

The role of limb strength and dynamic balance in sports performance: A study on adolescent wrestlers

MEMET BÖLÜKBAŞI¹, SELİM ASAN², CEBRAİL GENÇOĞLU³, SÜLEYMAN ULUPINAR⁴

^{1,2,3,4}Faculty of Sport Sciences, Erzurum Technical University, TÜRKİYE

Published online: August 31, 2025

Accepted for publication: August 15, 2025

DOI:10.7752/jpes.2025.08185

Abstract

Wrestling performance is shaped by explosive strength, coordination, and postural stability; however, limited research has focused on the combined effects of extremity strength and balance among young athletes. In this context study investigates the influence of upper and lower extremity strength and dynamic balance skills on the sports performance of adolescent wrestlers. A total of 39 wrestlers participated, including 19 successful (medal-winning) and 20 beginner (non-medal-winning) athletes. Data collection tools used in the study included the "Personal Information Form," "Special Judo Fitness Test (SJFT)," "Y Balance Test," "Standing Long Jump," "Vertical Jump Tests," "Grip Strength Test," and "Medicine Ball Throw Test." Data normality was verified with the Shapiro-Wilk test, and homogeneity of variances with Levene's test. Statistical comparisons were conducted using the Independent Samples T-Test, and relationships were examined through Pearson Correlation analyses. Results revealed no significant differences between successful and beginner wrestlers in dominant and non-dominant hand grip strength or medicine ball throw performance. Conversely, successful wrestlers demonstrated significantly higher outcomes in horizontal and vertical jump tests, highlighting the importance of lower extremity explosive power. Furthermore, SJFT performance index values were superior among successful athletes and showed strong correlations with jumping ability. Interestingly, balance test results displayed a negative association with SJFT performance, suggesting that excessive postural control demands may hinder high-intensity wrestling tasks. In conclusion, adolescent wrestlers with greater lower extremity power achieved superior performance, emphasizing the central role of explosive strength and functional balance in competitive success. These findings suggest that training programs emphasizing plyometric exercises, dynamic stability drills, and lower limb strength development can enhance wrestling-specific performance.

Keywords: Wrestling, Athletic Performance, Postural stability, Motor performance,

Introduction

Wrestling is widely recognized as one of the most physically and technically demanding Olympic sports, requiring athletes to integrate strength, balance, endurance, and tactical skills under high-intensity conditions (Aslan et al., 2013; Franchini et al., 2011). While many studies have examined isolated aspects of wrestling performance such as anaerobic capacity, grip strength, or explosive power (Hubner-Wozniak et al., 2004; Stockbrugger & Haennel, 2003), there remains a lack of comprehensive research addressing how upper and lower extremity strength and dynamic balance jointly contribute to adolescent wrestlers' success. This research gap is critical, as adolescence represents a decisive stage of physical and motor development that directly influences both long-term athletic performance and injury risk (Gorman et al., 2012; Shaffer et al., 2013). Moreover, dynamic balance has been shown to play a central role in injury prevention and performance enhancement, yet its relationship with extremity strength in young wrestlers has not been systematically investigated (Asan et al., 2025; Kaya et al., 2025). Therefore, the present study was designed to provide scientific evidence on the interactions between extremity strength, balance, and wrestling-specific performance, aiming to establish a foundation for training programs that target the development of biomotor abilities in adolescent wrestlers.

Wrestling is a complex combat sport that combines physical endurance, strength, balance, and strategic thinking. In this sport, athletes' physical capacities are just as crucial as their technical skills for achieving success (Aslan et al., 2013; Chernozub et al., 2024). Particularly, dynamic actions of the essence of wrestling, such as sudden changes in direction, pulling, and pushing movements, highlight the significant role of balance and strength in wrestling performance (Hubner-Wozniak et al., 2004). The demanding physical requirements of wrestling necessitate the intensive use of the anaerobic energy system. Explosive power is a key factor in gaining an advantage over the opponent and strategic superiority during critical moments of a match (Hubner-Wozniak et al., 2004). Additionally, isometric strength is emphasized as an essential component in controlling and stabilizing the opponent in wrestling (Franchini et al., 2011).

Upper and lower extremity strength in wrestling is crucial for executing technical skills and overall performance. Upper extremity strength enhances grip strength and improves control over the opponent, while

lower extremity strength plays a vital role in maintaining balance and executing explosive movements effectively (Özbay et al., 2024; Stockbrugger & Haennel, 2003). The influence of specific strength components, such as hand grip strength, on wrestling performance has been frequently highlighted in the literature (Bohannon, 2001; Gençoğlu & Şen, 2021). This situation necessitates wrestlers to focus on isometric and dynamic strength development in their training programs. Strength is recognized as a fundamental biomotor ability that allows wrestlers to apply their technical skills effectively. Both upper and lower extremity strength are key determinants in defensive and offensive strategies during matches (Stockbrugger & Haennel, 2003). For example, hand grip strength is an important advantage for wrestlers in technical applications and stabilizing opponents (Asan, 2023; Bohannon, 2001). Developing anaerobic capacity is another essential factor in improving strength performance for wrestlers. As wrestling requires short-duration, high-intensity efforts, the effective use of the anaerobic energy system is crucial. In particular, isometric strength is key in strategic maneuvers such as stabilizing and controlling the opponent (Franchini et al., 2011). Additionally, lower extremity muscle strength supports wrestlers in disrupting the opponent's balance, moving quickly, and efficiently changing positions (Shaffer et al., 2013). Balance is another crucial factor in wrestling. An athlete's ability to maintain balance both in a standing position and on the ground is a key determinant of success in wrestling competitions (Asan et al., 2025; Gorman et al., 2012). Dynamic balance gives wrestlers significant advantages by allowing them to react swiftly to their opponent's movements, change positions effectively, and regain control in cases of imbalance (Shaffer et al., 2013). Studies have shown that dynamic balance enhances athletic performance and significantly reduces the risk of injury (Franchini et al., 2011). Developing balance, particularly in young wrestlers, is vital for ensuring long-term athletic success and plays a fundamental role in injury prevention programs. Balance also enables wrestlers to maintain their position effectively during matches, respond to opponents' attacks, and recover from unstable positions. Balance skills are crucial for success in both the standing and ground phases of wrestling. Dynamic balance is particularly vital for rapid directional changes and quick reactions to the opponent's moves (Shaffer et al., 2013). Moreover, lower extremity dynamic balance is critical for maintaining stability and ensuring mobility during wrestling matches (Gorman et al., 2012).

