Physical fitness differences between Freestyle and Greco-Roman elite wrestlers

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Abstract

Background and Study Aim: The purpose of this study was to examine the differences in the anthropometrical, physical, neuromuscular and physiological markers between Freestyle and Greco-Roman elite male wrestlers. Secondly, this study was carried out in order to validate the crank-arm Wingate test to assess the anaerobic metabolism contribution during an official wrestling match.

Material/Methods: Ninety two male wrestlers, comprising of 39 Freestyle and 53 Greco-Roman competitors took part in a wrestling tournament. Depending on their wrestling style and their body mass (light, middle and heavy weight), 6 competition divisions were formed: Light Weight (body mass between 55–68 kg) in Freestyle (n=16) and Greco-Roman (n=18) style; Middle Weight (body mass between 68–84 kg) in Freestyle (n=12) and Greco-Roman (n=24) style; and Heavy Weight (body mass between 84–100 kg) in Freestyle (n=11) and Greco-Roman (n=11) style. The finalists in each group were recruited to carry out physical fitness marker comparisons (n=36).

Results: No differences were observed in any anthropometrical, physical, neuromuscular or physiological markers between Freestyle and Greco-Roman elite wrestlers in any weight class. The peak blood lactate values attained during the simulated tournament were significantly ($p \leq 0.05$) higher than those detected following the crank-arm Wingate test in the six studied groups.

Conclusions: The present results suggest that the current official rule differences between both wrestling styles do not promote any anthropometrical or physical fitness differences in elite wrestlers. The 30 s crank-arm Wingate test may not adequately simulate the metabolism involved during an official wrestling match, but it may still be a reasonable indicator of wrestling performance.

Key words: maximum strength • maxial power • Crank-arm Wingate • anthropometry • combat sport • tournament

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Background

Wrestling was an important part of the ancient Olympic Games and is still one of the most popular events of the modern Olympic Games. Nowadays, in the Olympics, two wrestling styles are included for men: Greco-Roman, a classic style in which only upper body moves are allowed, and Freestyle, which includes upper and lower body wrestling. Both wrestling styles are based on a weight class system which aims to protect the competitors' health, limiting as much as possible the risk of injuries, as well as balancing out the physical characteristics between wrestlers and therefore increasing the performance percentage that depends on technical, tactical and psychological skills [1].

Following a considerable number of changes in the official wrestling rules over the last decades [2], a Freestyle

Wrestling – martial art that uses grappling type techniques such as clinch fighting, throws and takedowns, joint locks, pins and other grappling holds.

Power – the rate of performing work; the product of force and velocity. The rate of transformation of metabolic potential energy to work or heat.

Anthropometry – the measurement of the size and proportions of the human body and its different parts.

wrestling match today is composed of three 2-minute rounds with a 30 second break, while the Greco-Roman period duration is also 2 minutes but with 1 minute 30 seconds of standing wrestling and 30 seconds of ground wrestling. In both styles the winner is decided by either a fall (i.e., when the opponent´s two shoulders are held to the mat) or by a scoring system that quantifies which wrestler is most superior when it comes to controlling his or her opponent during the match duration.

Wrestling has been described as an intermittent physical event which produces great strength and muscle power demands on both the upper and lower body, with high anaerobic energy metabolism requirements [2–10]. Numerous researchers have also reported that, although aerobic performance may be a basic requirement for wrestlers, it cannot be considered as a critical component of success in this sport [3,5,6,11,12].

Although these studies have attempted to establish the physical fitness profile of wrestlers at different competitive levels, currently there is a lack of scientific data addressing the effects that the current official competition rule differences between both wrestling styles have promoted over the physiological, neuromuscular and anthropometric markers in elite wrestlers. Traditionally, wrestling coaches and researchers have alleged some important differences in physical fitness markers between both Olympic wrestling styles, that have promoted an early specialization of the wrestlers in one or other style.

To our knowledge, during the last twenty-five years only two scientific studies have attempted to compare just a single physiological or neuromuscular performance marker between Greco-Roman and Freestyle counterparts [5,13] and no significant differences were reported. Examination of fitness profiles in Freestyle and Greco-Roman wrestlers of different weight classes can be of great interest for coaches and sports scientists when individualizing strength, power, and endurance training programs, as well as to optimize talent selection for both wrestling styles.

