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Laboratory Assessment of Aerobic and Anaerobic Performance in Elite Greco-Roman Wrestlers: A Case Series Using the Wingate Anaerobic Test and Graded Exercise Testing

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Abstract

Purpose: Greco-Roman wrestling demands a complex interplay of aerobic and anaerobic energy systems. The purpose of this study was to conduct a comprehensive laboratory assessment of both aerobic and anaerobic performance capacities in elite Greco-Roman wrestlers using standardized ergometric protocols. **Methods:** Three elite male Greco-Roman wrestlers (heavyweight division, body mass 99-100 kg) competing at the national and international level underwent physiological testing at a national sports science laboratory. Aerobic capacity was assessed via a graded exercise test (GXT) on a treadmill ergometer with continuous breath-by-breath gas exchange analysis and post-exercise blood lactate measurement. Anaerobic performance was evaluated using a 30-second Wingate anaerobic test (WAnT) on a mechanically braked cycle ergometer. **Results:** Maximal oxygen uptake (VO2max) ranged from 46 to 63 ml/min/kg. Notably, Athlete A exhibited a VO2max of 63 ml/min/kg, a value more characteristic of endurance-trained athletes than heavyweight combat sport competitors. His anaerobic threshold (AnT), identified via the onset of blood lactate accumulation (OBLA) method, occurred at 73% of VO2max (4.6 L/min). Peak anaerobic power (MAP) during the WAnT ranged from 1333 to 1652 W (13.46-16.52 W/kg), while mean anaerobic power ranged from 748 to 822 W (7.48-8.22 W/kg). Post-exercise peak blood lactate concentrations were 11.48-12.83 mmol/L. **Conclusion:** The findings demonstrate considerable inter-individual variability in both aerobic and anaerobic capacities among elite heavyweight Greco-Roman wrestlers. The exceptionally high VO2max observed in Athlete A underscores that elite wrestling performance may be supported by aerobic capacities well above previously reported norms for this weight class. The relatively low AnT as a percentage of VO2max suggests that targeted training to elevate the lactate threshold could yield further performance improvements. Training zone recommendations based on individualized physiological profiling are presented.

1. Introduction

Greco-Roman wrestling is one of the oldest competitive combat sports and has been a staple of the modern Olympic program since the inaugural Games of 1896. The sport imposes extraordinary physiological demands on athletes, requiring repeated high-intensity efforts interspersed with brief recovery periods across two three-minute periods of competition (Chaabene et al., 2017). Unlike freestyle wrestling, Greco-Roman rules prohibit holds below the waist, placing a premium on upper-body strength, explosive power, and the capacity to sustain high-intensity grappling exchanges using the torso and arms (Horswill, 1992).

From a bioenergetic perspective, wrestling is classified as a high-intensity intermittent sport that relies heavily on both anaerobic and aerobic metabolic pathways (Callan et al., 2000). During a competitive bout, the phosphocreatine (PCr) and glycolytic systems provide the immediate energy for explosive throws, lifts, and defensive maneuvers, while the aerobic system supports recovery between high-intensity bursts and sustains submaximal efforts during positional fighting (Hubner-Wozniak et al., 2004). The relative contribution of each energy system varies with match duration, competitive strategy, and the fitness profile of the individual athlete (Yoon, 2002).

Maximal oxygen uptake (VO2max) is widely regarded as the gold-standard measure of cardiorespiratory fitness and aerobic power. In wrestling populations, VO2max values have been reported across a broad range, typically between 40 and 60 ml/min/kg, with lighter weight classes generally exhibiting higher relative values than heavier wrestlers (Horswill et al., 1992; Yoon, 2002). However, the importance of aerobic fitness for wrestlers extends beyond the direct oxidative contribution to match energy expenditure: a well-developed aerobic system facilitates faster recovery of PCr stores between bouts and between high-intensity exchanges within a match, enhances lactate clearance capacity, and supports the grueling training volumes required at the elite level (Chaabene et al., 2017; Hubner-Wozniak et al., 2006).

The anaerobic threshold (AnT), defined as the exercise intensity at which blood lactate begins to accumulate exponentially above resting levels, represents a critical marker of endurance performance and fatigue resistance (Weltman, 1995). When expressed as a percentage of VO2max, the AnT provides insight into the athlete's capacity to sustain high-intensity work without excessive metabolic acidosis. In well-trained endurance athletes, the AnT typically occurs at 80-90% of VO2max, whereas in power-oriented or insufficiently endurance-trained athletes, it may occur at 50-70% (Bassett & Howley, 2000). For wrestlers, elevating the AnT relative to VO2max has direct practical implications: it allows the athlete to maintain a higher work rate during a match before the onset of debilitating fatigue (Barbas et al., 2011).

Anaerobic performance in wrestlers is commonly evaluated using the 30-second Wingate anaerobic test (WAnT), which provides measures of peak anaerobic power (PP), mean anaerobic power (MP), and the fatigue index (FI) (Bar-Or, 1987). The WAnT has been validated extensively in combat sport populations and remains the most widely used laboratory test of short-duration maximal anaerobic capacity (Franchini et al., 2011). Elite wrestlers typically demonstrate high absolute and relative peak and mean power values, reflecting the sport's demand for explosive force production and the ability to sustain near-maximal effort across the duration of a competitive exchange (Hubner-Wozniak et al., 2004).