Balance and strength are essential in gaining an advantage and preventing injury risk during competitions. Deficiencies in dynamic balance skills can increase athletes' risk of lower extremity injuries, while appropriate strength levels can significantly reduce these risks (Gorman et al., 2012; Kaya et al., 2025). Upper extremity strength is vital in resisting the opponent's grip and gaining an advantage in sudden movements (Shaffer et al., 2013). Accordingly, assessing balance and strength performance is crucial for wrestlers to optimize their training programs and increase their long-term athletic success. In this context, this study aims to investigate the role of upper and lower extremity strength and dynamic balance skills in the athletic performance of adolescent wrestlers. The study also aims to provide a scientific basis for improving the biomotor abilities of wrestlers.

Material & Methods

Research Design This study was conducted using a correlational survey model to investigate the role of upper and lower extremity strength and dynamic balance skills in the sports performance of adolescent wrestlers. The correlational survey model is appropriate for examining the relationship between variables (Karasar, 2009).

Research Group The study included a total of 39 adolescent male wrestlers, aged between 12-15 years, who regularly trained at least three days a week in various sports clubs. Among the participants, 19 were successful athletes with medals, while 20 were beginner athletes without medal achievements. Successful athletes were required to have at least three years of regular training experience and to have placed in the top three in the Turkish Inter-School Wrestling Championships. Beginner athletes had at least two years of regular training experience but had not achieved any national-level success. Before participating in the study, all participants were thoroughly informed about the research protocol and potential experimental risks.

Participation in the study was conducted after obtaining written consent from the participants' parents. Exclusion criteria included a history of upper or lower extremity injuries, cardiovascular or respiratory disorders, and any injuries sustained during the testing process. The sample size was determined using G*Power 3.1.9.4 software. In the power analysis, the significance level (α) was set at 5% ($\alpha = 0.05$, Type I error), and the power value ($1-\beta$) was targeted at 90% ($\beta = 0.10$, Type II error). The effect size ($|\rho|$) was set at a moderate level of 0.5. Based on these parameters, it was calculated that a minimum of 31 participants would be sufficient for the study. Considering potential participant dropouts or withdrawals during the research process, a total of 39 participants were included to enhance the reliability and statistical power of the study. The participants' demographic characteristics are presented in Table 1.

Table 1. Descriptive Statistical Analysis of Participants

Variable	Successful (n=19)	Beginner (n=20)	t	p	ES (Cohen's d)
Age	13.63 ± 0.96	13.40 ± 1.19	0.669	0.508	0.214
Training Age	3.42 ± 0.69	2.75 ± 0.64	3.148	0.003*	1.009
Body Weight	51.84 ± 10.75	57.05 ± 18.04	-1.088	0.284	-0.349
Height	1.60 ± 0.11	1.63 ± 0.10	-0.794	0.432	-0.254
BMI (kg/m ²)	20.02 ± 2.78	21.09 ± 4.37	-0.910	0.369	-0.291

*p<0.05, **BMI:** Body Mass Index, **ES:** Effect Size (Cohen's d)

Research Procedures

The study was conducted in two separate sessions, scheduled simultaneously (11:00-13:00) to account for circadian rhythms that could affect participants' physiological and performance levels. The Y Balance Test was administered in the first session to assess upper and lower extremity dynamic balance performance. At the same time, Vertical Jump and Standing Long Jump Tests were conducted to measure explosive power (Gençoğlu et al., 2023). In the second session, the Grip Strength Test was performed to determine isometric strength levels, the Medicine Ball Throw Test was applied to evaluate upper extremity explosive power, and the Special Judo Fitness Test (SJFT) was used to assess sport-specific performance (Šimenko & Karpljuk, 2016). All tests were conducted following standard protocols to ensure participant safety and the validity of the measurements.

Data Collection Tools

In this study, the following data collection tools were utilized: Personal Information Form, Special Judo Fitness Test (SJFT), Upper and Lower Extremity Balance (Y Balance Test), Lower Extremity Explosive Power (Standing Long Jump and Vertical Jump Tests), Upper Extremity Isometric Strength (Hand Dynamometer), and Upper Extremity Explosive Power (Medicine Ball Throw Test).

Personal Information

The researcher prepared and administered a questionnaire to collect demographic information about the participants. This form included age, height, body weight, training experience (training age), and body mass index (BMI).

Upper Extremity Y Balance Test (UEYBT)

The Upper Extremity Y Dynamic Balance Test (UEYBT) assessed shoulder stability and upper extremity balance (Gorman et al., 2012). The test began with participants assuming a push-up position. While one hand was placed on the designated balance point, the other extended toward a medial direction to reach a block at the farthest reachable point. Participants were instructed to maintain their body position while extending their hands as far as possible and pushing the block.

Three measurements were taken for each reaching direction, and participants were returned to the starting position after each attempt. The average of the three measurements was recorded in centimeters (cm). As indicated in the composite score for the UEYBT, it was calculated by summing the reach distances in three different directions (anterior, posteromedial, and posterolateral) and averaging these values (Shaffer et al., 2013). In this study, composite scores were calculated separately for the right and left arms, and the results were recorded in centimeters (Robinson & Gribble, 2008).

Composite Score (%) = $[(\text{Medial} + \text{Inferolateral} + \text{Superolateral}) / (3 \times \text{Arm Length})] \times 100$

Lower Extremity Y Balance Test (LEYBT)

The Y Balance Test (LEYBT) was employed in this study to assess lower extremity stability and balance asymmetries. The YBT is a widely preferred, reliable, and cost-effective measurement tool for evaluating balance performance and injury risk in athletes (Shaffer et al., 2013). Using both the right and left foot, the LEYBT measured participants' dynamic balance performance in three directions -anterior, posteromedial, and posterolateral (Gribble et al., 2012). The test platform was designed at a 45° angle for the posterior and 135° angles for the anterior directions. During the test, participants kept their hands on their hips while stabilizing one foot on the platform and reaching with the toes of the other foot to push a block as far as possible in the designated three directions. After each attempt, participants returned to the starting position. Participants' leg length was measured as the distance between the anterior superior iliac spine and the medial malleolus and was recorded accordingly. Three measurements were taken in each direction, and results were evaluated using a normalization formula (Plisky et al., 2009; Robinson & Gribble, 2008). The YBT is recognized as a reliable method for analyzing lower extremity dynamic balance performance and detecting potential balance asymmetries.