Regarding anaerobic metabolism, many previous researchers have accepted a single stimuli of a crank-arm Wingate test as a valid assessment to establish the anaerobic performance profiles of wrestlers [4,5,8,9,14–17], or even to differentiate successful and less successful counterparts [4,16,17]. Nevertheless, recent studies [9] have found lower metabolic responses following a 30 second crank-arm Wingate testing compared to the results reported immediately after a real wrestling combat [7,18–20].

Therefore, the first aim of this study was to investigate which anthropometric, physiological and neuromuscular factors are different between Freestyle and Greco-Roman elite male wrestlers. Our second aim was to assess the different metabolic responses between a crank-arm Wingate test and a current official tournament bout. It was hypothesized that the aforementioned official rule differences between wrestling styles (i.e., Freestyle and Greco-Roman) do not promote any anthropometrical or physical fitness distinctions. Also, it was hypothesized that the current official wrestling matches present higher anaerobic metabolic demands compared to a crank-arm Wingate assessment.

Material and Methods

Subjects

Ninety two male wrestlers, 53 Greco-Roman and 39 Freestyle competitors, from five different countries were assigned into 6 groups according to their wrestling style (i.e., Freestyle and Greco-Roman) and their body mass (i.e., light, middle and heavy weight) as follows: Light Weight (body mass ranged between 55–68 kg) in Freestyle (LW_{FS}, n=15) and Greco-Roman (LW_{GR}, n=18) style; Middle Weight (body mass ranged between 68–84 kg) in Freestyle (MW_{FS}, n=13) and Greco-Roman (MW_{GR}, n=24) style; and Heavy Weight (body mass ranged between 84–100 kg) in Freestyle (HW_{FS}, n=11) and Greco-Roman (HW_{GR}, n=11) style. In order to standardize the competitive level of the wrestlers for subsequent physical fitness markers comparisons, the four medal winners and the two 5th classified in a simulated international wrestling tournament, were recruited in each of the 6 studied divisions (n=36). All these 36 selected subjects had represented their respective countries in at least three International Federation of Associated Wrestling Styles (FILA) tournaments (i.e., European and/or World Championships), and had a minimum of 6 years regular training experience. Furthermore, 10 of them had won at least one medal during an international tournament. The physical characteristics and training background of the selected subjects are presented in Table 1.

Experimental design and testing schedule

The results of this training camp that took place in April 2010 were used by the selectors of the five different countries to choose their own national team members for an incoming international tournament.

None of these 92 wrestlers were involved in any form of weight reduction nor were following a diet of restricted water or food intake. All the wrestlers followed the same dietary plans during the experiments and none of these subjects, including the heavy weight wrestlers,

Table 1. Freestyle and Greco-roman elite wrestlers' characteristics in the three weight classes.

	Light weight		Middle weight		Heavy weight	
	LWFS (n=6)	LWGR (n=6)	MWFS (n=6)	MWGR (n=6)	HWFS (n=6)	HWGR (n=6)
Age (y)	18.0±1.1	17.5±1.0	18.3±1.5	18.0±1.1	18.9±1.5	20.0±1.1
Height (cm)	171.0±3.7	166.2±3.4*	173.4±4.6	174.3±5.3	178.7±5.4	175.0±4.9
Arm Span (cm)	172.4±3.6	169.3±4.8	177.1±4.5	178.0±4.8	181.0±5.3	178.5±6.3
Body mass (kg)	60.2±4.0	61.5±4.8	74.3±5.1	73.2±4.4	88.5±7.3	87.7±3.5
BMI ($kg \cdot m^{-2}$)	20.6±1.0	22.3±1.3*	24.7±1.3	24.1±1.9	27.7±3.2	28.6±1.6
Body fat (%)	10.3±2.0	10.3±1.9	11.1±2.3	10.9±1.9	14.1±4.6	13.2±2.5
FFM (kg)	54.0±3.9	55.2±3.7	66.1±4.5	65.2±2.8	76.0±3.4	76.1±2.4
Training experience (y)	7.2±2.6	7.7±1.6	8.2±3.4	7.8±1.4	8.7±2.9	8.0±2.4

Data is expressed as mean ±SD. * Significantly different (P≤0.05) when comparing to their respective Freestyle group. BMI – body mass index; FFM – Fat free mass.

increased or decreased their body weight more than 1% during the week of assessments.

The subjects and coaches were informed in detail about the experimental procedures and the possible risks and benefits of this project. The study, which complied with the Declaration of Helsinki, was approved by the Bioethics Commission of the University of Murcia, and written informed consent was obtained from athletes prior to participation.