Despite the established importance of both energy systems in wrestling performance, comprehensive laboratory assessments combining aerobic and anaerobic testing in the same cohort of elite Greco-Roman wrestlers remain relatively sparse in the published literature. Much of the existing research has focused on freestyle wrestlers, younger or sub-elite athletes, or has examined aerobic and anaerobic capacities in isolation rather than as complementary facets of a wrestler's physiological profile (Chaabene et al., 2017). Furthermore, heavyweight wrestlers (>96 kg) are particularly underrepresented in the physiological literature, as most studies have emphasized lighter weight classes where relative physiological values tend to be higher (Yoon, 2002).

The purpose of this investigation was to conduct a detailed laboratory assessment of aerobic and anaerobic performance in three elite heavyweight Greco-Roman wrestlers using a graded exercise test (GXT) with continuous gas exchange analysis on a treadmill ergometer and a 30-second Wingate anaerobic test on a cycle ergometer. A secondary objective was to derive individualized training zone recommendations based on the physiological data obtained, with particular attention to the relationship between the anaerobic threshold and VO2max as a guide for targeted endurance training interventions.

2. Methods

2.1 Participants

Three elite male Greco-Roman wrestlers in the heavyweight division (body mass: 99-100 kg; height: 179-203 cm) volunteered for physiological testing. All athletes were competing at the national and international level at the time of assessment. Testing was conducted at a national sports science laboratory during the preparatory phase of the annual training cycle. Testing dates were November 2006 (Athletes B and C) and November 2007 (Athlete A). The athletes were instructed to refrain from strenuous exercise for at least 24 hours prior to testing, to arrive in a rested and hydrated state, and to avoid caffeine and alcohol consumption on the day of testing. All participants provided informed consent prior to the assessments.

2.2 Graded Exercise Test (GXT)

Aerobic capacity was assessed using a continuous, incremental graded exercise test on a motorized treadmill ergometer. The protocol began at a low running speed with a fixed gradient and progressed with systematic speed increments at regular intervals until volitional exhaustion. The test was terminated when the athlete could no longer maintain the required pace despite strong verbal encouragement.

Pulmonary gas exchange was measured continuously on a breath-by-breath basis using an automated open-circuit metabolic analysis system. The system was calibrated prior to each test using known gas concentrations and a precision-volume syringe. The following variables were recorded and averaged over 30-second intervals: oxygen uptake (VO2, ml/min), carbon dioxide production (VCO2, ml/min), minute ventilation (VE, L/min), respiratory exchange ratio (RER = VCO2/VO2), ventilatory equivalents for oxygen (EqO2 = VE/VO2) and carbon dioxide (EqCO2 = VE/VCO2), and the fraction of expired oxygen (FEO2).

VO2max was accepted as the highest 30-second averaged VO2 value achieved during the test, provided at least two of the following criteria were met: (a) a plateau in VO2 despite increasing workload (<150 ml/min increase), (b) RER >1.10, (c) achievement of age-predicted maximal heart rate (220 minus age, plus or minus 10 bpm), and (d) post-exercise blood lactate concentration >8 mmol/L (Howley et al., 1995).

2.3 Anaerobic Threshold Determination

The anaerobic threshold was determined using the onset of blood lactate accumulation (OBLA) method, defined as the exercise intensity corresponding to a blood lactate concentration of 4.0 mmol/L (Heck et al., 1985). Capillary blood samples were collected from the earlobe at rest, at predetermined intervals during the GXT, and at 1, 3, and 5 minutes post-exercise. Blood lactate concentrations were analyzed enzymatically using a portable lactate analyzer. Peak post-exercise blood lactate was recorded as the highest value obtained in the post-exercise sampling period.

2.4 Wingate Anaerobic Test (WAnT)

Anaerobic performance was assessed using the 30-second Wingate anaerobic test on a mechanically braked cycle ergometer (Bar-Or, 1987). The braking resistance was set at 0.075 kp per kilogram of body mass, in accordance with standard recommendations for adult athletes (Inbar et al., 1996). Each athlete performed a standardized 5-minute warm-up at a selfselected moderate cadence with two brief (5-second) maximal sprints. Following a 3-minute rest period, the athlete was instructed to pedal at maximum effort for 30 seconds against the applied resistance. Strong verbal encouragement was provided throughout the test.

The following variables were derived: peak anaerobic power (PP, expressed as the highest power output achieved during any 5-second epoch), mean anaerobic power (MP, the average power output over the full 30 seconds), and minimum power (MinP, the lowest 5-second power output). All values were expressed in both absolute terms (watts) and relative to body mass (W/kg). The fatigue index was calculated as ((PP minus MinP) divided by PP) multiplied by 100 (%).