Composite Score (%) = $[(\text{Anterior} + \text{Posteromedial} + \text{Posterolateral}) / (3 \times \text{Leg Length})] \times 100$

Vertical Jump Test (VJT)

Athletes performed a maximal upward jump without stepping or rebounding to evaluate lower extremity explosive power capacity. Each participant attempted the jump three times, and the best result was recorded in seconds (s). Performance measurement was conducted using a precise measuring device. This test is widely used to assess performance in sports requiring explosive power, such as wrestling (Markovic et al., 2004).

Standing Long Jump Test (SLJT)

To assess the horizontal explosive power capacity of the lower extremities, athletes stood with their feet together, pulled their arms backward, and jumped forward with maximal force. Each participant attempted the jump thrice; the longest jump distance was recorded in centimeters (cm). Participants were instructed to maintain balance during the jump (Chamari et al., 2008).

Grip Strength Test (GST)

Upper extremity isometric strength capacity was measured using a Baseline Hydraulic Hand Dynamometer (Japan). Participants performed the test while seated, keeping their arms close to their body with elbows bent at 90° (Özbay et al., 2024). The forearm was supported in a neutral position, and the wrist remained relaxed. The test started with the dominant hand, followed by the non-dominant hand. A 60-second rest period was provided between each measurement, and the test was repeated three times for each hand. The average of

the three measurements was recorded in kilograms (kg) (Bohannon, 2001; Chamari et al., 2008; Pizzigalli et al., 2017).

Medicine Ball Throw Test (MBT)

This test was used to evaluate upper extremity explosive power capacity. The test aimed to assess the athletes' bilateral upper extremity strength (Stockbrugger & Haennel, 2003). Participants were instructed to throw a 2 kg medicine ball as far forward as possible. Participants sat with their backs, shoulders, and head against the wall during the test. Their upper extremities were positioned at 90° abduction with elbows flexed. Participants were instructed to maintain contact with the wall (head, shoulders, and back) throughout the test and to use the basketball chest pass technique to throw the ball directly forward (Cronin & Owen, 2004; Harris et al., 2011). The test began with three trial throws and a 2-minute rest period. Participants performed four maximum-effort throws, with 1-minute rest intervals between each attempt. Researchers ensured proper technique was maintained during each throw (Borms et al., 2016). Additionally, participants were instructed to maintain full elbow extension during the test position. To account for variations in upper extremity length, participants were asked to throw the ball directly onto a measuring tape for accurate distance recording (Harris et al., 2011).

Special Judo Fitness Test (SJFT)

The Special Judo Fitness Test (SJFT) is designed to assess anaerobic capacity and speed ability. Although originally developed for judo athletes, it is also utilized to evaluate the performance of wrestlers due to the shared mechanical and technical elements between judo and wrestling (Franchini et al., 2011). The test is conducted with three athletes: one performer and two partners. The partners are positioned 6 meters apart, while the performer is placed exactly 3 meters away from each partner at the middle point.

The test consists of three phases conducted in two circuits:

- Phase 1 (15 seconds): The performer applies the "one-arm" technique as often as possible on both partners.
- Phase 2 (30 seconds): Using the same technique, the performer executes maximum repetitions, followed by a 10-second rest.
- Phase 3 (30 seconds): This phase mirrors Phase 2, where the performer applies the technique as many times as possible, and the total number of attempts is recorded.

Following the test, the participant's heart rates were measured twice: immediately after the test and again after 1 minute of rest. Performance evaluation was based on the total number of "one-arm" techniques performed in each phase and the recorded heart rates. The SJFT is recognized as a reliable method for assessing wrestlers' anaerobic endurance, technical efficiency, and physical performance (Sterkowicz & Franchini, 2001). A lower performance index is considered an indicator of better performance.

Performance Index = (Heart Rate 1 + Heart Rate 2) / (Phase 1 + Phase 2 + Phase 3)

Data Analysis

Statistical analyses were conducted using SPSS 27 software. The normality assumption was tested with the Shapiro-Wilk test, confirming that the data were normally distributed ($p > 0.05$). The homogeneity of variances between groups was assessed using Levene's Test, which indicated that the variances were homogeneous ($p > 0.05$). Under these conditions, the Independent Samples T-Test was used to evaluate differences between the two independent groups. The significance level was set at $p < 0.05$. To assess the effect size of the observed differences, Cohen's d values were calculated and interpreted according to Hopkins' (2002) classification: 0.00 - 0.19: Trivial, 0.20 - 0.59: Small, 0.60 - 1.19: Moderate, 1.20 - 1.99: Large, ≥ 2.00 : Very Large. This analysis approach allows for evaluating the statistical significance of group differences and their practical and clinical significance (Hopkins, 2002).

Ethical Approval

Publication principles, research ethics, and publication ethics guidelines were conducted in this study. Ethical approval for the study was obtained from the Scientific Research and Publication Ethics Committee of Erzurum Technical University during the 01st meeting on January 2, 2025, with decision number 02.

Findings

Table 2. Statistical Analysis of Isometric Strength and Explosive Power Data of Participants

Variable	Successful (n=19)	Beginner (n=20)	t	p	ES (Cohen's d)
DHGST (kg)	26,70 ± 6,51	24,63 ± 8,52	0,851	0,400	0,273
NDHGST (kg)	25,03 ± 6,58	24,03 ± 8,66	0,513	0,611	0,164
MBT (cm)	291,53 ± 62,34	294,35 ± 58,56	-0,146	0,885	-0,047
SLJT (cm)	190,47 ± 21,11	175,65 ± 19,61	2,274	0,029*	0,728
VJT (cm)	38,91 ± 3,81	34,82 ± 4,82	2,903	0,006*	0,942

Note: * $p < 0.05$. **ES:** Effect Size (Cohen's d). **DHGST:** Dominant Hand Grip Strength Test, **NDHGST:** Non-Dominant Hand Grip Strength Test, **MBT:** Medicine Ball Throw Test, **SLJT:** Standing Long Jump Test, **VJT:** Vertical Jump Test, **Kg:** Kilogram, **cm:** Centimeter.