Testing was completed for all wrestlers in the same laboratory facilities on five consecutive days: day 1 – anthropometrics (7:00–8:30), sprint running (10:00–12:00) and crank-arm Wingate test (16:00–18:30); day 2 – counter movement jump (CMJ), one repetition maximum (1RM), strength and load-power relationship in squat and bench press (10:00–14:00); day 3 – muscle extensibility (16:00–17:30), maximal hand grip and back strength (18:00–19:30); day 4 – resting day; day 5 – simulated wrestling tournament (9:00–19:00). The same warm-up procedures and protocol for each type of test were repeated in subsequent occasions.

Physical characteristics

Anthropometric measurements included: standing height, arm span, body mass and skinfold thickness (triceps brachii, subscapular and abdominal) which were performed in accordance with guidelines from the International Society for the Advancement of Kineanthropometry (ISAK). Height and arm span were measured to the nearest 0.1 cm and body mass to the nearest 0.1 kg using a calibrated scale (Seca 714, Hamburg, Germany); skinfold thickness was assessed using a skinfold caliper (Holtain Ltd., UK, accurate to 0.2 mm). Body density was predicted by the United States National Collegiate Athletic Association (NCAA) method [21] that had been previously cross validated on wrestlers [22] and body fat percentage was calculated by the Brozek et al. [23] formula.

Sprint running test

After a standardized 15-min warm-up period, (low-intensity running, several acceleration runs and stretching exercises), the subjects undertook a sprint running test consisting of two maximal sprints of 10 m, with a 3 minute rest period between each sprint. Subjects were instructed to begin from a stationary start position, with their preferred foot forward on a line marked on the floor. The running speed of the wrestlers was evaluated using dual-beam electronic timing gates (Polifemo, Microgate, Bolzano, Italy). Speed was measured to the nearest 0.01 second. The recorded time used for this test was the better one of the two trials.

Crank-arm Wingate test

All tests were performed on an adjustable SRM Indoortrainer (Schoberer Rad Meßtechnik, Germany, 2% accuracy) which was specifically modified for standing arm cranking. Before each test, the SRM crankset was calibrated according to the manufacturer's recommended procedure. The accuracy, validity and reliability of the SRM power meter were previously established by Gardner et al., [24]. The crank arm trials were 30 s in duration and participants were instructed to crank as powerfully as possible on each revolution throughout the trial and not to adopt any pacing strategy. Power and cranking rate were recorded using 1 s data averages. Peak Power (W_{peak}) was defined as the greatest power value recorded by the SRM power meter and minimum power (W_{min}) was defined as the smallest power value recorded. The average power (W_{mean}) of the 30 s was also established.

Fatigue index was calculated as: $FI=W_{peak}/W_{min}$. Earlobe blood samples were taken and immediately analyzed for the lactate concentration using a portable lactate analyzer (Lactate Pro, Arkray Inc., Kyoto, Japan). This was performed after the 30 s trial until the maximum lactate value (Wingate_$[La\text{-}]_{peak}$) was determined from post-exercise blood samples taken every two minutes.

Jumping test (CMJ)

Participants were instructed to complete a standard countermovement vertical jump (CMJ) in which they squatted down into a self-selected depth prior to explosively performing the concentric action. Participants were instructed to keep their hands on their hips at all times and to maintain the same position at take-off and landing. Flight times were measured using a vertical jump mat (Ergojump, Rome, Italy). The recorded height for this test was the average of three trials. Absolute mechanical power during CMJ was calculated with the following formula: $CMJ_p=BM\cdot g\cdot(2\cdot g\cdot h)^{1/2}$ in which "BM" is body mass in kg, "g" the acceleration of gravity in $m\cdot s^{-2}$, and "h" the jumping height in meters.

