 5-minute light rowing, they had 1-minute rest and performed a 30-second maximal test.

The second testing day included SWFT and 300 yd test. General warm-up lasted for 15 minutes and consisted of light running, mobility and stretching, and their regular warm-up on the wrestling mat. Afterward, wrestlers underwent a 20-minute familiarization process for the SWFT test that consisted of theoretical and practical explanation and practice. After a 10-minute rest, participants performed a maximal SWFT test. After a 30-minutes break, wrestlers performed a 300 yd running test once.

Statistical analyses

The normality of the variables was checked by the Kolmogorov-Smirnov test. Descriptive statistics included arithmetic means and standard deviations. Pearson's correlation coefficients were used to determine the correlation between SWFT and other anthropometric and fitness variables. To determine the differences between quality categories and weight classes, a t-test for independent samples was used. Additionally, Cohen's d effect sizes (ES) were calculated for differences in quality and weight category in the studied variables, and were interpreted as: <0.02 = trivial; 0.2–0.6 = small; >0.6–1.2 = moderate; >1.2–2.0 = large ES (Cohen, 2013). The p-level of 0.05 was applied for all analyses. A minimum level of significance of $p<0.05$ was established.

Statistical package Statistica ver.13 (Tibco, Palo Alto, California) was used for all analyses.

Results

Descriptive statistics and differences in anthropometric and fitness variables according to wrestlers' quality are displayed in Table 1. Team members had higher results in the maximal height during CJ30 (t-value=2.52, p=0.02). There were no significant differences in any other variable.

Table 1. Descriptive statistics and differences in anthropometric and fitness variables according to wrestlers' quality.

	Team members (N=12)		Non-team members (N=11)		T-test	
	Mean	SD	Mean	SD	t-value	p-level
Body mass (kg)	74.07	9.85	70.33	8.61	0.97	0.35
Body height (cm)	175.04	7.19	173.68	3.17	0.58	0.57
Body fat percentage	11.95	1.75	11.35	2.75	0.62	0.54
30s maximal height (cm)	31.38	2.03	28.31	3.60	2.52	0.02
30s maximal power (W)	40.22	5.21	38.14	4.82	0.96	0.35
30s maximal RSI (index)	1.48	0.21	1.37	0.21	1.18	0.25
Broad jump (cm)	243.00	22.42	233.20	19.11	1.09	0.29
Countermovement jump (cm)	39.23	4.66	36.63	6.16	1.13	0.27
Push up jump (cm)	11.87	4.30	10.77	3.90	0.62	0.54
300 yards (sec)	63.60	3.76	63.20	2.07	0.28	0.78
Wingate average power (w/kg)	6.31	0.82	6.00	0.79	0.79	0.44
Wingate peak power (w/kg)	7.54	0.94	7.29	0.76	0.61	0.55

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Table 1. Descriptive statistics and differences in anthropometric and fitness variables according to wrestlers' quality.

	Team members (N=12)		Non-team members (N=11)		T-test	
	Mean	SD	Mean	SD	t-value	p-level
SWFT repetitions total	28.42	2.39	26.33	3.43	1.64	0.12
Heart rate 1	334.00	15.14	336.56	10.24	-0.44	0.67
Heart rate 2	450.25	21.30	458.22	17.82	-0.91	0.38
SWFT index 1	11.85	1.33	12.97	1.71	-1.69	0.11
SWFT index 2	15.97	1.76	17.68	2.50	-1.84	0.08

Note: RSI - Reactive Strength Index, SWFT – Specific Wrestling Fitness Test, Heart rate 1 – Sum of heart rate at test end and 1-minute rest, Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest.

Figure 1 shows effect size differences between team members and non-team members in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters. The moderate effect size was found for the CJ30.