2.5 Statistical Analysis

Given the small sample size (n = 3), data are presented as individual values and descriptive statistics. No inferential statistical analyses were performed. Inter-individual comparisons are discussed in narrative form with reference to published normative data and values reported in the wrestling physiology literature.

3. Results

3.1 Graded Exercise Test and Aerobic Capacity

The individual results of the GXT are presented in Table 1. Test durations ranged from 13:00 to 16:30 minutes. Athlete A achieved the highest VO2max at 63 ml/min/kg (6,166 ml/min absolute), while Athletes B and C achieved values of 50 and 46 ml/min/kg, respectively. Maximal minute ventilation (VEmax) ranged from 156 to 204 L/min. Peak post-exercise blood lactate concentrations were 12.83, 12.80, and 11.48 mmol/L for Athletes A, B, and C, respectively.

Table 1. Results of the graded exercise test (GXT) and Wingate anaerobic test (WAnT) for three elite Greco-Roman wrestlers.

Parameter	Athlete A	Athlete B	Athlete C
Date tested	12.11.2007	20.11.2006	20.11.2006
Body mass (kg)	100	100	99
Height (cm)	203	179	184
GXT duration (min:sec)	16:30	13:06	13:00
VO2max (ml/min/kg)	63	50	46
VEmax (L/min)	204	156	163
VO2 at AnT (L/min)	4.6	NR	NR
AnT (% of VO2max)	~73	-	-
Peak power / MAP (W)	1,652	1,387	1,333
MAP (W/kg)	16.52	13.87	13.46
Mean power (W)	822	748	792
Mean power (W/kg)	8.22	7.48	8.00
Minimum power (W)	391	529	459
Minimum power (W/kg)	3.91	5.29	4.63
Peak blood lactate (mmol/L)	12.83	12.80	11.48

NR = not recorded.

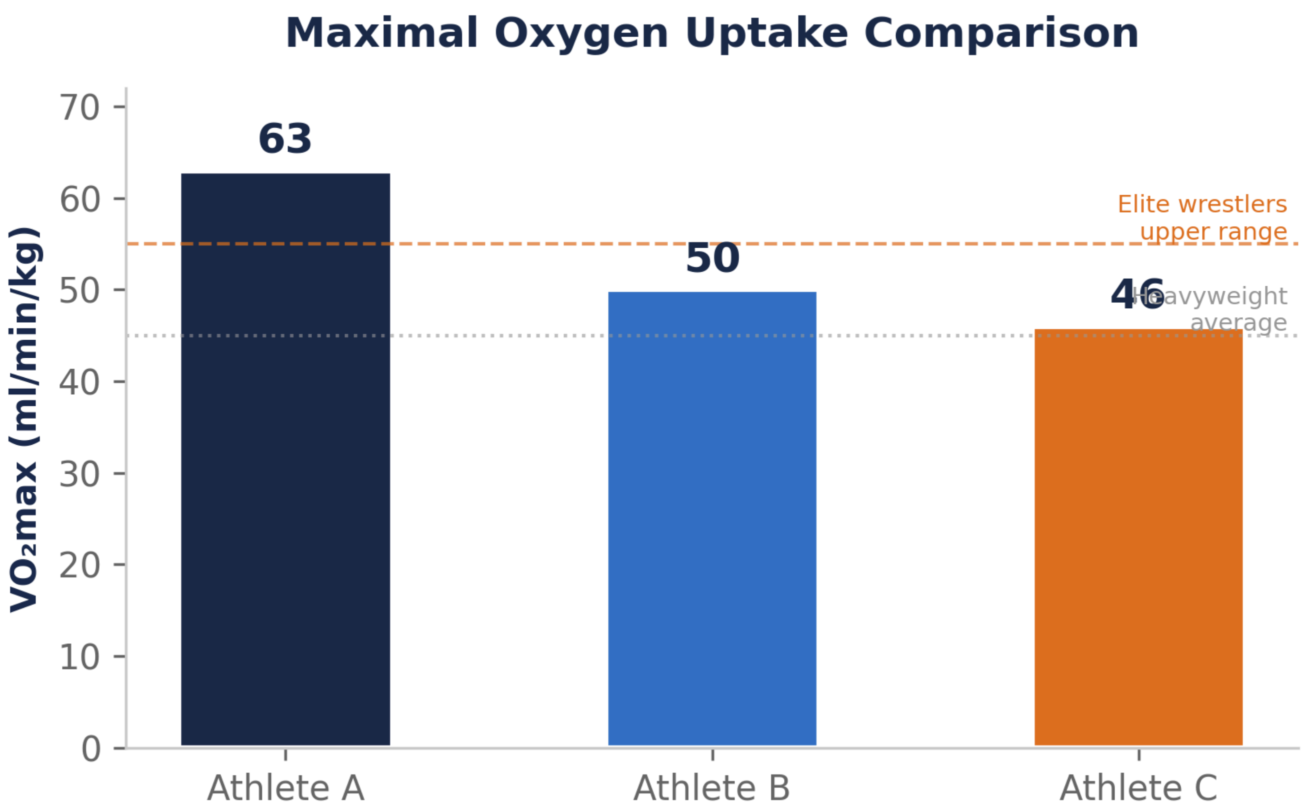

Figure 1. Maximal Oxygen Uptake Comparison

3.2 Gas Exchange Kinetics: Athlete A

Detailed breath-by-breath gas exchange data for Athlete A during the GXT are presented in Table 2. Oxygen uptake increased progressively from 925 ml/min at 0:15 to a peak of 6,181 ml/min at 15:00, with a slight decrease to 6,166 ml/min at exhaustion (16:30). Minute ventilation increased from 32 L/min at the onset of exercise to 229 L/min at exhaustion. The respiratory exchange ratio remained below 1.00 through the first 9 minutes of the test, crossed unity between 9:00 and 11:00, and reached a peak of 1.15 at exhaustion, confirming maximal effort.