1RM strength and load-power relationship

All the subjects performed a full squat strength test using a smith machine as well as a bench press strength test using a free weight barbell for the determination of the 1 repetition maximum (1RM) and the full load-power relationship. A dynamic measurement system (T-Force System, Ergotech, Murcia, Spain, 0.25% accuracy) automatically calculated the relevant kinematic and kinetic parameters of every repetition, provided real time information on screen and stored data on a disk for subsequent analysis. The detailed testing procedures, validity and reliability of this system have recently been reported elsewhere [25]. Each subject was carefully instructed to perform each concentric phase of both the squat and the bench press in an explosive manner. Strong verbal encouragement and velocity feedback in every repetition was provided in order to motivate the participants to give a maximal effort. For the bench press, the initial load was set at 20 kg for all subjects, and was progressively increased in 10 kg increments until the attained mean propulsive velocity (MPV) was lower than 0.4 $m\cdot s^{-1}$. Thereafter, the load was adjusted with smaller increments (5–2.5 kg). The heaviest load that each subject could properly lift to the full extension of his elbows was considered to be his 1RM. For squat, the initial load was set at 50% of their own body mass, and was progressively increased to 75%, 100% and 125% when it was feasible. When MPV was lower than 0.5 $m\cdot s^{-1}$, the load was adjusted with smaller increments (5–2.5 kg). The heaviest load that each subject could properly lift to the full extension of his knees was considered to be his 1RM. For comparisons, the relative strength ratio (1RM value divided by fat free mass) and the maximum muscle power attained during the incremental test in both exercises (i.e., bench press and squat), were calculated.

Muscle extensibility

Passive straight leg rise for dominant (SLR_D) and non dominant (SLR_{ND}) legs and the sit and reach test were used to determine hamstring muscle extensibility. The detailed testing procedures, validity and reliability have recently been established elsewhere [26]. Briefly, for the SLR test, each subject was placed supine on an examination table, and the axis of a universal goniometer was aligned with the axis of the hip joint. The tester placed the stationary arm in line with the trunk and positioned the moveable arm in line with the femur. The subject's leg was lifted passively by the tester into hip flexion until tightness was felt by both the subject and the tester. The criterion score of hamstring extensibility was the maximum angle (degrees) read from the goniometer at the point of maximum hip flexion (1 degree accuracy). Two trials were performed for each leg, and the average of the 2 trials on each leg was used for subsequent analyses. The sit and reach scores were measured with a sit and reach box (Eveque, Sit and Reach bench, Cheshire, England). A centimeter scale was placed on the top surface of the box. A reach distance of 15 cm corresponded to the position of the feet against the box. The final position that the subject reached was the score for each test. The recorded score for this test was the average of two trials. Scores were recorded in centimeters to the nearest 1.0 cm.

Maximal hand grip and back strength tests

Each subject's grip strength was measured for dominant ($Grip_D$) and non-dominant ($Grip_{ND}$) hands with a Baseline Hydraulic Dynamometer (Country Technology Inc; Gays Mills, Wis.) Participants were placed sitting with 0 degrees of shoulder flexion, 90 degrees of elbow flexion and the forearm in neutral. The average result of the two trials was recorded. Maximal back strength (BS) was measured using a back muscle dynamometer (Takei, model T.K.K.5402, Tokyo, Japan). The length of the handle chain was adjusted to fit each subject so that the angle of the subjects' knees was at 45°. The average of the two trials was recorded. The detailed testing procedures have been reported elsewhere [7].

Simulated tournament

According to the FILA official regulations, the three Greco-Roman and the three Freestyle divisions competed respectively during the morning and the afternoon of the fifth

Table 2. Sprint running time, jump height and power, muscle extensibility, hand grip strength and maximal back strength for Greco-roman and Freestyle elite wrestlers in the three weight classes.

	Light weight			Middle weight			Heavy weight		
	LWFS (n=6)	LWGR (n=6)	FS *vs.* GR Dif.%	MWFS (n=6)	MWGR (n=6)	FS *vs.* GR Dif.%	HWFS (n=6)	HWGR (n=6)	FS *vs.* GR Dif.%
CMJ (cm)	35.0±1.6	34.5±5.6	1.4	36.5±2.9	33.6±3.5	7.9	35.2±7.5	35.1±6.4	0.3
CMJ_P (W)	1548±116	1570±209	–1.4	1951±139	1844±150	5.5	2282±188	2258±234	1.0
$Grip_D$ (kg)	43.6±5.5	47.5±4.8	–8.9	55.1±8.5	51.9±11.2	5.8	52.4±9.3	56.4±6.5	–7.6
$Grip_{ND}$ (kg)	44.7±6.3	45.3±8.0	–1.5	50.0±10.0	47.9±11.9	4.2	52.6±8.7	55.7±2.0	–6.0
BS (kg)	120.3±12.2	126.0±16.1	–4.7	133.5±8.8	134.0±9.5	–0.4	141.5±10.3	138.0±9.5	2.5
BS/FFM	2.23±0.20	2.28±0.21	–2.5	2.02±0.13	2.05±0.11	–1.8	1.86±0.12	1.81±0.14	2.6
Time in 10 m (s)	1.79±0.05	1.79±0.05	–0.2	1.76±0.06	1.77±0.04	–0.3	1.79±0.12	1.74±0.07	3.2
Sit and Reach (cm)	24.1±7.4	21.1±10.3	12.8	20.3±5.7	18.1±10.7	11.0	22.4±10.7	18.3±9.8	18.2
SLR_D (degrees)	97.7±14.1	78.5±16.8*	19.6	83.2±16.1	83.8±14.9	–0.8	94.5±11.1	84.3±11.9	10.8
SLR_{ND} (degrees)	97.2±11.9	80.5±14.5	17.2	86.7±20.0	90.0±9.9	–3.8	94.0±10.6	93.3±12.9	0.7