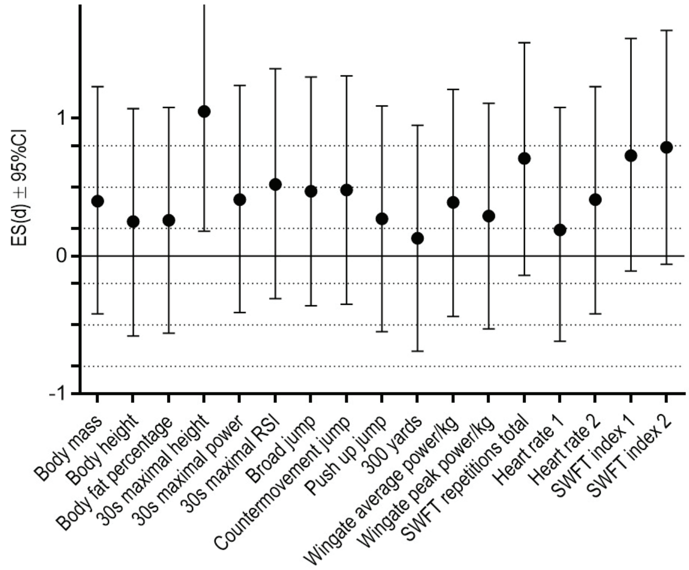

FIGURE 1. Effect size differences between team members and non-team members in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters.

According to the weight category, wrestlers from the heavier category had higher body mass (t=4.33, p=0.001) and body height (t=2.99, p=0.01) than lighter wrestlers. They did not differ in any other variable (Table 2).

Table 2. Descriptive statistics and differences in anthropometric and fitness variables according to weight categories.

	Heavier category (N=15)		Lighter category (N=6)		T-test	
	Mean	SD	Mean	SD	t-value	p-level
Body mass (kg)	76.90	7.47	62.65	4.48	4.33	0.00
Body height (cm)	176.67	5.22	169.67	3.66	2.99	0.01
Body fat percentage	11.96	2.35	11.30	1.87	0.61	0.55
30s maximal height (cm)	29.72	3.38	30.38	2.74	-0.39	0.70
30s maximal power (W)	38.22	4.11	39.56	6.06	-0.55	0.59
30s maximal RSI (index)	1.36	0.19	1.50	0.20	-1.38	0.19
Broad jump (cm)	245.14	20.68	224.40	12.74	2.08	0.05
Countermovement jump (cm)	39.44	5.92	36.22	3.30	1.14	0.27
Push up jump (cm)	11.19	3.53	12.04	6.56	-0.37	0.72
300 yards (sec)	62.49	1.95	64.93	4.29	-1.66	0.12
Wingate average power (w/kg)	6.18	0.67	6.11	1.14	0.15	0.88

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Table 2. Descriptive statistics and differences in anthropometric and fitness variables according to weight categories.

	Heavier category (N=15)		Lighter category (N=6)		T-test	
	Mean	**SD**	**Mean**	**SD**	**t-value**	**p-level**
Wingate peak power (w/kg)	7.49	0.73	7.27	1.17	0.48	0.64
SWFT repetitions total	27.53	2.80	27.50	3.73	0.02	0.98
Heart rate 1	336.53	14.28	331.50	9.27	0.79	0.44
Heart rate 2	457.07	21.84	445.17	10.72	1.26	0.22
SWFT index 1	12.36	1.51	12.26	1.87	0.13	0.90
SWFT index 2	16.80	2.21	16.46	2.47	0.30	0.76

Note: RSI - Reactive Strength Index; SWFT – Specific Wrestling Fitness Test; Heart rate 1 – Sum of heart rate at test end and 1-minute rest; Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest.

Figure 2 shows effect size differences between team members and non-team members in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters. Large differences are noted for the body mass and height.