The anaerobic threshold was identified at approximately 9:00 minutes into the test, corresponding to a VO2 of 4,583 ml/min (45.83 ml/min/kg), which represents approximately 73% of the measured VO2max.

Table 2. Breath-by-breath gas exchange data for Athlete A during the graded exercise test (selected 30-second averages).

Time (min:sec)	VO2 (ml/min)	VE (L/min)	RER	VO2rel (ml/min/kg)
0:15	925	32	0.99	9.25
1:00	1,554	41	0.86	15.54
3:00	3,261	80	0.88	32.61
5:00	3,848	102	0.93	38.48
7:00	4,220	110	0.90	42.20
9:00 (AnT)	4,583	117	0.93	45.83
11:00	5,326	152	1.00	53.26
13:00	5,574	168	1.02	55.74
15:00	6,181	192	1.05	61.81
16:30	6,166	229	1.15	61.66

AnT = anaerobic threshold, identified at approximately 9:00 min via the OBLA method.

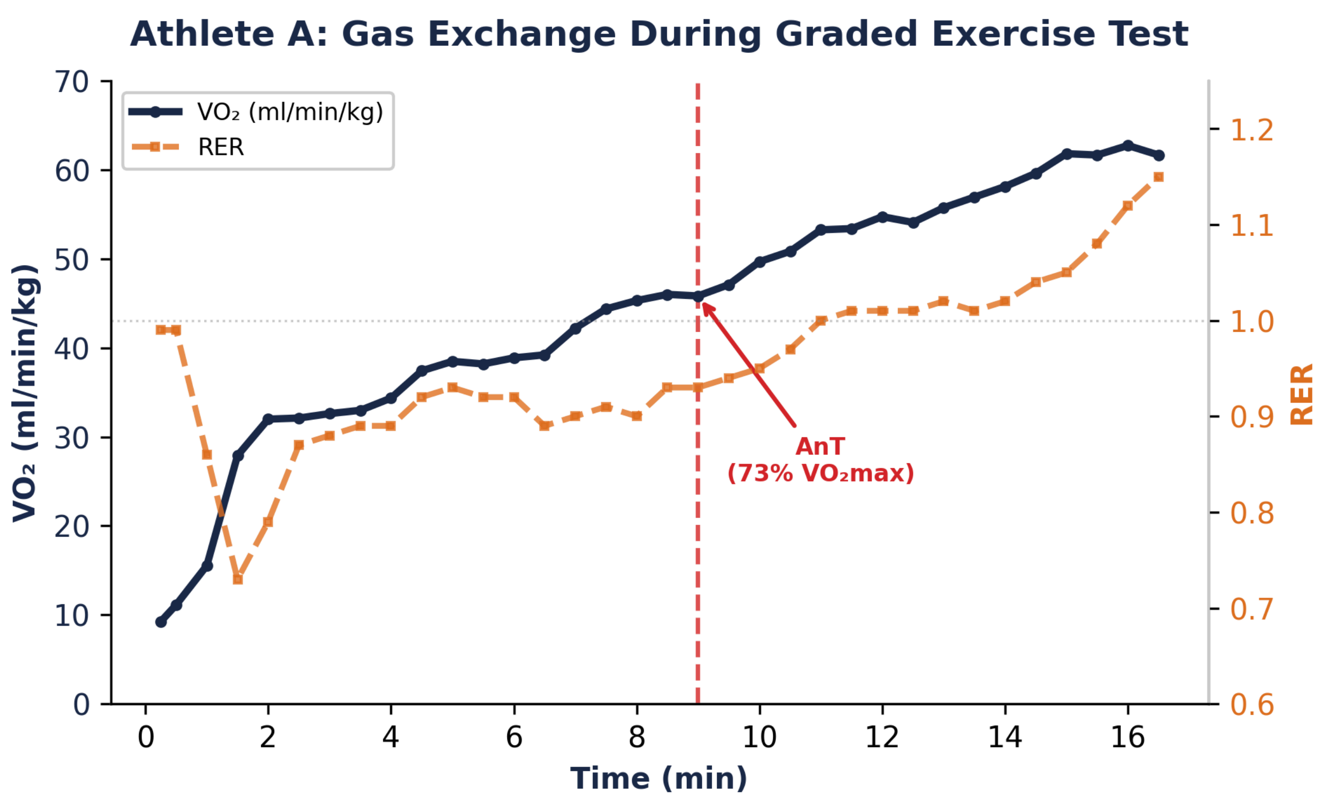

Figure 2. Gas Exchange During Graded Exercise Test (Athlete A)