When Table 2 is examined, no significant difference was found between the groups in terms of dominant hand grip strength (successful: 26.70 ± 6.51; beginner: 24.63 ± 8.52) and non-dominant hand grip strength (successful: 25.03 ± 6.58; beginner: 24.03 ± 8.66) ($p > 0.05$). Similarly, no significant difference was identified between successful (291.53 ± 62.34) and beginner (294.35 ± 58.56) athletes regarding medicine ball throw

distances ($p = 0.885$). On the other hand, in the standing long jump performance, successful athletes (190.47 ± 21.11) achieved significantly higher results compared to beginner athletes (175.65 ± 19.61) ($p = 0.029$). In terms of vertical jump performance, successful athletes (38.91 ± 3.81) demonstrated significantly higher averages than beginner athletes (34.82 ± 4.82) ($p = 0.006$).

Table 3. Statistical Analysis of Participants' Lower Extremity Balance Measurements

	Variable	Successful (n=19)	Beginner (n=20)	t	p	ES (Cohen's d)
Right	Medial	63,37 $\pm$ 6,50	62,05 $\pm$ 6,50	0,633	0,531	0,203 _(SES)
	Inferolateral	65,47 $\pm$ 9,67	65,20 $\pm$ 4,77	0,113	0,911	0,036 _(TES)
	Superolateral	59,37 $\pm$ 9,58	60,50 $\pm$ 9,57	-0,369	0,714	-0,118 _(TES)
	Composite	88,06 $\pm$ 10,30	87,37 $\pm$ 9,75	0,214	0,831	0,069 _(TES)
Left	Medial	63,32 $\pm$ 6,73	61,00 $\pm$ 6,36	0,818	0,418	0,262 _(SES)
	Inferolateral	65,42 $\pm$ 6,89	64,65 $\pm$ 7,23	0,340	0,735	0,109 _(TES)
	Superolateral	61,95 $\pm$ 8,78	59,90 $\pm$ 8,81	0,726	0,472	0,233 _(SES)
	Composite	89,36 $\pm$ 9,95	86,53 $\pm$ 9,79	0,894	0,377	0,286 _(SES)

Note: * $p < 0.05$. **ES:** Effect Size (Cohen's d); **SES:** Small Effect Size. **TES:** Trivial Effect Size.

When Table 3 is examined, no statistically significant difference was found for any of the variables ($t < 0.894$, $p > 0.377$, $ES < 0.286$). These findings indicate that there is no significant difference in balance performance between the groups.

Table 4. Statistical Analysis of Upper Extremity Balance Measurements of the Participants

	Variable	Successful (n=19)	Beginner (n=20)	t	p	ES (Cohen's d)
Right	Medial	72,32 $\pm$ 5,15	70,10 $\pm$ 7,44	1,076	0,289	0,345 _(SES)
	Inferolateral	48,32 $\pm$ 8,94	44,70 $\pm$ 5,54	1,086	0,285	0,345 _(SES)
	Superolateral	56,37 $\pm$ 8,13	54,60 $\pm$ 7,91	0,688	0,496	0,216 _(SES)
	Composite	66,32 $\pm$ 7,34	62,94 $\pm$ 5,20	1,665	0,104	0,381 _(SES)
Left	Medial	69,69 $\pm$ 6,22	70,25 $\pm$ 7,23	-0,164	0,871	-0,053 _(TES)
	Inferolateral	47,79 $\pm$ 7,49	45,50 $\pm$ 9,69	0,822	0,416	0,263 _(SES)
	Superolateral	55,26 $\pm$ 8,98	51,45 $\pm$ 8,30	1,402	0,169	0,440 _(SES)
	Composite	64,84 $\pm$ 9,36	61,45 $\pm$ 8,30	1,189	0,242	0,373 _(SES)

Note: * $p < 0.05$. **ES:** Effect Size (Cohen's d). **MES:** Medium Effect Size, **SES:** Small Effect Size. **TES:** Trivial Effect Size

When Table 4 is examined, no statistically significant difference was found for any of the variables ($t < 1.665$, $p > 0.104$, $ES < 0.440$). These findings indicate that there is no significant difference in balance performance between the groups.

Table 5. Statistical Analysis of Participants' SJFT Data

Variable	Successful (n=19)	Beginner (n=20)	t	p	ES (Cohen's d)
SJFT 15 sec (T)	5.37 $\pm$ 0.50	5.05 $\pm$ 0.60	1.793	0.081	0.574 _(SES)
SJFT 30 sec (T)	9.47 $\pm$ 0.70	8.90 $\pm$ 0.97	2.115	0.041*	0.677 _(MES)
SJFT 30 sec (T)	8.42 $\pm$ 0.69	8.15 $\pm$ 0.88	1.069	0.292	0.342 _(SES)
Resting HR	81.79 $\pm$ 5.28	84.55 $\pm$ 4.57	-1.749	0.089	-0.560 _(SES)
Post-SJFT HR	171.16 $\pm$ 6.57	173.80 $\pm$ 7.40	-1.177	0.247	-0.377 _(SES)
Post-SJFT 1MinHR	125.05 $\pm$ 8.64	128.75 $\pm$ 11.26	-1.146	0.259	-0.367 _(SES)
SJFT PI	12.76 $\pm$ 0.87	13.77 $\pm$ 1.18	-3.051	0.004*	-0.970 _(MES)

Note: * $p < 0.05$. **T:** Trial, **HR:** Heart Rate, **SJFT:** Special Judo Fitness Test, **SJFT PI:** Special Judo Fitness Test Performance Index, **SJFT:** Special Judo Fitness Test, **ES:** Effect Size (Cohen's d), **MES:** Medium Effect Size, **SES:** Small Effect Size.

According to Table 5, the SJFT Phase 2 (30-second test) showed a statistically significant difference between the groups ($t = 2.115$; $p = 0.041$; Cohen's $d = 0.677$). Additionally, a statistically significant difference was found between successful and beginner athletes in the SJFT performance index ($t = -3.051$; $p = 0.004$; Cohen's $d = 0.970$). These results suggest that the SJFT performance index score is lower in successful athletes than beginner athletes (a lower index score indicates better performance). No significant difference was found between the groups for any other variables ($t < 1.793$; $p > 0.081$; Cohen's $d < 0.574$).