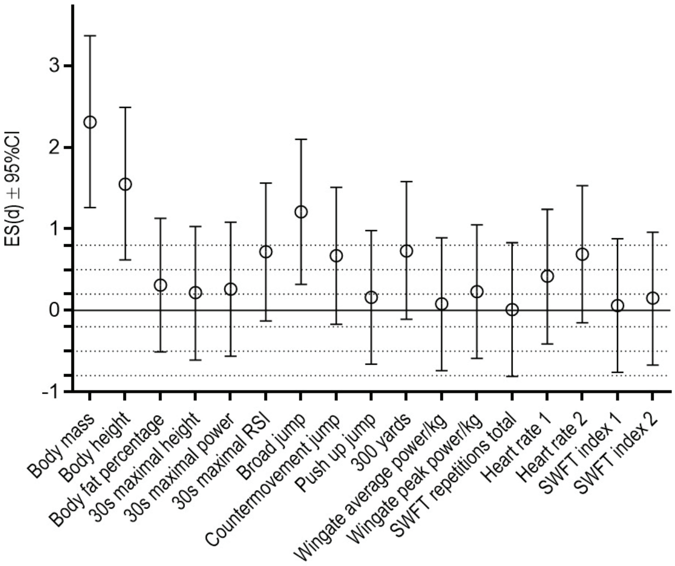

FIGURE 2. Effect size differences between lighter and heavier weight categories in anthropometric variables, generic fitness tests, and Specific Wrestling Fitness Test parameters.

Pearson's correlation coefficients are shown in Table 3. Body fat percentage was positively associated with all SWFT parameters except for SWFT repetitions for the total sample. Moreover, maximal height during 30 seconds of consecutive jumps and the CMJ test was positively correlated with SWFT repetitions. The CMJ test was negatively correlated with SWFT index 1 and SWFT index 2, where the lower index represents the better result. When looking separately among team members, only body height was negatively correlated with SWFT parameter Heart rate 1. Among non-team members, body height and body fat percentage were positively correlated with Hearth rates 1 and 2.

Table 3. Pearson's correlation coefficients between Specific Wrestling Fitness Test parameters and anthropometric and generic-fitness variables.

Variable	SWFT repetitions total	Heart rate 1	Heart rate 2	SWFT index 1	SWFT index 2
			Total sample		
Body mass	0.14	-0.02	0.08	-0.15	-0.11
Body height	0.23	-0.43	-0.35	-0.34	-0.31
Body fat percentage	-0.43	0.58*	0.61**	0.59*	0.60*
30s maximal height	0.48	-0.01	-0.06	-0.47	-0.48
30s maximal power	0.48*	0.11	0.11	-0.44	-0.42
30s maximal RSI	0.34	0.23	0.17	-0.26	-0.26
Broad jump	0.14	-0.31	-0.22	-0.26	-0.23

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Table 3. Pearson's correlation coefficients between Specific Wrestling Fitness Test parameters and anthropometric and generic-fitness variables.

Variable	SWFT repetitions total	Heart rate 1	Heart rate 2	SWFT index 1	SWFT index 2
Push up jump	0.28	0.05	0.03	-0.25	-0.25
Countermovement jump	0.49*	-0.20	-0.15	-0.54*	-0.51*
300 yards	-0.26	-0.05	-0.17	0.24	0.18
Wingate average power/kg	0.26	0.17	0.17	-0.20	-0.18
Wingate peak power/kg	0.17	0.16	0.19	-0.12	-0.10
			Team members		
Body mass	0.27	-0.33	-0.29	-0.42	-0.41
Body height	0.36	-0.67*	-0.64	-0.60	-0.60
Body fat percentage	-0.49	0.56	0.55	0.61	0.63
30s maximal height	0.07	0.18	0.22	-0.01	0.00
30s maximal power	0.62	0.30	0.39	-0.42	-0.39
30s maximal RSI	0.31	0.48	0.50	-0.06	-0.05
Broad jump	0.22	-0.44	-0.39	-0.39	-0.38
Push up jump	0.26	0.16	0.17	-0.14	-0.14
Countermovement jump	0.27	-0.36	-0.31	-0.38	-0.37
300 yards	-0.60	-0.05	-0.20	0.54	0.48
Wingate average power/kg	0.42	0.15	0.11	-0.28	-0.30
Wingate peak power/kg	0.51	0.11	0.08	-0.38	-0.40
			Non-team members		
Body mass	-0.10	0.64	0.69	0.24	0.30
Body height	-0.19	0.75*	0.74*	0.37	0.41
Body fat percentage	-0.45	0.74*	0.73*	0.66	0.68
30s maximal height	0.54	-0.26	-0.18	-0.60	-0.57
30s maximal power	0.22	-0.51	-0.42	-0.38	-0.38
30s maximal RSI	0.18	-0.51	-0.42	-0.34	-0.34
Broad jump	-0.03	0.00	0.14	-0.06	-0.02
Push up jump	0.32	-0.18	-0.17	-0.38	-0.37
Countermovement jump	0.65	0.01	0.06	-0.67	-0.62
300 yards	0.04	-0.06	-0.03	-0.09	-0.08
Wingate average power/kg	-0.01	0.20	0.34	0.01	0.06
Wingate peak power/kg	-0.32	0.31	0.44	0.31	0.36

