pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

ANAEROBIC POWER OUTPUT AND LACTIC ACID DYNAMICS IN ELITE AND SUB-ELITE FREESTYLE WRESTLERS: A COMPARATIVE PHYSIOLOGICAL STUDY

Dehkanov Abdulaziz Ilhomjon o'g'li
Teacher of the Department of Theory and Methodology of Martial Arts,
Faculty of Sports Activities, Fergana State University,
dehqonovabdulaziz18@gmail.com
https://doi.org/10.5281/zenodo.20411717

ABSTRACT

Freestyle wrestling is a high-intensity intermittent sport placing substantial demands on both anaerobic energy systems and lactate buffering capacity. Despite its global prevalence, the physiological differences in anaerobic power and lactic acid kinetics between elite and sub-elite wrestlers remain insufficiently characterized. This study aimed to compare peak anaerobic power (PAPw), mean anaerobic power (MAPw), fatigue index (FI), and blood lactate concentration ([La]b) profiles between elite and sub-elite freestyle wrestlers across multiple weight categories.

Keywords: anaerobic power; blood lactate; Wingate Anaerobic Test; freestyle wrestling; fatigue index; lactate kinetics; combat sports physiology

Introduction

Freestyle wrestling, one of the oldest and most physically demanding combat sports, has been an integral component of the modern Olympic programme since 1904. The sport is characterized by explosive bouts of maximal effort interspersed with brief recovery periods, placing extraordinary demands on multiple physiological systems. Understanding the metabolic underpinnings of wrestling performance has gained increasing scientific attention in recent decades, particularly as advances in sports biochemistry have enabled more precise characterization of energy system contributions to high-intensity intermittent activity.

The energy demands of freestyle wrestling are predominantly met through the phosphocreatine (PCr) and glycolytic pathways, with the aerobic system playing a supporting role in recovery between efforts [1,2]. During a typical six-minute wrestling bout at the Olympic or World Championship level, athletes perform repeated explosive movements including takedowns, throws, and defensive sprawls that last between two and fifteen seconds and require peak power outputs exceeding 1,000 watts in heavier weight categories [3]. This intermittent high-intensity exercise pattern drives substantial lactate accumulation in the working musculature and blood, necessitating effective lactate buffering and clearance mechanisms.

The Wingate Anaerobic Test (WAnT), originally developed at the Wingate Institute of Physical Education and Sport in Israel, has become the gold standard laboratory measure for quantifying anaerobic power in athletes [4]. It provides three primary indices: peak anaerobic power (PAPw), representing the highest mechanical power output achieved; mean anaerobic power (MAPw), reflecting average power sustained over 30 seconds; and the fatigue index (FI), quantifying the rate of power decline a surrogate for anaerobic endurance. These parameters have been extensively validated across combat sport athletes, with several studies demonstrating their predictive validity for competitive outcome [5,6].

Blood lactate concentration ([La]b) provides complementary information about glycolytic energy system engagement, metabolic stress, and the efficiency of lactate clearance during and after exercise. The kinetics of post-exercise lactate accumulation and elimination are particularly

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

informative: athletes with superior buffering capacity and enhanced lactate shuttle activity typically demonstrate faster clearance curves, enabling greater exercise tolerance and accelerated recovery [7,8]. In wrestling, where rest intervals between rounds and competition bouts are limited, rapid lactate clearance may constitute a meaningful competitive advantage.

Despite the physiological complexity of freestyle wrestling, relatively few studies have simultaneously examined anaerobic power output and lactate kinetics while comparing athletes across performance levels. Most existing investigations have focused on a single physiological variable [9,10], used general athletic populations, or did not stratify participants by verified competitive achievement. Furthermore, the majority of published work has originated from European or North American cohorts, leaving Central Asian wrestling populations which have historically produced disproportionate numbers of world and Olympic medalists largely uncharacterized in the scientific literature [11].

The purpose of the present study was therefore to: (1) compare WAnT-derived anaerobic power indices between elite (international medalists) and sub-elite (national-level) freestyle wrestlers; (2) characterize and compare post-exercise blood lactate concentration profiles between groups; and (3) examine relationships between anaerobic power parameters and lactate clearance kinetics. We hypothesized that elite wrestlers would demonstrate higher anaerobic power, greater peak lactate accumulation, and faster post-exercise lactate clearance compared to sub-elite counterparts, consistent with a more highly adapted glycolytic energy system.