3.3 Wingate Anaerobic Test

Anaerobic performance data from the 30-second WAnT are included in Table 1. Athlete A produced the highest peak anaerobic power at 1,652 W (16.52 W/kg), followed by Athlete B at 1,387 W (13.87 W/kg) and Athlete C at 1,333 W (13.46 W/kg). Mean power values were more closely clustered, ranging from 748 W (7.48 W/kg) in Athlete B to 822 W (8.22 W/kg) in Athlete A. Athlete A exhibited the lowest minimum power (391 W, 3.91 W/kg) and consequently the highest fatigue index, calculated at approximately 76.3%. Athletes B and C demonstrated fatigue indices of approximately 61.9% and 65.6%, respectively.

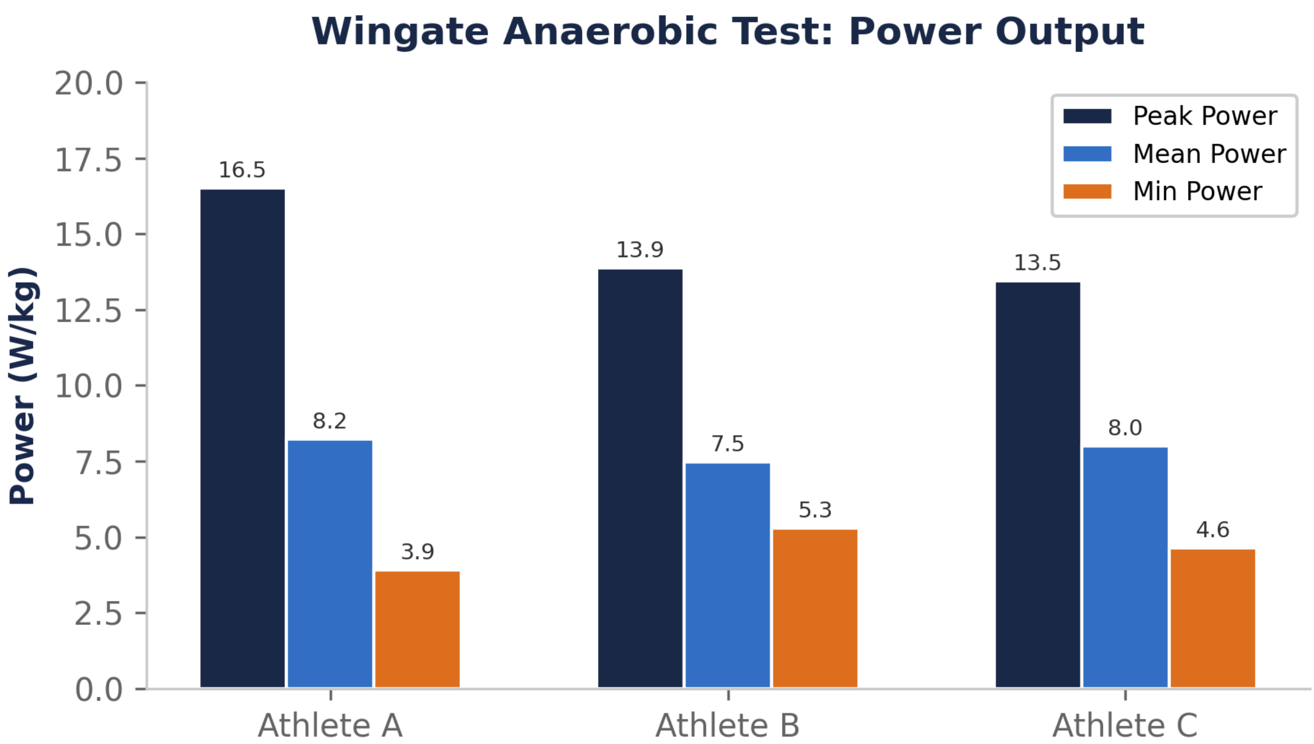

Figure 3. Wingate Anaerobic Test: Power Output

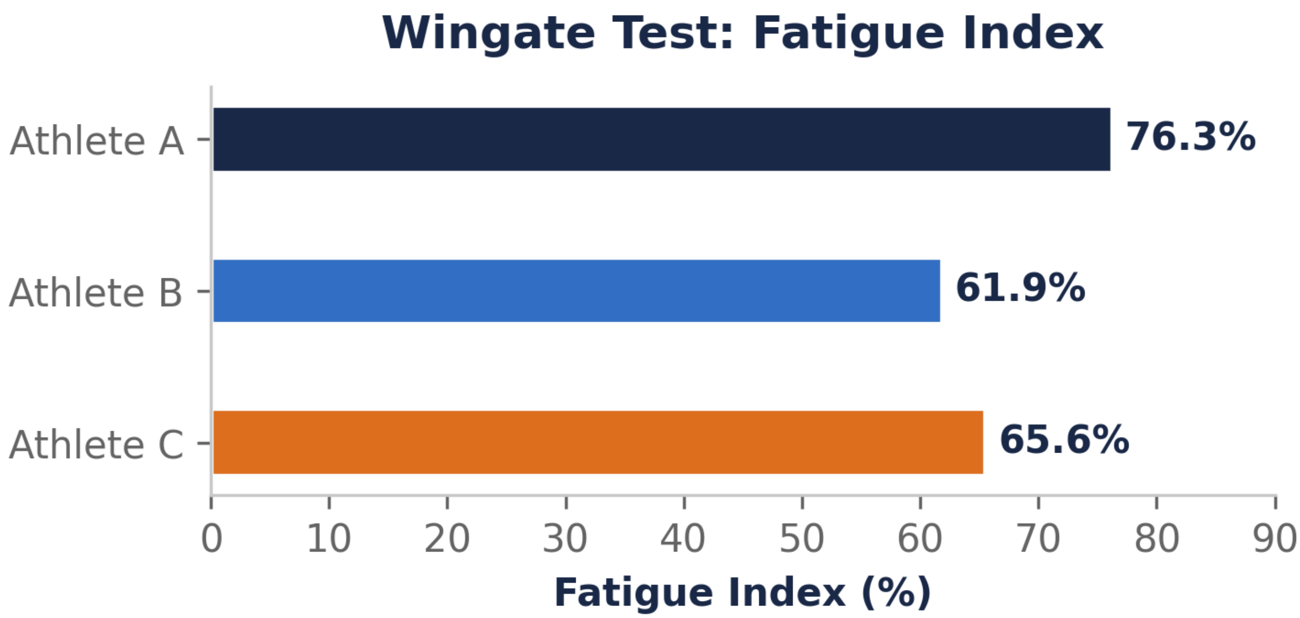

Figure 4. Wingate Test: Fatigue Index

4. Discussion

4.1 Aerobic Capacity

The principal finding of this investigation is the remarkably high VO2max of 63 ml/min/kg exhibited by Athlete A, a 100-kg heavyweight Greco-Roman wrestler. This value substantially exceeds published norms for wrestlers in this weight class. Horswill (1992) reported that elite wrestlers typically demonstrate VO2max values between 45 and 60 ml/min/kg, with the higher end of this range usually observed in lighter weight categories. Yoon (2002), in a comprehensive review of physiological profiles in wrestling, noted that heavyweight wrestlers commonly present VO2max values between 40 and 50 ml/min/kg. More recently, Chaabene et al. (2017), in a systematic review of physiological responses to combat sports, reported mean VO2max values for senior wrestlers ranging from 42 to 55 ml/min/kg, with heavier athletes consistently at the lower end of the distribution.

The VO2max of 63 ml/min/kg observed in Athlete A places his aerobic capacity in a range more commonly associated with well-trained endurance athletes, such as competitive cyclists or middle-distance runners (Joyner & Coyle, 2008). For a 100-kg athlete, this represents an absolute VO2max of approximately 6.3 L/min, which is an extraordinarily high oxygen transport and utilization capacity. This finding suggests that Athlete A possesses an unusually well-developed cardiovascular system for a heavyweight combat sport athlete, likely reflecting a combination of genetic predisposition and sustained high-volume endurance-oriented training.

