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CLASSIFICATION OF STRENGTH-SPEED INDICATORS IN ADOLESCENT AND ADULT WRESTLERS: A COMPARATIVE CROSS-SECTIONAL ANALYSIS

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ANNOTATION

Strength and speed are foundational physical qualities in wrestling performance, yet normative classification frameworks distinguishing developmental trajectories across age groups remain insufficiently established, particularly for wrestlers from Central Asian training systems. This study aimed to classify and compare strength-speed indicators between adolescent (15–17 years) and adult (18–26 years) freestyle wrestlers, and to propose age-stratified normative benchmarks for practical use in talent identification and training programme design.

Keywords: strength-speed; freestyle wrestling; adolescent athletes; adult wrestlers; normative classification; countermovement jump; anaerobic power; talent identification; Fergana; Uzbekistan

Introduction

Freestyle wrestling is among the most physically demanding of all Olympic combat sports, requiring athletes to repeatedly execute explosive movements — including powerful takedowns, hip throws, defensive lifts, and rapid direction changes — over the course of a six-minute competitive bout. The biomechanical and physiological demands of these actions place strength and speed at the apex of physical qualities necessary for competitive success [1,2]. Within the sport science literature, the terms 'strength-speed' and 'speed-strength' are frequently used to describe the capacity to produce high force outputs at high velocities — a physical quality closely aligned with the concept of muscular power [3].

Classifying and benchmarking these qualities across athlete populations is of critical importance for several applied purposes: talent identification, training load prescription, developmental monitoring, and return-to-competition readiness assessment. However, normative data for strength-speed indicators in wrestling are sparse, and most existing frameworks have been developed from European, North American, or East Asian cohorts [4,5]. Central Asian wrestlers — whose nations, including Uzbekistan, Kazakhstan, and Kyrgyzstan, consistently rank among the world's most successful wrestling countries — have been largely excluded from this normative literature, leaving coaches and practitioners without population-specific reference values [6].

A particular gap concerns the comparison of strength-speed profiles between adolescent and adult wrestlers. The transition from adolescent to adult competition involves profound physiological changes driven by biological maturation: increases in muscle cross-sectional area, shifts in fibre type distribution, hormonal milieu changes, and enhanced neuromuscular coordination [7,8]. These adaptations collectively translate to improvements in force production velocity, reactive strength, and explosive power. Understanding the magnitude and pattern of these developmental differences has direct implications for age-appropriate training programming: training stimuli optimally matched to an athlete's developmental stage are more likely to induce positive adaptation without risking overtraining or growth-related injury [9].

The Fergana Valley region of Uzbekistan has historically produced a disproportionate number of elite freestyle wrestlers relative to its population, yet no published study has examined the physical characteristics of wrestlers from this region or proposed normative classification systems based on local athlete data. Given that training environments, dietary habits, and competitive calendars differ meaningfully between Central Asian and Western wrestling cultures, it is methodologically inappropriate to apply foreign normative standards to Uzbek wrestlers without empirical validation [10].

Field-based testing protocols — including the standing broad jump, countermovement jump, medicine ball throw, grip dynamometry, and sprint timing — have been extensively validated as reliable indicators of lower-body explosive power, upper-body power, and maximal speed in combat sport athletes [11,12]. These tests are practically applicable in training centre environments without requiring expensive laboratory equipment, making them ideal for routine monitoring in wrestling academies with limited resources.

Therefore, the objectives of this study were: (1) to compare strength-speed test performance between adolescent (15–17 years) and adult (18–26 years) male freestyle wrestlers from Fergana, Uzbekistan; (2) to examine the relationships between individual strength-speed test scores and age, body composition, and training experience; and (3) to develop age-stratified normative classification tables (Excellent, Good, Average, Below Average, Poor) for each test, based on percentile rankings within the study sample. We hypothesized that adult wrestlers would demonstrate significantly superior strength-speed performance across all measures, and that normative thresholds would differ substantially between age groups.

Materials and Methods

Study Design and Participants

A cross-sectional comparative design was employed. Sixty male freestyle wrestlers were recruited from wrestling sports schools and academies in the Fergana region of Uzbekistan. Participants were assigned to one of two age groups: adolescents (n = 30; age range 15–17 years) and adults (n = 30; age range 18–26 years). Inclusion criteria were: active freestyle wrestling competition with a minimum of three years of structured training, no musculoskeletal injury within eight weeks of testing, and absence of chronic illness or use of performance-enhancing substances. The study protocol was reviewed and approved by the Ethics Committee of Fergana State University (Protocol No. FerSU-2024-EC-11). Written informed consent was obtained from all adult participants and from the parents/guardians of adolescent participants, with adolescent assent also recorded.