Table 6. Correlation Analysis between Isometric Strength and Explosive Strength and SJFT Performance

Variable	Relationship with SJFT Test Pearson Correlation (r)	p
DHGST (kg)	0.006	0.970
NDHGST (kg)	-0.068	0.682
MBT (cm)	-0.071	0.666
SLJT (cm)	-0.478	0.002*
VJT (cm)	-0.663	0.001*

Note: * $p < 0.05$. **ES:** Effect Size (Cohen's d). **DHGST:** Dominant Hand Grip Strength Test, **NDHGST:** Non-Dominant Hand Grip Strength Test, **MBT:** Medicine Ball Throw Test, **SLJT:** Standing Long Jump Test, **VJT:** Vertical Jump Test, **SJFT:** Special Judo Fitness Test, **Kg:** Kilogram, **cm:** Centimeter.

Table 6 shows significant negative correlations between SJFT performance and vertical jump ($r = -0.663$, $p = 0.001$) and horizontal jump ($r = -0.478$, $p = 0.002$) variables. This negative relationship is because a lower SJFT Index indicates better performance. This finding suggests that medal-winning (successful) athletes possess better lower extremity explosive strength values. No significant correlation was found between SJFT performance and other variables, such as dominant and non-dominant hand grip strength or medicine ball throw ($p > 0.66$, $r < [0.071]$). These results demonstrate that SJFT performance is statistically significantly associated, particularly with lower extremity explosive strength tests.

Table 7. Correlation Analysis Between Balance Performances and SJFT Performance

Variable	SJFT Pearson Correlation (r)	Performance p
Right Lower Composite (%)	-0,514	< 0,001*
Left Lower Composite (%)	-0,420	0,008*
Right Upper Composite (%)	-0,252	0,121
Left Upper Composite (%)	-0,212	0,196

Note: * $p < 0.05$. %: Percentage.

When Table 7 is examined, a statistically significant and negative correlation was found between SJFT performance and the right lower composite score ($r = -0.514$, $p < 0.001$). Similarly, an important and negative correlation was observed between the lower left composite score and SJFT performance ($r = -0.420$, $p = 0.008$). However, no statistically significant correlation was found between SJFT performance and the right upper composite ($r = -0.252$, $p = 0.121$) or left upper composite ($r = -0.212$, $p = 0.196$) parameters ($p > 0.05$). These findings indicate that SJFT performance is significantly associated with lower extremity balance performance. A lower SJFT Performance Index, indicating better performance, can explain the negative correlation with composite scores. This outcome suggests that medal-winning (successful) athletes have better composite scores.

Discussion

In this study, the sports performance of adolescent wrestlers was compared in terms of upper and lower extremity strength, dynamic balance skills, and explosive power. The findings indicate that successful athletes achieved significantly higher results in standing long jump and vertical jump performances compared to beginner athletes. Conversely, no significant difference was found between the groups in hand grip strength and medicine ball throw tests. Additionally, successful athletes performed better in the Special Judo Fitness Test (SJFT) Performance Index. These results highlight the crucial contribution of lower extremity explosive power to wrestling performance.

The study compared the isometric and explosive strength levels of athletes. The findings showed that successful athletes had higher hand grip strength scores than beginner athletes, but this difference was not statistically significant. When examining the literature, it is evident that parameters such as maximal dynamic strength, isometric strength, explosive power, and strength endurance are closely associated with high performance in wrestling (Chaabene et al., 2017; Myers et al., 2010). Research on various exercise types has shown that movements performed with the dominant side generally perform better than those performed with the non-dominant side (Guette et al., 2005; Sachlikidis & Salter, 2007; Sugiyama et al., 2014). Due to the nature of wrestling, upper extremity, lower extremity, and overall body strength are also crucial factors. The study by Cisa et al. (1987) revealed that moderate leg and forearm strength levels could predict wrestling success (Cisa et al., 1987). These findings suggest that hand grip strength alone may have a limited role in determining success, while combined strength components such as lower extremity and trunk strength may be more decisive. A study by Çelikel et al. (2020) observed an increase in grip strength with age in 15-year-old wrestlers. This finding was linked to the natural increase in strength capacity during the developmental period (Çelikel et al., 2020). However, it was noted that this increase alone is not a determining factor in performance; rather, comprehensive development in strength and technical skills is critical for wrestling success. Similarly, Aslan et al. (2013) identified a significant increase in grip strength among wrestlers aged 13-15 over a one-year developmental period (Aslan et al., 2013). Likewise, a study by Cicioğlu et al. (2007) reported increased grip strength among wrestlers aged 15-17 following a 40-week training program; however, this difference was not statistically significant (Cicioğlu et al., 2007). These findings indicate that wrestling performance cannot be explained solely by hand grip strength. Instead, performance should be evaluated through training duration, technical skills, general strength, and endurance.

The study found no significant difference between successful and beginner athletes in terms of medicine ball throw distances. This finding suggests that the medicine ball throw test is not a determining factor for performance differences between the two groups. Similarly, Bayraktar et al. (2012) reported no significant difference in medicine ball throw distances between freestyle and Greco-Roman wrestlers, consistent with the present study's findings (Bayraktar et al., 2012). Our research observed noticeable differences in jump performance between successful and beginner athletes. The literature emphasizes lower extremity strength is associated with performance components such as jump height and speed (Struzik et al., 2014). Cisa et al. (1987) also identified forearm and leg strength as key factors influencing wrestling performance (Cisa et al., 1987; Struzik et al., 2014).

These findings suggest that lower extremity strength may be crucial in sports like wrestling, where explosive movements are frequently required. Although successful athletes had higher averages in upper and lower extremity balance tests in the study, no significant difference was found between the groups. The literature emphasizes balance as an important parameter in sports requiring technical skills, such as wrestling (Ateş et al., 2017). Soyuer et al. (2006) reported a relationship between balance and lower extremity muscle strength (Soyuer & Mirza, 2006). These findings suggest that while leg strength may influence wrestling performance, balance skills may not always be a decisive factor. The literature highlights that balance and strength are integrated elements crucial for performance in sports requiring technical skills like wrestling (Basar et al., 2014). Bayati et al. (2019) also emphasized that balance is a significant component of motor skills. Based on this context, the strategic use of balance and strength in wrestling is important in enhancing athlete performance and minimizing injury risk. The conflicting results in the literature compared to our study's findings may be related to differences in sample age ranges, training levels, or training history.