Athletes B and C presented VO2max values of 50 and 46 ml/min/kg, respectively, which fall within the expected range for elite heavyweight wrestlers as reported in the literature (Horswill, 1992; Yoon, 2002; Chaabene et al., 2017). The 17-unit spread in VO2max across the three athletes (46-63 ml/min/kg) highlights the substantial inter-individual variability in aerobic fitness that can exist even among elite competitors in the same weight class, and underscores the importance of individualized physiological profiling for training prescription.

4.2 Anaerobic Threshold

The anaerobic threshold for Athlete A was identified at approximately 73% of VO2max via the OBLA method. While this represents a substantial absolute oxygen uptake at threshold (4.6 L/min), the relative position of the AnT is somewhat lower than the 80-95% of VO2max typically observed in highly trained endurance athletes (Bassett & Howley, 2000). In the context of wrestling, where training traditionally emphasizes high-intensity interval work, strength development, and technical practice rather than prolonged steady-state endurance training, an AnT at 73% of VO2max is not unusual (Barbas et al., 2011).

However, given Athlete A's exceptionally high VO2max ceiling, raising the AnT from 73% to 80-85% of VO2max would yield significant practical benefits. Such an improvement would mean that the athlete could sustain a higher absolute work rate during prolonged grappling exchanges before the onset of metabolic acidosis and associated fatigue. Concretely, shifting the AnT from 4.6 L/min (73% of 6.3 L/min) to approximately 5.0-5.4 L/min (80-85% of VO2max) would represent a substantial elevation in the sustainable intensity ceiling. This adaptation would be expected to improve recovery between high-intensity exchanges within a match, enhance the capacity to maintain technical proficiency under fatigue, and reduce the accumulation of performance-degrading metabolic by-products (Weltman, 1995; Kindermann et al., 1979).