Data is expressed as mean ±SD. * Significantly different ($P \leq 0.05$) when comparing to their respective Freestyle group. CMJ – Counter movement jump height; CMJ_P – Counter movement jump power; BS – Back strength; BS/FFM – Back strength relative to kilogram of fat free mass; SLR_D and SLR_{ND} – Straight leg rise for dominant and non dominant leg; $Grip_D$ and $Grip_{ND}$ – Grip strength for dominant and non dominant hand.

day of assessments. The results of this simulated tournament were used by the selectors of the five different countries to choose their own national team members for an incoming international tournament. Each match consisted of three periods of 2 minutes with a 30 second break, which was formally refereed and scored. Depending on the number of victories and defeats, each wrestler competed in 1–5 combats during the tournament. Immediately after the conclusion of each match, capillary blood samples were taken from each wrestler´s earlobe during a passive recovery at minutes 1, 3, 5, 7 and 10, until the maximum value was detected (Lactate Pro, Arkray Inc., Kyoto, Japan). The recovery periods between combats were not less than 15 minutes. The combat peak lactate concentration (Combat_$[La\text{-}]_{peak}$) was defined as the highest peak blood lactate attained for each wrestler during the whole tournament.

Statistical procedures

Standard statistical methods were used for the calculation of the mean and standard deviations (SD). One-way analysis of variance (ANOVA) was used to examine the mean differences in all the variables analyzed between Greco-Roman (LW_{GR}, MW_{GR} and HW_{GR}) and Freestyle (LW_{FS}, MW_{FS} and HW_{FS}) wrestlers in each weight class. Also independent t-tests were used to examine the differences in the six studied groups between the peak blood lactate attained following the Wingate test (Wingate_$[La\text{-}]_{peak}$) and the combat peak lactate concentration (Combat_$[La\text{-}]_{peak}$). The $p \leq 0.05$ criterion was used for establishing the statistical significance.

Results

Physical characteristics and training experience

The physical characteristics and training experience of the wrestlers are presented in Table 1. No differences were observed in any of the anthropometrical and physical characteristics between the Freestyle and Greco-Roman groups, except the height and the BMI in the Light Weight class, where the LW_{GR} showed significantly higher values when compared to LW_{FS} ($p \leq 0.05$).

Wingate, Sprint running and Jumping tests

No differences were observed in the 10 m sprint running time between the Freestyle and Greco-Roman groups at any weight class (Table 2).

No differences were observed in the crank-arm Wingate mean or peak power between Greco-Roman and Freestyle subjects. When mean and peak power values were normalized to kilogram of fat free mass, no significant differences were detected between subjects of both styles (i.e., Greco-Roman *vs.* Freestyle). Furthermore, no differences were detected in the Wingate fatigue index or peak blood lactate (Wingate_$[La\text{-}]_{peak}$) between Greco-Roman and Freestyle wrestlers of any weight class (Table 3).

No differences were observed in the jumping height (CMJ) or jumping power (CMJ_P) between Freestyle and Greco-Roman competitors of any weight class (Table 2).