Note: RSI - Reactive Strength Index; SWFT – Specific Wrestling Fitness Test; Heart rate 1 – Sum of heart rate at test end and 1-minute rest; Heart rate 2 – Sum of heart rate at test end, at 1min rest and 3-minute rest; * $p<0.05$; ** $p<0.01$.

Discussion

This study aimed to investigate the validity of the Specific Wrestling Fitness Test (SWFT), correlating it with other generic anaerobic tests in elite youth wrestlers and determining whether wrestlers differ according to quality and weight categories in all tests. According to the aims of the study, the most important findings are: (i) generic fitness tests are not associated with SWFT, (ii) wrestlers did not differ according to quality categories, and (iii) wrestlers did not differ according to weight categories.

Generic fitness tests and specific wrestling fitness test

The finding that generic fitness tests were poorly or not associated with SWFT could be explained by the fact that SWFT is a highly sport-specific test that includes complex movements of the whole body, with constant changes in body positions (Markovic et al., 2021). Specifically, the throwing manoeuvre starts in an upright position and finishes in the lying position, after which wrestlers have to stand up quickly and repeat the throwing. Thus, this test relies on the synergistic functioning of the whole body in a very specific movement. To support our findings, anaerobic performance variables accounted for less than 60% of the variance in a somewhat similar test for Brazilian judo athletes - Special Judo Fitness Test (SJFT) (Paulo Lopes-Silva et al., 2021). Supportively, SJFT was not correlated with upper-body Wingate test mean (R=-0.28) and peak power (R=-0.26) in Iranian judokas (Hesari et al., 2014).

However, our results did evidence weak to a moderate association of SWFT with vertical jumping capacity. Indeed, probably the most powerful movement of the SWFT is when wrestlers have to explosively lift the dummy off the mat, which is mainly enabled by powerful movement from the lower extremities (Markovic, 2017). Similar to our study, a study on youth Tunisian wrestlers aged 16-17 years found an association between peak power of legs evaluated by the Wingate test and a specific wrestling test that consisted of throwing a partner, similar to SWFT (Melki et al., 2019). Thus, our results could lead to a hypothesis that lower-body power capacity determines performance in SWFT and potentially better performance in the wrestling match. Therefore, it could be proposed that wrestling coaches focus on developing muscle power in the lower extremities to enhance wrestling performance.

Differences according to quality groups and weight category

The SWFT did not differentiate team members and non-team members, implying that the test is not sensitive enough for this specific sample. Precisely, all participants in our study were advanced-level athletes; Besides selected team wrestlers, even non-team members were close to entering the team, meaning the differences between those quality groups are probably very small. Indeed, one potential reason could be the subjective evaluation of the team selector on the decision of which athlete to include in the team and which not to include, which can be based on the selector's self-perception of the wrestler. Opposite to the results of our study, a study conducted on Serbian wrestlers aged 20-21 years noted that wrestlers from different competitive levels (1st vs. 2nd Wrestling League of Serbia) differed in the wrestling-specific performance test, i.e., 1st league wrestlers outperformed 2nd league wrestlers (Markovic et al., 2018). However, the reason we recorded opposite results could be because we included only advanced-level wrestlers.