Unfortunately, AnT data were not recorded for Athletes B and C, which limits the ability to make inter-individual comparisons on this parameter. Future assessments should prioritize the collection of threshold data for all athletes, as the AnT provides arguably the most actionable information for endurance training prescription among the variables measured in a GXT (Faude et al., 2009).

4.3 Anaerobic Performance

The peak anaerobic power values observed in this cohort (1,333-1,652 W; 13.46-16.52 W/kg) are among the highest reported for combat sport athletes. Hubner-Wozniak et al. (2004), in a study of Polish wrestlers, reported mean peak power values of approximately 10-12 W/kg for elite wrestlers across multiple weight classes. Franchini et al. (2011) reported peak power values of approximately 9-11 W/kg in elite judokas, a related combat sport with similar physiological demands. The values observed in the present cohort, particularly Athlete A's 16.52 W/kg, exceed these published norms substantially and reflect exceptionally well-developed phosphocreatine and glycolytic energy system capacities.

Mean anaerobic power values (7.48-8.22 W/kg) also compare favorably with published data for elite wrestlers. Hubner-Wozniak et al. (2006) reported mean power values of approximately 6-8 W/kg in elite Polish wrestlers, while Horswill et al. (1992) reported similar ranges in American collegiate wrestlers. The relatively narrow range of mean power values across the three athletes (7.48-8.22 W/kg), compared with the wider range in peak power (13.46-16.52 W/kg), suggests that the capacity to sustain anaerobic effort over 30 seconds was more homogeneous within this group than the ability to generate maximal instantaneous power.

Athlete A exhibited the highest fatigue index (approximately 76%), indicating a substantial decline in power output across the 30-second test. While a high fatigue index is sometimes interpreted negatively as an indicator of poor anaerobic endurance, it must be considered in context: Athlete A's peak power was exceptionally high (1,652 W), meaning that even his minimum power (391 W) was achieved from a much higher starting point. Athletes B and C, who started at lower peak power values, demonstrated lower fatigue indices (approximately 62% and 66%, respectively), partly because their power output had less room to decline. Nonetheless, the relatively low minimum power of Athlete A (391 W, 3.91 W/kg) compared with Athletes B (529 W, 5.29 W/kg) and C (459 W, 4.63 W/kg) does suggest that interventions aimed at improving anaerobic endurance could benefit Athlete A specifically.

4.4 Blood Lactate Responses

Peak post-exercise blood lactate concentrations ranged from 11.48 to 12.83 mmol/L across the three athletes. These values are consistent with maximal or near-maximal glycolytic engagement and confirm that all three athletes achieved high-intensity effort during testing. Kraemer et al. (2001) reported post-match blood lactate values of 10-19 mmol/L in collegiate wrestlers, while Barbas et al. (2011) observed values of 12-16 mmol/L following simulated wrestling bouts. The post-GXT lactate values in the present study fall within the lower portion of the range reported for actual competition, which is expected given that the GXT protocol involves continuous incremental running rather than the intermittent, whole-body grappling of competition.

4.5 Physiological Profile Integration

Perhaps the most instructive observation from this case series is the composite physiological profile of Athlete A, who demonstrated elite-level capacity in both aerobic (VO2max = 63 ml/min/kg) and anaerobic (PP = 16.52 W/kg) domains. This combination is relatively rare in heavyweight combat sport athletes and suggests a physiological profile uniquely suited to the demands of Greco-Roman wrestling. An athlete who can generate extraordinary explosive power for throws and lifts (high PP) while also possessing the aerobic capacity to recover quickly between such efforts and sustain a high work rate across an entire match (high VO2max) would possess a significant competitive advantage (Callan et al., 2000).

However, the anaerobic threshold at 73% of VO2max represents a potential performance limiter that, if addressed through targeted training, could unlock even greater competitive potential. The gap between the AnT and VO2max represents an "untapped" aerobic reserve that the athlete cannot currently access without incurring excessive lactate accumulation and associated fatigue (Faude et al., 2009).

4.6 Limitations

Several limitations of this investigation should be acknowledged. First, the sample size of three athletes limits the generalizability of the findings and precludes inferential statistical analysis. Second, the athletes were tested at different time points (November 2006 and November 2007), introducing potential confounds related to training status, seasonal variation, and equipment calibration across testing sessions. Third, anaerobic threshold data were not available for Athletes B and C, preventing complete inter-individual comparisons. Fourth, the WAnT was performed on a cycle ergometer, which may not fully represent the upper-body-dominant movement patterns of Greco-Roman wrestling; an upper-body Wingate protocol (arm cranking) might have provided more sport-specific data (Hubner-Wozniak et al., 2004). Finally, the absence of sport-specific performance outcome data (e.g., competition results, match analysis metrics) prevents direct linkage of the physiological data to competitive performance.

5. Practical Applications and Recommendations

Based on the physiological data obtained, the following training recommendations are offered, with particular reference to the individualized profile of Athlete A (for whom the most complete dataset is available).