According to the findings of this study, a significant difference was found between successful and beginner athletes in terms of the SJFT Phase 2 (30-second test) and the SJFT performance index. Successful athletes were found to have a lower SJFT performance index score compared to beginner athletes. As the SJFT performance index decreases, performance improves. No significant difference was found between the groups for any other variables. The Special Judo Fitness Test (SJFT) is considered an important method not only for evaluating general performance in elite wrestlers but also for monitoring anaerobic performance development (Barbas et al., 2017; Lopez, 2018; Zylfi et al., 2013). The literature indicates that the SJFT can assess athletes' anaerobic systems. It has been reported that elite judokas tend to have lower index values. In comparison, intermediate-level judokas typically have higher values (Ceylan et al., 2022), which aligns with the present study's findings. Heart rate during and after exercise is recognized as a significant indicator of exercise intensity (James et al., 2012). Additionally, the perceived exertion level during exercise can be used to determine intensity, and a positive correlation between these two variables has been reported (Scherr et al., 2013). Furthermore, the perceived exertion scale can provide insights into the intensity of exercise based on the score reported by the athletes during the activity (Bromley et al., 2018; Slimani et al., 2017). Similar findings regarding heart rate responses have been reported in studies conducted on young judokas (Šimenko & Karpljuk, 2016). These studies identified significant relationships between physical and judo-specific performance, highlighting anaerobic endurance as a key indicator in monitoring athletes' performance.

According to another study, successful athletes achieved higher scores on the SJFT test than beginner athletes. This indicates that experienced athletes possess lower extremity explosive power and the ability to use this power effectively. In the study conducted by Arazı et al. (2017), the relationship between senior male judokas' anthropometric and bio-motor characteristics and the Special Judo Fitness Test (SJFT) was examined (Arazı et al., 2017). The study found a negative correlation between low body strength, vertical jump height, flexibility, hand grip strength, and anaerobic power with the SJFT index. In contrast, a positive correlation was observed between speed and agility with the SJFT index.

Another study found a significant and negative correlation between SJFT performance and lower composite scores on the right and left. On the other hand, no significant correlation was found between SJFT performance and right and left upper composite scores. Since a lower SJFT index indicates better performance, successful athletes were found to have better composite scores. Balance is essential in various motor skills, from maintaining a simple stance to performing complex sports skills (Davlin, 2004). Particularly in wrestling, the relationship between strength and balance can influence athletes' technical performance (Ulupinar et al., 2021). In a research, it was reported that there was a weak correlation between wrestling performance and Y balance test results; there was a significant correlation between lower extremity Y balance test results only in posteromedial direction (Alper & Kolayış, 2020). This suggests that balance tests may contribute indirectly to wrestling performance. Additionally, a study reported that high lumbopelvic stability effectively transfers the force generated from the lower extremities to the upper extremities through the trunk and contributes to athletic performance (Mills et al., 2005). These findings are consistent with the results of the present study.

Conclusion and Recommendations

The study compared successful and beginner wrestlers' physiological and performance parameters, and significant differences were identified in some tests. Successful athletes demonstrated higher performance in standing long jump and vertical jump tests, indicating that lower extremity explosive power contributed to their performance. Successful athletes also achieved better results in the Special Judo Fitness Test (SJFT), with lower (better) SJFT index scores observed. Significant negative correlations were also found between SJFT performance and standing long jump and vertical jump tests. The negative correlation between balance tests and SJFT performance suggests that improving lower extremity balance skills positively influences SJFT performance. Based on these findings, it is considered beneficial to implement training programs to enhance lower extremity explosive power and balance skills to improve wrestlers' performance. This study has some limitations. The research was conducted only with male wrestlers aged 12-15, which limits the generalizability of the findings to different age groups and genders. Additionally, the study did not assess psychological factors such as motivation, stress, and focus, preventing the determination of their impact on wrestling performance.

Acknowledgement

In this study, AI-based proofreading tools were used to assist in the language editing of the manuscript to ensure clarity and consistency in the writing process. This process was conducted under human supervision to maintain academic integrity. The present article was produced from the master's thesis titled "The Role of Upper and Lower Extremity Strength and Dynamic Balance Skills in the Sports Performance of 12–15-Year-Old Wrestlers" completed at Erzurum Technical University, Institute of Health Sciences, Department of Physical Education and Sport, in 2025 by Memet BOLUKBASI. We also want to express our sincere gratitude to all the athletes who voluntarily participated in this study.

Conflict of interest

All authors confirm that there is no conflict of interest in this study.