The research conducted on Croatian advanced wrestlers supports the results of our study. Specifically, top-level (national-team members) and high-level (non-selected for the national team) wrestlers did not differ in strength parameters (pull-ups and bench press) (Karnincic et al., 2015). Even though strength level is crucial for determining the fitness status of wrestlers, it can only discriminate lower-quality from high-quality wrestlers (García-Pallarés et al., 2011), while it does not efficiently differentiate advanced-level wrestlers. This has also been proven in numerous studies (Horswill et al., 1989; García-Pallarés et al., 2011). Specifically, a study on elite and amateur wrestlers from five countries recorded that elite wrestlers reached significantly greater results in most physical performance variables, including maximal grip strength, upper-body Wingate test, jumping height, and maximum muscle strength, than amateur wrestlers (García-Pallarés et al., 2011). Moreover, a study on youth wrestlers aged 16-17 years recorded that elite wrestlers had better results than non-elite wrestlers in the upper-body and lower-body Wingate test (Horswill et al., 1989).

However, advanced-level wrestlers have similar strength levels because they must possess a high level of strength and power, or they will not be categorized as advanced wrestlers. Indeed, a study on Polish wrestlers noted that successful wrestlers had higher muscle power, strength, and endurance levels than unsuccessful wrestlers (Cieśliński et al., 2021). Thus, to determine whether SWFT is sensitive for discriminating performance and quality levels, future studies should include wrestlers of lower quality (e.g., club-level wrestlers) and not only elite wrestlers.

Finally, wrestlers did not differ according to the weight categories in the SWFT, which could be explained by the fact that the test was performed with a dummy with a specifically determined weight according to their weight category (Markovic et al., 2021). Thus, by matching the weight of the dummy to the weight of the wrestler, the impact of an athlete's lower or higher mass was somewhat diminished. Moreover, there is another additional explanation for the lack of differences between the weight categories. It is possible that the quality of wrestlers interfered in the results and that they were of similar physical capacities regardless of weight. Similar to the results of our study, a study on wrestlers aged 20-22 years noted that elite wrestlers from three weight categories did not differ in maximum muscle strength in the bench press and squat exercise (García-Pallarés et al., 2011). The authors explained such findings by hypothesizing that neural activation patterns and twitch tension per muscle mass during maximal concentric contractions are similar between elite wrestlers, irrespective of the weight category (Izquierdo et al., 2002; García-Pallarés et al., 2011). Therefore, matching the dummy to the wrestler's weight and probable similarity in the physical capacities between wrestlers most likely led to not finding differences between the weight categories in the studied wrestlers.

The study's main limitation is the cross-sectional character and the inability to conclude the relationship between success and physical capacities. Therefore, intervention studies that include exercises and training protocols that tackle capacities included in this study should be performed in the future. Further, we included a relatively small sample size. However, we have to mention that we included advanced-level wrestlers, and, as such, it was hard to collect more wrestlers of this level. Precisely, 170 wrestlers competed at cadet and junior championships (which corresponds to the age category of our participants). Thus, as we included wrestlers that were top performers in those competitions, this could also be the strength of this study. Indeed, including athletes at the top performance and testing their physical capacities could aid in creating more specific training programs for enabling less successful wrestlers to become more successful.

To conclude, SWFT was not associated with generic-fitness tests, possibly because of its high specificity. Furthermore, team members and non-team members did not differ in the SWFT, which could be explained by the fact that only advanced-level wrestlers were included in this study. Thus, future studies should include wrestlers of lower quality. Also, the authors propose that future research/testing should consist of two consecutive SWFTs, with only a few minutes of rest between the trials. This way, wrestlers of greater quality will probably display better results and will be able to maintain higher performance levels during both testing trials compared with wrestlers of less quality.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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