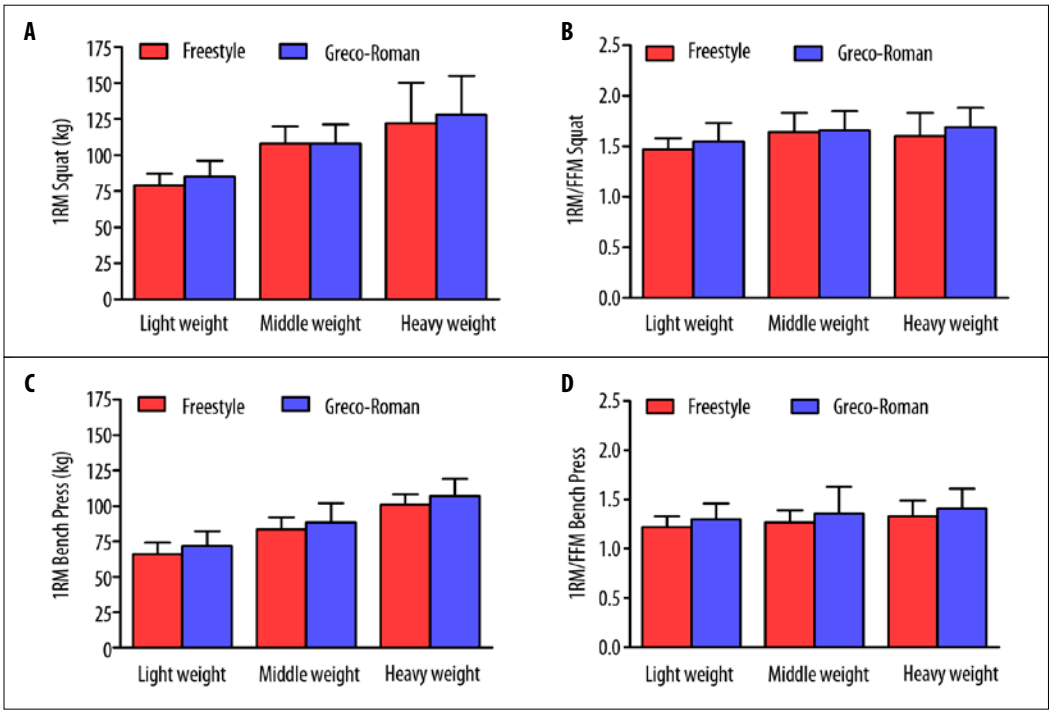

Figure 1. One repetition maximum (**A** and **C**) and one repetition maximum normalized to fat free mass (**B** and **D**) in the squat and bench press exercises according to the wrestling style (Freestyle *vs.* Greco-Roman) and the weight class (Light Weight, Middle Weight and Heavy Weight). Data presented as mean ±SD. Significant differences * when compared to freestyle wrestlers. ($p \leq 0.05$).

1RM strength and load-power relationship

No differences were detected in absolute and fat free mass normalized 1RM strength values for squat and bench press exercises between Greco-Roman and Freestyle wrestlers (Figure 1). Furthermore, no significant differences were observed in the maximum muscle power output attained during the incremental test in squat and bench press exercises between both wrestling styles (Freestyle *vs.* Greco-Roman).

Maximal hand grip and back strength tests

The isometric maximal hand grip and back strength tests results are presented in Table 2. No differences were detected in the Grip strength for the dominant ($Grip_D$) and non-dominant ($Grip_{ND}$) hand between Greco-Roman and Freestyle competitors of any weight class. Similarly, no differences were detected in the back strength in absolute and normalized to fat free mass values between both wrestling styles.

Muscle extensibility

The straight leg rise for dominant (SLR_D) and non dominant (SLR_{ND}) as well as the sit and reach test results are presented in Table 2. No differences were observed in any of three extensibility tests between the Freestyle and Greco-Roman wrestlers of any weight class, except the SLR_D between LW_{FS} and LW_{GR} competitors, where significant differences ($p \leq 0.05$) were detected (Table 2).

Simulated tournament

No significant differences were detected in the Combat_$[La^-]_{peak}$ values attained during the simulated tournament between Freestyle and Greco-Roman wrestlers in their respective weight class (Table 3). When the Wingate_$[La^-]_{peak}$ and the Combat_$[La^-]_{peak}$ values of each group were compared, significant higher peak lactic acid concentration values ($p \leq 0.05$) were detected following the official wrestling bouts (Table 3).