Anthropometric and Body Composition Assessment

Body mass was measured to the nearest 0.1 kg using a calibrated digital scale (SECA 803, Hamburg, Germany) and height to the nearest 0.1 cm using a portable stadiometer (SECA 213). Body mass index (BMI) was computed as mass (kg) / height² (m²). Percent body fat (%BF) was estimated via three-site skinfold measurement (chest, abdomen, thigh for adults; triceps, subscapular, suprailiac for adolescents) using the age-specific Jackson-Pollock equations with Harpenden callipers (Baty International, UK). Fat-free mass (FFM) was derived from total mass and %BF.

Strength-Speed Test Battery

All testing was conducted indoors on a suspended hardwood sports floor between 09:00 and 12:00 hours, preceded by a standardised 10-minute dynamic warm-up. The test order was: (1) grip strength, (2) standing broad jump, (3) 30-metre sprint, (4) medicine ball chest throw, (5) countermovement jump, and (6) Wingate Anaerobic Test, with at least five minutes of passive rest between tests.

Dominant handgrip strength (HGS) was assessed using a calibrated hydraulic hand dynamometer (Jamar Plus+, Patterson Medical, USA) with the participant in a standardised standing position. The best of three trials (1-minute inter-trial rest) was recorded in kilograms. Standing broad jump (SBJ) distance was measured from the takeoff line to the nearest heel contact, with the best of three attempts recorded in centimetres. The 30-metre sprint was timed using dual photocell gates (Witty, Microgate, Italy) with the participant starting from a static standing position; the average of two trials was used.

The medicine ball chest throw (MBCT) was performed with a 3 kg rubber medicine ball from a seated position against a wall-mounted backstop; distance was measured to the nearest centimetre from the wall to the nearest ball contact point, using the best of three attempts. Countermovement jump (CMJ) height was assessed using a validated contact mat system (Ergojump Plus, Psion Teklogix, Italy) with the best of five attempts recorded. Peak and mean anaerobic power were assessed via the 30-second Wingate Anaerobic Test (WAnT) on a calibrated electromagnetically-braked cycle ergometer (Lode Excalibur Sport, Netherlands) at a resistance of 0.075 $kg \cdot kg^{-1}$ body mass.

Normative Classification Framework

Percentile-based normative thresholds were derived separately for the adolescent and adult groups using the following cut-off scheme: Excellent (≥90th percentile), Good (75th–89th percentile), Average (25th–74th percentile), Below Average (10th–24th percentile), and Poor (<10th percentile). This five-tier classification scheme is consistent with frameworks used in national fitness assessment systems and has precedent in combat sport normative studies [13,14].

Statistical Analysis

Data were analysed using IBM SPSS Statistics v27.0 (IBM Corp., Armonk, NY). Normality was assessed via the Shapiro-Wilk test. Normally distributed variables were compared using independent samples t-tests; non-normally distributed variables used the Mann-Whitney U test. Cohen's d effect sizes were reported (small ≥ 0.2, medium ≥ 0.5, large ≥ 0.8). Pearson's or Spearman's correlations (as appropriate) examined associations between strength-speed scores, age, FFM, and training experience across the full sample. Statistical significance was set at $p < 0.05$. Descriptive data are reported as mean ± standard deviation (M ± SD).

Results

Participant Characteristics

The two groups were significantly different in age, body mass, BMI, body fat percentage, fat-free mass, and training experience (all $p \leq 0.023$). Adult wrestlers had substantially greater fat-free mass (67.2 ± 11.8 kg vs. 55.4 ± 9.6 kg; $p < 0.001$; d = 1.10) and more than double the training experience (11.8 ± 2.9 years vs. 5.6 ± 1.4 years; $p < 0.001$; d = 2.73). Adolescents exhibited modestly higher body fat percentage (12.6 ± 2.8% vs. 10.1 ± 2.3%; $p = 0.001$). Detailed anthropometric data are presented in Table 1.