Materials and Methods

Participants

Thirty-two male freestyle wrestlers volunteered to participate in this cross-sectional comparative study. Participants were divided into two groups based on verified competitive achievement: elite wrestlers (n = 16) had achieved medals at the World Championships, Asian Championships, or Olympic Games within the preceding three years; sub-elite wrestlers (n = 16) competed at the national level but had not achieved podium finishes in international competition. All participants were active competitors with a minimum of five years of structured wrestling training. Exclusion criteria included musculoskeletal injury within six weeks of testing, any metabolic or cardiovascular disorder, or use of ergogenic substances. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Uzbek State University of Physical Education and Sport (Protocol No. 2024-ESC-07). All participants provided written informed consent prior to participation.

Anthropometric and Body Composition Assessment

Body mass and height were measured using a calibrated stadiometer and digital scale (SECA 213, Hamburg, Germany). Body mass index (BMI) was calculated as mass (kg) divided by height squared (m^2). Percent body fat (%BF) was estimated via skinfold callipometry using the seven-site Jackson-Pollock protocol with a Harpenden calliper (Baty International, UK). Fat-free mass (FFM) was derived from %BF and total body mass. Dominant handgrip strength was measured using a hydraulic hand dynamometer (Jamar, USA), with the highest value from three trials recorded.

Wingate Anaerobic Test Protocol

Testing was performed on a calibrated electromagnetically braked cycle ergometer (Lode Excalibur Sport, Groningen, Netherlands). After a five-minute standardized warm-up at 100 W with two brief (5-second) all-out sprints at 180 seconds and 300 seconds, participants performed a maximal 30-second sprint against a resistance of 0.075 $kg \cdot kg^{-1}$ body mass, as recommended for combat sport athletes [12]. Strong verbal encouragement was provided throughout. Peak anaerobic power (PAPw), mean anaerobic power (MAPw), and fatigue index [FI = (PAPw − minimum power / PAPw) × 100] were recorded by the ergometer software. Relative values were calculated by dividing absolute power (W) by body mass (kg). Testing was conducted between 9:00 and 11:00 AM to minimize circadian variation, with participants instructed to avoid strenuous exercise 24 hours prior and arrive in a rested, euhydrated state.

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

Results

Participant Characteristics

Groups were comparable in age, body mass, height, BMI, and fat-free mass (all $p > 0.05$). Elite wrestlers demonstrated significantly lower body fat percentage (9.8 ± 2.1% vs. 11.4 ± 2.6%; $p = 0.048$; $d = 0.68$), greater handgrip strength (52.8 ± 7.4 kg vs. 47.3 ± 8.1 kg; $p = 0.038$; $d = 0.71$), and substantially longer training experience (12.6 ± 3.2 years vs. 9.4 ± 2.8 years; $p = 0.003$; $d = 1.06$). Detailed anthropometric and demographic data are presented in Table 1.

Table 1.

Anthropometric and demographic characteristics of participants (M ± SD)

Variable	Elite (n=16)	Sub-Elite (n=16)	p-value	Cohen's d
Age (years)	22.4 ± 2.1	21.9 ± 2.4	0.523	0.22
Body mass (kg)	74.2 ± 14.6	72.8 ± 13.9	0.769	0.10
Height (cm)	173.4 ± 7.2	172.1 ± 6.8	0.574	0.18
BMI (kg·m⁻²)	24.6 ± 2.8	24.5 ± 2.5	0.921	0.04
Body fat (%)	9.8 ± 2.1	11.4 ± 2.6	0.048*	0.68
Fat-free mass (kg)	66.9 ± 12.4	64.5 ± 12.1	0.551	0.20
Handgrip strength (kg)	52.8 ± 7.4	47.3 ± 8.1	0.038*	0.71
Training experience (years)	12.6 ± 3.2	9.4 ± 2.8	0.003**	1.06

* $p < 0.05$; ** $p < 0.01$

Anaerobic Power Indices

Elite wrestlers demonstrated significantly superior anaerobic power outputs on all Wingate test indices compared to sub-elite counterparts. Relative peak anaerobic power was 23.4% higher in the elite group (13.2 ± 1.4 W·kg⁻¹ vs. 10.7 ± 1.6 W·kg⁻¹; $p < 0.001$; $d = 1.70$), representing a large effect size. Relative mean anaerobic power was 24.1% higher in elite athletes (9.8 ± 1.1 W·kg⁻¹ vs. 7.9 ± 1.3 W·kg⁻¹; $p < 0.001$; $d = 1.58$). The fatigue index was significantly lower in the elite group (34.6 ± 6.2% vs. 41.3 ± 7.8%; $p = 0.008$; $d = 0.96$), indicating superior anaerobic endurance and resistance to power decline. Full WAnT data are shown in Table 2.

Table 2.