5.1 Individualized Heart Rate Training Zones

Using the measured maximal heart rate of Athlete A (HRmax approximately 198 bpm), five training zones were established in accordance with standard exercise physiology guidelines (American College of Sports Medicine, 2018):

Table 3. Heart rate-based training zones for Athlete A (HRmax = 198 bpm).

Zone	Intensity (% HRmax)	HR Range (bpm)	Primary Training Objective
5	90-100%	180-198	Anaerobic capacity, speed-strength, VO2max intervals
4	80-90%	160-180	Aerobic-anaerobic transition, lactate tolerance, interval training
3	75-80%	150-160	Base endurance, local muscular endurance, AnT development
2	60-75%	120-149	Fat oxidation, cardiovascular development, aerobic base
1	<60%	60-120	Warm-up, cool-down, active recovery

5.2 Aerobic Fitness Maintenance

Given the exceptionally high VO2max of Athlete A, the primary objective for aerobic training should be maintenance rather than further development of maximal aerobic power. This can be achieved with 2-3 sessions per week of continuous moderate-intensity exercise (Zone 2-3) lasting 45-90 minutes, incorporating activities such as running, cycling, rowing, or swimming (Issurin, 2010). These sessions serve the dual purpose of maintaining cardiovascular fitness and supporting recovery from high-intensity wrestling training.

5.3 Anaerobic Threshold Development

The most impactful training intervention for Athlete A would be a focused effort to raise the anaerobic threshold from the current 73% toward 85-95% of VO2max. This can be accomplished through structured threshold training, including (a) tempo runs or cycling at an intensity corresponding to the current AnT (HR approximately 165-170 bpm) for durations of 20-40 minutes, (b) cruise interval sessions consisting of 4-6 repetitions of 5-8 minutes at AnT intensity with 1-2 minutes of active recovery, and (c) progressive increases in the duration and intensity of threshold work across training mesocycles (Weltman, 1995; Billat et al., 2003).

This training emphasis should be implemented during the general and specific preparatory phases of the annual training cycle. In the immediate pre-competition phase, the focus should shift toward sport-specific high-intensity intervals and technical-tactical preparation, with threshold work reduced to a maintenance volume.

5.4 Anaerobic Power and Capacity

The high peak anaerobic power values observed across the cohort suggest that the existing strength and power training programs are effective. However, the high fatigue index observed in Athlete A indicates that targeted glycolytic capacity training may be beneficial. Recommended interventions include repeated sprint training (6-10 repetitions of 10-30-second all-out efforts with 2-4-minute recovery), wrestling-specific interval drills mimicking match intensity patterns, and high-intensity circuit training incorporating wrestling-specific movements (Chaabene et al., 2017; Nilsson et al., 2002).

5.5 Periodization Considerations

Integration of these training recommendations into an annual periodization plan should follow established models for combat sports (Issurin, 2010; Bompa & Haff, 2009):

- **General Preparatory Phase (8-12 weeks):** Emphasis on aerobic base development (Zones 2-3) and general strength training. Volume is high; intensity is moderate.
- **Specific Preparatory Phase (6-8 weeks):** Progressive introduction of threshold training (Zone 3-4), sport-specific anaerobic intervals (Zone 4-5), and maximal strength/power development.
- **Pre-Competition Phase (3-4 weeks):** High-intensity sport-specific training (Zone 4-5), technical-tactical refinement, tapering of volume while maintaining intensity. AnT should be at its highest percentage of VO2max during this phase.

- **Competition Phase:** Maintenance of all fitness components with reduced volume. Focus on peaking, recovery, and match preparation.
- **Transition Phase (2-4 weeks):** Active recovery, low-intensity cross-training (Zone 1-2), restoration.

6. Conclusion

This case series provides a detailed laboratory assessment of aerobic and anaerobic performance in three elite heavyweight Greco-Roman wrestlers. The findings reveal substantial inter-individual variability in both aerobic capacity (VO2max: 46-63 ml/min/kg) and peak anaerobic power (MAP: 13.46-16.52 W/kg) within a homogeneous competitive group. The most notable finding is the exceptionally high VO2max of 63 ml/min/kg observed in Athlete A, which exceeds published norms for heavyweight wrestlers and approaches values typical of trained endurance athletes. Combined with his high peak anaerobic power of 16.52 W/kg, Athlete A's profile represents a rare combination of aerobic and anaerobic capacities that provides a strong physiological foundation for elite wrestling performance.

However, the identification of the anaerobic threshold at only 73% of VO2max in Athlete A highlights a specific area for targeted training intervention. Raising the AnT toward 85-95% of VO2max through structured threshold training would enable this athlete to utilize a greater proportion of his exceptional aerobic capacity before the onset of performance-limiting metabolic acidosis, with expected benefits for sustained high-intensity performance during competition.

These findings reinforce the value of comprehensive, individualized physiological profiling in elite combat sport athletes. Laboratory assessments combining both aerobic (GXT with gas analysis) and anaerobic (WAnT) testing protocols provide actionable data for training prescription that cannot be obtained from field-based or sport-specific testing alone. Regular reassessment at key points in the annual training cycle is recommended to monitor training adaptations and adjust programming accordingly.

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