Table 1.
Anthropometric and demographic characteristics of participants (M ± SD)

Variable	Adolescents (n=30)	Adults (n=30)	p-value	Cohen's d
Age (years)	15.9 ± 0.9	21.4 ± 2.3	<0.001***	—
Body mass (kg)	63.4 ± 11.2	74.8 ±	0.001**	0.89

Variable	Adolescents (n=30)	Adults (n=30)	p-value	Cohen's d
		14.1		
Height (cm)	169.2 ± 7.4	173.6 ± 7.1	0.023*	0.61
BMI (kg·m⁻²)	22.1 ± 2.6	24.7 ± 2.9	0.001**	0.94
Body fat (%)	12.6 ± 2.8	10.1 ± 2.3	0.001**	0.97
Fat-free mass (kg)	55.4 ± 9.6	67.2 ± 11.8	<0.001***	1.10
Training experience (yrs)	5.6 ± 1.4	11.8 ± 2.9	<0.001***	2.73
Weight category (kg range)	55–84	57–97	—	—

* p < 0.05; ** p < 0.01; *** p < 0.001. BMI = body mass index.

Strength-Speed Performance Comparison

Adult wrestlers outperformed adolescents on all six strength-speed measures with large-to-very-large effect sizes (d range: 1.13–2.33). The most pronounced differences were observed for absolute peak anaerobic power (964.6 ± 152.7 W vs. 641.3 ± 128.4 W; d = 2.33), medicine ball chest throw (6.84 ± 0.72 m vs. 5.31 ± 0.68 m; d = 2.19), and handgrip strength (52.8 ± 7.4 kg vs. 38.6 ± 6.2 kg; d = 2.09). In relative terms, CMJ height was 24% greater in adults (38.7 vs. 31.2 cm), SBJ distance 12.4% greater (232.4 vs. 206.8 cm), and relative peak anaerobic power 27.7% greater (12.9 vs. 10.1 $W·kg^{-1}$). Sprint speed was 7.8% faster in adults (4.12 ± 0.21 s vs. 4.47 ± 0.24 s). The fatigue index was 16.4% lower in adults (35.4 ± 6.8% vs. 43.8 ± 8.1%; d = 1.13), indicating superior anaerobic endurance. Complete test results are shown in Table 2.

Table 2.

Strength-speed test performance by age group (M ± SD)

Test	Adolescents (n=30)	Adults (n=30)	p-value	Cohen's d
CMJ height (cm)	31.2 ± 4.1	38.7 ± 4.6	<0.001***	1.72
SBJ distance (cm)	206.8 ± 17.3	232.4 ± 18.6	<0.001***	1.42
30-m sprint (s)	4.47 ± 0.24	4.12 ± 0.21	<0.001***	1.57
Handgrip strength (kg)	38.6 ± 6.2	52.8 ± 7.4	<0.001***	2.09
MBCT distance (m)	5.31 ± 0.68	6.84 ± 0.72	<0.001***	2.19

Test	Adolescents (n=30)	Adults (n=30)	p-value	Cohen's d
Relative PAPw (W·kg⁻¹)	10.1 ± 1.6	12.9 ± 1.5	<0.001***	1.82
Absolute PAPw (W)	641.3 ± 128.4	964.6 ± 152.7	<0.001***	2.33
Relative MAPw (W·kg⁻¹)	7.6 ± 1.2	9.7 ± 1.1	<0.001***	1.84
Fatigue Index (%)	43.8 ± 8.1	35.4 ± 6.8	<0.001***	1.13

CMJ = countermovement jump; SBJ = standing broad jump; MBCT = medicine ball chest throw; PAPw = peak anaerobic power; MAPw = mean anaerobic power. *** $p < 0.001$.

Normative Classification Tables

Percentile-based normative thresholds are presented separately for adolescent (Table 3) and adult (Table 4) wrestlers. These tables provide age-appropriate benchmarks for each of the six strength-speed measures across five classification categories.

Table 3.
Normative classification thresholds for adolescent freestyle wrestlers (15–17 years)

Classification	CMJ (cm)	SBJ (cm)	Sprint 30m (s)	Grip (kg)	MBCT (m)	PAPw (W·kg⁻¹)
Excellent (≥90th)	≥37	≥228	≤4.18	≥47	≥6.18	≥12.2
Good (75–89th)	33–36	218–227	4.19–4.28	43–46	5.72–6.17	11.1–12.1
Average (25–74th)	26–32	195–217	4.29–4.62	33–42	4.74–5.71	8.9–11.0
Below Average (10–24th)	22–25	183–194	4.63–4.78	28–32	4.21–4.73	7.8–8.8
Poor (<10th)	≤21	≤182	≥4.79	≤27	≤4.20	≤7.7

Values represent raw score cut-offs based on percentile ranking within the adolescent sample (n = 30). Sprint: lower score = better performance.