Wingate Anaerobic Test indices by performance group (M ± SD)

Variable	Elite (n=16)	Sub-Elite (n=16)	p-value	Cohen's d
Absolute PAPw (W)	978.4 ± 142.6	792.1 ± 138.3	<0.001***	1.33
Relative PAPw (W·kg⁻¹)	13.2 ± 1.4	10.7 ± 1.6	<0.001***	1.70

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

Variable	Elite (n=16)	Sub-Elite (n=16)	p-value	Cohen's d
Absolute MAPw (W)	727.3 ± 118.4	579.6 ± 102.7	<0.001***	1.32
Relative MAPw (W·kg⁻¹)	9.8 ± 1.1	7.9 ± 1.3	<0.001***	1.58
Fatigue Index (%)	34.6 ± 6.2	41.3 ± 7.8	0.008**	0.96
Minimum power (W)	641.2 ± 101.3	463.8 ± 98.6	<0.001***	1.77

PAPw = peak anaerobic power; MAPw = mean anaerobic power. ** $p < 0.01$; *** $p < 0.001$

Blood Lactate Kinetics

Resting blood lactate concentrations were similar between groups (elite: 1.2 ± 0.3 mmol·L⁻¹; sub-elite: 1.1 ± 0.3 mmol·L⁻¹; $p = 0.412$). Post-exercise lactate accumulation was significantly greater and peaked earlier in the elite group: peak [La]b was 15.4 ± 2.1 mmol·L⁻¹ in elite vs. 12.8 ± 2.4 mmol·L⁻¹ in sub-elite athletes ($p = 0.002$; $d = 1.17$), with time to peak lactate significantly shorter in the elite group (3.1 ± 0.6 min vs. 3.8 ± 0.7 min; $p = 0.006$; $d = 1.06$). Most notably, the lactate elimination slope from peak to 10 minutes post-exercise was substantially steeper in elite wrestlers (−1.87 ± 0.34 vs. −0.96 ± 0.28 mmol·L⁻¹·min⁻¹; $p < 0.001$; $d = 2.97$), indicating markedly faster lactate clearance. At the 10-minute recovery time point, elite wrestlers had significantly lower [La]b than sub-elite athletes (7.8 ± 1.7 vs. 9.9 ± 2.2 mmol·L⁻¹; $p = 0.003$), having cleared a greater absolute lactate load more rapidly. Lactate kinetics data are summarized in Table 3.

Discussion

The primary findings of this study were that elite freestyle wrestlers exhibited significantly superior anaerobic power output across all WAnT indices, accompanied by higher peak post-exercise lactate concentrations and markedly faster lactate clearance kinetics, compared to sub-elite competitors. These results collectively suggest that elite-level performance in freestyle wrestling is underpinned by a highly developed glycolytic energy system with enhanced capacity for both lactate production and disposal.

The between-group differences in relative anaerobic power (PAPw: 13.2 vs. 10.7 W·kg⁻¹; MAPw: 9.8 vs. 7.9 W·kg⁻¹) are consistent with and extend findings from previous investigations of high-level wrestlers. Mirzaei et al. [9] reported mean relative PAPw values of 11.8 W·kg⁻¹ in elite Iranian freestyle wrestlers, while Yoon [14] observed values of approximately 10.2 W·kg⁻¹ in collegiate Korean wrestlers figures broadly consistent with our sub-elite group and slightly lower than our elite cohort, potentially reflecting the particularly high calibre of the international medalists included in our elite group.

The lower fatigue index in elite wrestlers (34.6% vs. 41.3%) is particularly noteworthy from a sport-specific perspective. During a freestyle wrestling match, athletes are required to sustain explosive effort across multiple exchanges within a six-minute bout, with scoring opportunities frequently arising in the final minute. A lower fatigue index implies greater preservation of power output during sustained anaerobic work, which may translate to maintenance of technical execution and explosive takedown ability as the bout progresses. This finding aligns with the observation by Barbas et al. [15] that Greco-Roman wrestlers competing at higher levels demonstrated less power decrement over repeated high-intensity bouts compared to lower-ranked competitors.