Discussion

To our knowledge, this is the first reported case that simultaneously analyses and compares current anthropometric, physiological, neuromuscular, and speed and muscle extensibility characteristics for elite wrestlers of different weight classes in the two Olympic wrestling styles (i.e., Greco-Roman and Freestyle). Also, the current study compared the metabolic response of highly trained wrestlers during an official tournament and following a crank-arm Wingate test. In doing so we established the validity of a single 30 s crank-arm Wingate test to examine the anaerobic performance profiles of wrestlers. The primary findings of this investigation indicate that, independent of the weight class, elite level

Table 3. Mean power relative to fat free mass, peak power, fatigue index, peak blood lactate attained during the 30 second crank-arm Wingate test and peak blood lactate attained during the simulated tournament for Freestyle and Greco-roman elite wrestlers in the three weight classes.

	Light weight			Middle weight			Heavy weight		
	LWFS (n=6)	LWGR (n=6)	FS *vs.* GR Dif.%	MWFS (n=6)	MWGR (n=6)	FS *vs.* GR Dif.%	HWFS (n=6)	HWGR (n=6)	FS *vs.* GR Dif.%
Mean Power(W)	429±38	414±35	3.6	518±67	5088±98	1.7	569±106	587±102	–3.1
Mean Power/FFM (W/kg)	7.95±1.08	7.50±1.07	5.7	7.84±0.73	7.80±1.21	0.5	7.48±1.20	7.70±1.11	–2.9
Peak Power (W)	628±108	668±72	–6.3	793±146	759±178	4.2	873±166	890±131	–1.9
Peak Power/FFM (W/kg)	11.6±1.6	12.1±1.7	–4.1	12.0±1.7	11.6±2.2	3.0	11.5±2.0	11.7±1.6	–1.8
Fatigue Index	2.22±0.32	2.31±0.44	–3.9	2.38±0.28	2.16±0.39	9.2	2.16±0.32	1.92±2.42	11.1
Wingate_[La-]peak	9.3±1.2	9.6±2.2	–3.2	10.5±2.2	11.5±1.9	–9.5	10.9±1.4	11.8±1.6	–8.3
Combat_[La-]peak	12.8±2.0**	12.1±0.8**	5.5	14.8±2.1**	14.3±1.1**	3.4	13.9±1.4**	14.4±2.0**	–3.6

Data is expressed as mean ±SD. * Significantly different (P≤0.05) when comparing to their respective Freestyle group. ** Significantly different (P≤0.05) when comparing to their respective Wingate peak blood lactate levels. Mean Power/FFM – mean power relative to fat free mass attained during the Wingate test; Wingate_[La-]$_{peak}$ – Wingate peak blood lactate; Combat_[La-]$_{peak}$ – Combat peak blood lactate.

Greco-Roman (LW_{GR}, MW_{GR}, HW_{GR}) and Freestyle (LW_{FS}, MW_{FS}, HW_{FS}) wrestlers present similar training background, body composition, anthropometrical, physiological and neuromuscular levels. Furthermore, the six studied groups attained significant higher peak blood lactate levels during the simulated tournament when compared to their own 30 s crank-arm Wingate test values.

Although several previous researchers have found some anthropometrical, neuromuscular, physiological and psychological differences between successful and less successful wrestlers [4,9,10,16,17,27,28], currently there is a paucity of scientific data regarding the anthropometric or physical fitness differences among elite wrestlers of the two Olympic styles (i.e., Greco-Roman and Freestyle). Among these limited studies, Horswill et al., [5] found no significant differences in the lower and upper limb mean and peak power attained during a 30 s Wingate test between wrestlers of both styles. Furthermore, this study also found no significant differences in the peak oxygen uptake attained during an upper and lower body incremental exercise test between both wrestling styles. The present results also confirm these findings due to wrestlers of both styles (i.e., Freestyle *vs.* Greco-Roman) in the same weight class (i.e., light, middle or heavy weight) showing no significant differences in the crank-arm Wingate test in absolute or in normalized to fat free mass values.

Nevertheless, some previous studies conducted in the 70's and 80's, under considerably different official wrestling rules (i.e., mainly related to the periods and match duration [2]), found slight but not significant peak oxygen uptake differences between wrestlers of both styles following some incremental exercise tests [3,29]. The VO_{2max} values that have been detected in highly trained wrestlers were similar to those of athletes who were specialists of other short duration events or even just the physically active population, but not comparable to the values of highly trained endurance athletes [6].