References

- Alper, E., & Kolayış, İ. E. (2020). Examination of the Relationship Between Wrestling Performance and Trunk Stability, Dynamic Balance, and Functional Mobility in Cadet Wrestlers. *CBU Journal of Physical Education and Sport Sciences*, 15(1), 48-66. <https://doi.org/10.33459/cbubebd.697636>
- Arazi, H., Noori, M., & Izadi, M. (2017). Correlation of anthropometric and bio-motor attributes with Special Judo Fitness Test in senior male judokas. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, 17(4), 19-24.
- Asan, S. (2023). Investigation of the relationship between upper extremity neuromuscular control and grip strength with shooting accuracy in elite handball players. *Spor Bilimleri Araştırmaları Dergisi*, 8(3), 522-534. <https://doi.org/10.25307/jssr.1278645>
- Asan, S., Özdemir, E., & Gençoğlu, C. (2025). The Role of Lower Extremity Neuromuscular Control and Stability in Predicting Biomotor Skills in Soccer Players. *Journal of Sport Sciences Research*, 10(1), 15-28. <https://doi.org/10.25307/jssr.1570091>
- Aslan, C., Karakollukçu, M., Gül, M., & Fişne, M. (2013). Comparison of One-Year Changes in the Physical and Motor Characteristics of 13–15-Year-Old Wrestlers. *Turkish Journal of Sports Medicine*, 48(1).
- Ateş, B., Çetin, E., & Yarım, İ. (2017). Balance Ability and Balance Training in Female Athletes. *Gaziantep University Journal of Sport Sciences*, 2(2), 66-79.
- Barbas, I., Giannakou, E., Aggeloussis, N., & Gourgoulis, V. (2017). 3D DUTH wrestling dummy and training. *Applicable Research in Wrestling*, 52.
- Basar, S., Duzgun, I., Guzel, N. A., Cicioglu, I., & Celik, B. (2014). Differences in strength, flexibility and stability in freestyle and Greco-Roman wrestlers. *J Back Musculoskeletal Rehabil*, 27(3), 321-330. <https://doi.org/10.3233/BMR-130451>
- Bayraktar, I., Deliceoğlu, G., & Kahraman, E. (2012). Comparison of certain physical parameters of 15–17-year-old wrestlers according to wrestling styles. *International Peer-Reviewed Journal of Health and Medical Sciences*, 2(2), 56-67.
- Bohannon, R. W. (2001). Dynamometer measurements of hand-grip strength predict multiple outcomes. *Perceptual and motor skills*, 93(2), 323-328.
- Borms, D., Maenhout, A., & Cools, A. M. (2016). Upper Quadrant Field Tests and Isokinetic Upper Limb Strength in Overhead Athletes. *Journal of Athletic Training*, 51(10), 789-796. <https://doi.org/10.4085/1062-6050-51.12.06>
- Bromley, S. J., Drew, M. K., McIntosh, A., & Talpey, S. (2018). Rating of perceived exertion is a stable and appropriate measure of workload in judo. *Journal of science and medicine in sport*, 21(10), 1008-1012.
- Ceylan, B., Şimenko, J., & Balci, Ş. S. (2022). Which Performance Tests Best Define the Special Judo Fitness Test Classification in Elite Judo Athletes? *Journal of functional morphology and kinesiology*, 7(4), 101.
- Chaabene, H., Negra, Y., Bouguezzi, R., Mkaouer, B., Franchini, E., Julio, U., & Hachana, Y. (2017). Physical and physiological attributes of wrestlers: an update. *The Journal of Strength & Conditioning Research*, 31(5), 1411-1442. <https://doi.org/10.1519/JSC.0000000000001738>
- Chamari, K., Chaouachi, A., Hambli, M., Kaouech, F., Wisloff, U., & Castagna, C. (2008). The Five-Jump Test for Distance as a Field Test to Assess Lower Limb Explosive Power in Soccer Players. *Journal of Strength and Conditioning Research*, 22(3), 944-950. <https://doi.org/10.1519/JSC.0b013e31816a57c6>
- Chernozub, A., Korobeynikov, G., Zoriy, Y. B., Koval, V., Husieva, I., Hryhoriev, V., Xianyu, W., Khasanov, O., & Potop, V. (2024). Mechanism for assessing the adaptive reserves of elite wrestlers under anaerobic energy supply conditions. *Journal of Physical Education and Sport*, 1072-1079.
- Cicioğlu, İ., Kürkçü, R., Eroğlu, H., & Yüksek, S. (2007). Seasonal Changes in the Physical and Physiological Characteristics of Wrestlers Aged 15–17. *Spormetre Journal of Physical Education and Sport Sciences*, 5(4), 151-156. https://doi.org/10.1501/Sporm_00000000085
- Cisa, C. J., Johnson, G. O., Fry, A. C., Housh, T. J., Hughes, R. A., Ryan, A. J., & Thorland, W. G. (1987). Preseason body composition, build, and strength as predictors of high school wrestling success. *The Journal of Strength & Conditioning Research*, 1(4), 66-70. <https://doi.org/10.1519/00124278-198711000-00002>

- Cronin, J. B., & Owen, G. J. (2004). Upper-body strength and power assessment in women using a chest pass. *Journal of Strength and Conditioning Research*, 18(3), 401-404. <https://doi.org/10.1519/00124278-200408000-00001>
- Çelikel, B. E., Sezer, S. Y., & Karadağ, M. (2020). The Effect of Reaction Speed on Target Shooting Accuracy Scores in Male Archers. *Journal of Sport Education*, 4(1), 30-42.
- Davlin, C. D. (2004). Dynamic balance in high level athletes. *Perceptual and motor skills*, 98(3_suppl), 1171-1176. <https://doi.org/10.2466/pms.98.3c.1171-1176>
- Franchini, E., Del Vecchio, F. B., Matsushigue, K. A., & Artioli, G. G. (2011). Physiological profiles of elite judo athletes. *Sports medicine*, 41, 147-166. <https://doi.org/10.2165/00007256-200232040-00002>
- Gençoğlu, C., & Şen, İ. (2021). Comparison of CrossFit Barbara and classic resistance trainings for the protection of strength performance during off-season in kickboxers. *Isokinetics and Exercise Science*, 29(3), 319-326. <https://doi.org/10.3233/IES-203190>
- Gençoğlu, C., Ulupinar, S., Özbay, S., Turan, M., Savaş, B. Ç., Asan, S., & İnce, İ. (2023). Validity and reliability of “My Jump app” to assess vertical jump performance: a meta-analytic review. *Scientific reports*, 13(1), 20137. <https://doi.org/10.1038/s41598-023-46935-x>
- Gorman, P. P., Butler, R. J., Plisky, P. J., & Kiesel, K. B. (2012). Upper Quarter Y Balance Test: Reliability and Performance Comparison between Genders in Active Adults. *Journal of Strength and Conditioning Research*, 26(11), 3043-3048. <https://doi.org/10.1519/JSC.0b013e3182472fdb>
- Gribble, P. A., Hertel, J., & Plisky, P. (2012). Using the Star Excursion Balance Test to Assess Dynamic Postural-Control Deficits and Outcomes in Lower Extremity Injury: A Literature and Systematic Review. *Journal of Athletic Training*, 47(3), 339-357. <https://doi.org/10.4085/1062-6050-47.3.08>
- Guette, M., Gondin, J., & Martin, A. (2005). Time-of-day effect on the torque and neuromuscular properties of dominant and non-dominant quadriceps femoris. *Chronobiol Int*, 22(3), 541-558. <https://doi.org/10.1081/CBI-200062407>
- Harris, C., Wattles, A. P., DeBeliso, M., Sevene-Adams, P. G., Berning, J. M., & Adams, K. J. (2011). The Seated Medicine Ball Throw as a Test of Upper Body Power in Older Adults. *Journal of Strength and Conditioning Research*, 25(8), 2344-2348. <https://doi.org/10.1519/JSC.0b013e3181ecd27b>
- Hopkins, W. G. (2002). A scale of magnitudes for effect statistics. *A new view of statistics*, 502(411), 321.
- Hubner-Wozniak, E., Kosmol, A., Lutoslawska, G., & Bem, E. Z. (2004). Anaerobic performance of arms and legs in male and female free style wrestlers. *J Sci Med Sport*, 7(4), 473-480. [https://doi.org/10.1016/s1440-2440\(04\)80266-4](https://doi.org/10.1016/s1440-2440(04)80266-4)
- James, D. V., Munson, S. C., Maldonado-Martin, S., & De Ste Croix, M. B. (2012). Heart rate variability: effect of exercise intensity on postexercise response. *Res Q Exerc Sport*, 83(4), 533-539. <https://doi.org/10.1080/02701367.2012.10599142>
- Karasar, N. (2009). Scientific Research Method: Concepts, Principles, and Techniques. *Ankara: Nobel Publishing and Distribution*.
- Kaya, O., Tutar, M., Caglayan, A., & Korkmaz, H. (2025). Effects of lower extremity isoinertial strength training on shooting speed, dynamic balance, and dribbling skills in adolescent football players. *Journal of Physical Education and Sport*, 25(1), 209-217.
- Lopez, D. (2018). Scoring analysis of the senior world wrestling championships-2017. *International Journal of Wrestling Science*, 8(1), 27-82.
- Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. *Journal of Strength and Conditioning Research*, 18(3), 551-555. <https://doi.org/10.1519/1533-4287>
- Mills, J. D., Taunton, J. E., & Mills, W. A. (2005). The effect of a 10-week training regimen on lumbo-pelvic stability and athletic performance in female athletes: A randomized-controlled trial. *Physical Therapy in Sport*, 6(2), 60-66. <https://doi.org/10.1016/j.ptsp.2005.02.006>
- Myers, R. J., Linakis, S. W., Mello, M. J., & Linakis, J. G. (2010). Competitive wrestling-related injuries in school aged athletes in US emergency departments. *Western journal of emergency medicine*, 11(5), 442. <https://doi.org/PMC3027436>
- Özbay, S., Gençoğlu, C., Ulupinar, S., Çınar, V., Ouergui, I., & Hölbling, D. (2024). The effect of fatigue on strength-power tests for distinguishing elite-level male kickboxers. *Isokinetics and Exercise Science* (Preprint), 1-12. <https://doi.org/10.3233/IES-240023>
- Pizzigalli, L., Micheletti Cremasco, M., A. L. A. T., Rainoldi, A., & Benis, R. (2017). Hand grip strength and anthropometric characteristics in Italian female national basketball teams. *J Sports Med Phys Fitness*, 57(5), 521-528. <https://doi.org/10.23736/S0022-4707.16.06272-1>
- Plisky, P. J., Gorman, P. P., Butler, R. J., Kiesel, K. B., Underwood, F. B., & Elkins, B. (2009). The reliability of an instrumented device for measuring components of the star excursion balance test. *N Am J Sports Phys Ther*, 4(2), 92-99. <https://www.ncbi.nlm.nih.gov/pubmed/21509114>
- Robinson, R., & Gribble, P. (2008). Kinematic Predictors of Performance on the Star Excursion Balance Test. *Journal of Sport Rehabilitation*, 17(4), 347-357. <https://doi.org/DOI.10.1123/jsr.17.4.347>