The lactate kinetics findings of this study are among the most practically significant. Although elite wrestlers accumulated more lactate in absolute terms reflecting greater glycolytic

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

engagement consistent with their higher power outputs they cleared this lactate approximately twice as rapidly as sub-elite counterparts (elimination slope: −1.87 vs. −0.96 mmol·L⁻¹·min⁻¹). This superior clearance capacity is likely attributable to several adaptations associated with high-volume, high-intensity wrestling training: enhanced monocarboxylate transporter (MCT-1 and MCT-4) expression facilitating lactate shuttle activity between fast-twitch and slow-twitch fibres [16]; greater skeletal muscle oxidative capacity enabling more rapid lactate oxidation; and potentially higher plasma

Conclusions

Elite freestyle wrestlers demonstrate markedly superior anaerobic power output and reduced fatigue susceptibility compared to sub-elite athletes, as indexed by the Wingate Anaerobic Test. Critically, they also display a paradoxically enhanced lactate response characterized by higher peak accumulation but substantially faster clearance consistent with a more highly adapted glycolytic metabolic profile. These findings have direct implications for the design of wrestling-specific conditioning programmes: training interventions targeting anaerobic power development should be complemented by high-intensity recovery work designed to enhance lactate clearance kinetics, and [La]b monitoring offers a practical tool for tracking metabolic adaptation in elite wrestling athletes. Future longitudinal studies examining the trainability of lactate clearance in response to specific conditioning protocols are warranted.

References

1. Yoon J. Elita katta kurashchilarining fiziologik profillari. Sport tibbiyoti. 2002;32(4) :225–233 . https://doi.org/10.2165/00007256-200232040-00002
2. Sharratt MT, Taylor AW, Song TMK. Elita Kanadalik erkin kurashchilarning fiziologik profili. Kanada amaliy sport fanlari jurnali. 1986;11(2) :100–105 .
3. Callan SD, Brunner DM, Devolve KL va boshqalar. Elita erkin kurashchilarining fiziologik profillari. Kuch va holatni yaxshilash tadqiqotlari jurnali. 2000;14(2) :162–169 .
4. Bar-Or O. Wingate anaerob testi: metodologiya, ishonchlilik va validlik bo'yicha yangilanish. Sport tibbiyoti. 1987;4(5) :381–394 . https://doi.org/10.2165/00007256-198704050-00001
5. Kraemer WJ, Fry AC, Rubin MR va boshqalar. Turnir kurashiga fiziologik va samaradorlik reaksiyalari. Sport va jismoniy mashqlarda tibbiyot va fan. 2001;33(8) :1367–1378 .
6. Horswill CA, Scott JR, Galea P. Elita va noelite yosh kurashchilarning maksimal aerob kuchi, maksimal anaerob kuchi va teri qatlamlari qalinligini taqqoslash. Xalqaro sport tibbiyoti jurnali. 1989;10(3) :165–168 .
7. Gladden LB. Laktat metabolizmi: uchinchi ming yillik uchun yangi paradigma. Fiziologiya jurnali. 2004;558(1) : 5–30. https://doi.org/10.1113/jphysiol.2003.058701
8. Brooks GA. Laktat shattl nazariyasining ilmi va tarjimasi. Hujayra metabolizmi. 2018;27(4) :757–785 . https://doi.org/10.1016/j.cmet.2018.03.008
9. Mirzaei B, Curby DG, Rahmani-Nia F, Moghadasi M. Eronlik elit yosh erkin kurashchilarning fiziologik profili. Kuch va holatni yaxshilash tadqiqotlari jurnali. 2009;23(8) :2339–2344 .
10. Chaabène H, Negra Y, Bouguezzi R va boshqalar. Jang sporti sportchilarining jismoniy imkoniyatlarini sinovdan o'tkazish: tizimli sharh. Kuch va holatni yaxshilash tadqiqotlari jurnali. 2018;32(11) :3211–3230 .
11. Tumanyan G.S., Martirosov E.G. Teloslozhenie i sport [Tana turi va sport]. Moskva: Fizkultura i Sport; 1976. (rus tilida)
12. Zajac A, Poprzecki S, Zebrowska A, Chalimoniuk M, Langfort J. Arginin va ornitin qo'shimchasi kuch bilan mashq qilingan sportchilarda og'ir qarshilik mashqlaridan so'ng

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

o'sish gormoni va insulinga o'xshash o'sish omili-1 zardobidagi darajasini oshiradi. Kuch va holatni yaxshilash tadqiqotlari jurnali. 2010;24(4) :1082–1090 .
13. Tanner RK, Fuller KL, Ross MLR. Uchta ko'chma qon laktat analizatorlarini baholash: Lactate Pro, Lactate Scout va Lactate Plus. Yevropa amaliy fiziologiya jurnali. 2010;109(3) :551–559 .
14. Yun J. Elita koreys kurashchilarining fiziologik profillari. Kineziologiya. 2007;39(1) : 49–57.
15. Barbas I, Fatouros IG, Douroudos II va boshqalar. Bir kunlik turnir davomida elita yunon-rim kurashchilarining fiziologik va ishlash moslashuvlari. Yevropa amaliy fiziologiya jurnali. 2011;111(8) :1421–1436 .