None of the neuromuscular markers assessed in the current study (i.e., maximal dynamic and isometric strength as well as muscle power output for upper and lower body extremity actions) showed significant differences between elite wrestlers of both styles. The only previous research that to our knowledge was able to evaluate and compare any neuromuscular marker between the two main wrestling styles found that isometric cervical flexion and extension strength of the Greco-Roman competitors were slightly higher than those reported in the Freestyle wrestlers, although these differences didn´t become significant [13]. Wrestling neuromuscular performance has been previously examined during isokinetic [3,7,11,30], isometric strength testing [3,7,27,31] and even with highly specific exercises like the isometric "bear hug" designed to simulate many upper body holds used by wrestlers [7,20]. Unfortunately, a small number of researchers have examined dynamic muscle strength and muscle power profiles in exercises closely related to specific skills in wrestling, as has been performed in current research [9,10,15].

In addition, height, BMI and the straight leg rise for the dominant leg between LW_{FS} and LW_{GR} groups were the *only* anthropometrical or physical fitness *differences detected in the present study*, although no other distinctions were found in the heavier weight classes. These

results also agree with previous research that compared some somatotype and anthropometrical parameters between wrestlers of both styles [23].

Although running sprint and muscle extensibility tests have been traditionally used in wrestling performance assessment [3,9,11,15,27], no significant differences were detected in these two fitness markers between elite competitors of both wrestling styles. In order to clarify this issue, it would be helpful to assess muscle extensibility in other muscle groups related to wrestling performance such as psoas, latisimus dorsi and pectoralis or neck and core muscles. Similarly, it may also be advantageous to assess other speed components for wrestlers, such as reaction time, which seems to be related to wrestling performance [6,7].

Taken together these results seem to indicate that the aforementioned differences between the official rules of both styles, mainly related to the lower body actions allowed in Freestyle and the 30 s ground wrestling in Greco-Roman, do not promote any anthropometrical, physiological or neuromuscular differences among elite wrestlers of both styles. These findings may serve as a huge help to the coaches of each respective team, helping them to avoid any unnecessary early specializations, allowing the youngest wrestlers to become familiar with the techniques and tactics of both styles during a longer period of their sporting career.

The capillary peak blood lactate values described in the current study, after the simulated tournament matches (12.1–14.8 mmol·l^{-1}), were similar to those reported by others researchers following official wrestling bouts (i.e., 12.5–15.7 mmol·l^{-1}) [18,19], although slightly lower than those reported by Kraemer et al. [7] and Barbas et al. [20] in blood samples collected via venipuncture with highly trained Freestyle and Greco-Roman wrestlers respectively (i.e., 15.8–20.0 mmol·l^{-1}). Nevertheless, one of the major findings in the present study was the significant differences detected in the peak blood lactate concentration attained during the wrestling tournament bouts compared to a single 30 second crank-arm Wingate test values. The six studied groups showed between 18–29% higher capillary peak blood lactate levels during the passive recovery following wrestling bouts when compared to their own crank-arm Wingate test values. Although previous studies have shown the relationship between a single 30 s crank-arm Wingate peak blood lactate with success in wrestling [9,16,17], to our knowledge this is the first reported case that simultaneously analyzes and compares the metabolic response to the official wrestling combat and the crank arm 30 s Wingate test, which is one of the most widely used assessments to establish the wrestlers anaerobic performance [4,5,8,9,16,17]. These differences in blood lactate levels may be related to the lower muscle mass involved in the crank-arm ergometry test compared to the great amount of muscle mass (i.e., upper and lower limbs) used in the complex technical actions performed during an official wrestling bout. It is also likely that in such conditions, a single 30 s test doesn't seem to be long enough to achieve the anaerobic metabolic demands that occur during an official combat bout. Therefore, as has been suggested previously, the administration of multiple 30 s crank-arm tests may be helpful to effectively simulate a competitive wrestling match [33].

Conclusions

The obtained research results make it possible to draw the following conclusions:

- The current official competition rule differences between both Olympic wrestling styles, mainly related to the lower body actions allowed in Freestyle and the 30 seconds ground wrestling in Greco-Roman, do not promote any anthropometrical (i.e., height or arm span), body composition (i.e., body mass, lean mass or body fat), physiological (i.e., anaerobic power or capacity) or neuromuscular (i.e., dynamic and isometric muscle strength or muscle power) difference among elite wrestlers of both Olympic styles.

- A single 30 second crank-arm Wingate test doesn't seem to be a valid assessment to simulate the metabolism involved in wrestling, but it may still be a reasonable indicator of wrestling performance.

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