- Sachlikidis, A., & Salter, C. (2007). A biomechanical comparison of dominant and non-dominant arm throws for speed and accuracy. *Sports Biomechanics*, 6(3), 334-344. <https://doi.org/10.1080/14763140701491294>
- Scherr, J., Wolfarth, B., Christle, J. W., Pressler, A., Wagenpfeil, S., & Halle, M. (2013). Associations between Borg's rating of perceived exertion and physiological measures of exercise intensity. *European Journal of Applied Physiology*, 113(1), 147-155. <https://doi.org/10.1007/s00421-012-2421-x>
- Shaffer, S. W., Teyhen, D. S., Lorenson, C. L., Warren, R. L., Koreerat, C. M., Straseske, C. A., & Childs, J. D. (2013). Y-balance test: a reliability study involving multiple raters. *Mil Med*, 178(11), 1264-1270. <https://doi.org/10.7205/MILMED-D-13-00222>
- Šimenko, J., & Karpljuk, D. (2016). Can special judo fitness test be used to detect asymmetries in movement patterns? *ZBORNIK*.
- Slimani, M., Davis, P., Franchini, E., & Moalla, W. (2017). Rating of Perceived Exertion for Quantification of Training and Combat Loads During Combat Sport-Specific Activities: A Short Review. *Journal of Strength and Conditioning Research*, 31(10), 2889-2902. <https://doi.org/10.1519/JSC.0000000000002047>
- Soyuer, F., & Mirza, M. (2006). Relationship between lower extremity muscle strength and balance in multiple sclerosis. *Journal of Neurological Sciences (Turkish)*, 23(4), 257-263.
- Sterkowicz, S., & Franchini, E. (2001). Specific fitness of elite and novice judoists. *Journal of Human Kinetics*, 6(1), 81-98.
- Stockbrugger, B. A., & Haennel, R. G. (2003). Contributing factors to performance of a medicine ball explosive power test: a comparison between jump and nonjump athletes. *The Journal of Strength & Conditioning Research*, 17(4), 768-774.
- Struzik, A., Pietraszewski, B., & Zawadzki, J. (2014). Biomechanical Analysis of the Jump Shot in Basketball. *Journal of Human Kinetics*, 42(1), 73-79. <https://doi.org/10.2478/hukin-2014-0062>
- Sugiyama, T., Kameda, M., Kageyama, M., Kiba, K., Kanehisa, H., & Maeda, A. (2014). Asymmetry between the Dominant and Non-Dominant Legs in the Kinematics of the Lower Extremities during a Running Single Leg Jump in Collegiate Basketball Players. *Journal of Sports Science and Medicine*, 13(4), 951-957. <Go to ISI>://WOS:000345121400029
- Ulupinar, S., Özbay, S., Gençoğlu, C., & Ince, I. (2021). Performance differences between Greco-Roman and freestyle wrestlers: A systematic review and meta-analysis. *The Journal of Strength & Conditioning Research*, 35(11), 3270-3279. <https://doi.org/10.1519/JSC.00000000000004129>
- Zylfi, S., Avni, H., Ermir, H., & Perparim, F. (2013). Physical Profile Of Partizani Team In Greek-Roman Wrestling For Youngsters. *Ovidius University Annals, Series Physical Education & Sport/Science, Movement & Health*, 13.