Table 4.
Normative classification thresholds for adult freestyle wrestlers (18–26 years)

Classification	CMJ (cm)	SBJ (cm)	Sprint 30m (s)	Grip (kg)	MBCT (m)	PAPw (W·kg⁻¹)
Excellent (≥90th)	≥45	≥254	≤3.88	≥62	≥7.78	≥14.9

Classification	CMJ (cm)	SBJ (cm)	Sprint 30m (s)	Grip (kg)	MBCT (m)	PAPw (W·kg⁻¹)
Good (75–89th)	41–44	244–253	3.89–3.97	58–61	7.24–7.77	13.6–14.8
Average (25–74th)	35–40	218–243	3.98–4.24	47–57	6.14–7.23	11.4–13.5
Below Average (10–24th)	31–34	204–217	4.25–4.37	41–46	5.52–6.13	10.2–11.3
Poor (<10th)	≤30	≤203	≥4.38	≤40	≤5.51	≤10.1

Values represent raw score cut-offs based on percentile ranking within the adult sample (n = 30). Sprint: lower score = better performance.

Discussion

The principal findings of this investigation were that adult freestyle wrestlers demonstrated significantly and substantially superior performance across all six strength-speed tests compared to their adolescent counterparts, with all between-group comparisons yielding large effect sizes (d ≥ 1.13). Furthermore, the development of age-stratified normative classification tables represents a practical contribution to the field of wrestling sports science, providing coaches and practitioners in Fergana and the broader Uzbek wrestling community with locally-derived reference standards.

The magnitude of the between-group differences in explosive leg power — reflected in CMJ height (38.7 vs. 31.2 cm; d = 1.72) and standing broad jump distance (232.4 vs. 206.8 cm; d = 1.42) — is consistent with the well-documented developmental trajectory of lower-limb neuromuscular power during adolescence and early adulthood. Biological maturation during mid-to-late adolescence drives substantial increases in testosterone, growth hormone, and insulin-like growth factor-1, collectively promoting muscle hypertrophy, increased motor unit recruitment, and enhanced rate of force development [7,15]. The adult CMJ values observed in our study (38.7 ± 4.6 cm) are comparable to those reported by Chaabene et al. [16] for elite senior wrestlers (39.1 ± 5.2 cm), supporting the representativeness of our adult sample.

The particularly large effect sizes for handgrip strength (d = 2.09) and medicine ball chest throw (d = 2.19) suggest that upper-body power and grip force develop more steeply across the adolescent-to-adult transition than lower-body explosive power. This is consistent with longitudinal data from combat sport studies [17] and may reflect the specific training demands of wrestling, which places intense demands on the hands, wrists, and shoulder girdle through gripping, pulling, and throwing actions. The practical implication is that adolescent wrestlers should receive substantial volumes of upper-body pulling and pushing power training to accelerate development in these qualities during the sensitive developmental window of late adolescence.

The fatigue index advantage observed in adults (35.4% vs. 43.8%; d = 1.13) indicates that adult wrestlers are better able to sustain explosive power output over the 30-second Wingate test, reflecting superior glycolytic endurance. This finding aligns with Toshmatov et al. [18] and Mirzaei et al. [19], who both reported lower fatigue indices in elite compared to developing wrestlers. The development of anaerobic endurance is thought to be driven by adaptations in glycolytic enzyme activity, muscle buffering capacity, and monocarboxylate transporter density

— adaptations that accumulate over years of high-intensity training and may require a minimum training age before reaching adult-comparable levels.

Conclusions

This study provides comprehensive evidence that adult freestyle wrestlers from Fergana, Uzbekistan, possess substantially greater strength-speed capacities than adolescent wrestlers across all measured physical qualities, with large effect sizes confirming the practical significance of these differences. The proposed age-stratified normative classification tables offer a locally validated, practically applicable tool for coaches, talent scouts, and sports scientists working within Uzbek wrestling programmes. Future longitudinal investigations are needed to characterise the developmental trajectory of strength-speed qualities across adolescence in wrestling, and to determine the optimal timing of training emphases aligned with maturational windows.

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