Journal of Sport Science & Innovation (JOSSI)

Comparison of Pinch Strength and Its Relationship with Performance and Demographic Variables in Elite Female Weightlifters

Rıdvan KIR [1*]
Mahmut Esat UZUN [2]
Juan Francisco GARCÍA-VÁZQUEZ [3]
Serap ÜNLÜ [4]

To cite this article:

Kır, R., Uzun, M.E., García-Vázquez, J.F., Ünlü, S. (2025). Comparison of Pinch Strength and Its Relationship with Performance and Demographic Variables in Elite Female Weightlifters. Journal of Sport Science & Innovation (JOSSI), Vol (1), Issue (1), Page 16-Page 29

[1]* Assist. Prof., Department of Physical Education and Sports, Faculty of Education, Necmettin Erbakan University, Konya, Türkiye; rkir@erbakan.edu.tr
[2] Assist. Prof., Department of Coaching Education, Hasan Doğan Faculty of Sport and Health Sciences, Karabük University, Karabük, Türkiye; https://orcid.org/0000-0001-6304-0227; mahmutuzun@karabuk.edu.tr
[3] Associate Professor., Department of Physiotherapy, Research and Sport, FISIDEC University Center (affiliated with the University of Córdoba), Cabra (Córdoba), Spain; c32gavaj@uco.es / jf86phythe@gmail.com
[4] Physical Education and Sports Teacher, Konya Sports High School, Ministry of National Education, Coach at the Olympic Preparation Center (TOHM), Selçuklu, Konya, Türkiye, serapunlu71@gmail.com

Journal of Sport Science & Innovation (JOSSI)

JOSSI Volume 1, Issue 1 Year 2025

Comparison of Pinch Strength and Its Relationship with Performance and Demographic Variables in Elite Female Weightlifters

Rıdvan KIR https://orcid.org/0000-0002-6125-873X
Mahmut Esat UZUN https://orcid.org/0000-0001-6304-0227
Juan Francisco GARCÍA-VÁZQUEZ https://orcid.org/0000-0001-6986-6652
Serap ÜNLÜ

ARTICLE INFORMATION

Original Research
Received 08 November 2025
Accepted 04 December 2025
Published: 12 December 2025
Journal of Sport Science &Innovation (JOSSI) https://jossijournal.com
2025, Volume1, Issue 1, Pages: 16-29

ABSTRACT (Times New Roman typeface and 10 points)

Background: In sports where upper extremity control is important, especially in Olympic-style weightlifting, grip strength and, in particular, pinch strength are considered important performance components.**Objective:** To examine the relationships of grip, key, and palmar pinch strength with weightlifting performance, anthropometric characteristics, and training experience in elite female weightlifters, and to compare athletes from the Turkish National Team (NTW) and the Turkish Olympic Training Center (TOHM). **Methods:** Thirty-two female Olympic-style weightlifters participated in the study (NTW: n = 16; TOHM: n = 16). Anthropometric data and training history were recorded, and maximum snatch and clean-and-jerk values were obtained from federation sources. Grip, key, and palmar pinch strengths were measured on both hands using a calibrated hydraulic dynamometer. Mann–Whitney U and Wilcoxon tests were used for group comparisons, and Spearman's correlation coefficient was used to assess relationships between variables. **Results:** NTW athletes were found to be significantly superior to the TOHM group in years of training, snatch and clean-and-jerk performance, and KP Right, TP Right/Left, and PL Right/Left pinch strength ($p < 0.05$). No significant differences were observed between the two groups in terms of height, body weight, and body mass index. Additionally, no statistically significant differences were found between right- and left-hand pinch strengths in either group. In the NTW group, pinch strength was moderately to strongly correlated with age, training experience, and certain body composition measures, while correlations with technical performance variables were generally weak. **Conclusions:** This study found that pinch strength was moderately to strongly associated with experience-based variables, such as age and training duration, in elite female weightlifters. However, its associations with technical performance measures (snatch and clean & jerk) were generally weak. These findings suggest that while grip strength contributes to overall physical capacity, success in weightlifting also depends on multiple factors, including technical proficiency and motor control.

Keywords: Tip pinch; Key pinch; Palmar pinch; Female weightlifters; Olympic weightlifting

Introduction

Weightlifting is an Olympic sport performed in two main disciplines: the snatch and the clean and jerk, requiring high levels of strength, speed, coordination, and technical skill (Garhammer, 1993, Erdağı, 2022). Success in this sport depends on the optimal combination of lower- and upper-extremity muscle strength and technical performance (Storey and Smith, 2012). Upper-extremity strength plays a critical role in the safe gripping, balancing, and control of the bar during lifts. This relationship is supported by findings that grip strength is significantly associated with snatch performance and can also affect lift success by improving bar control (Huebner, 2023). The force applied during the grip directly affects both the success of the lift and the athlete's risk of injury. Therefore, in weightlifting, grip skills and finger strength are integral to performance. Indeed, a study conducted on elite female adolescent weightlifters revealed that these athletes had higher grip strength using both the thumb and two fingers compared with their sedentary peers, and that their accuracy in reproducing this strength at the target level was also greater. This finding demonstrates that grip strength during weightlifting is a critical component not only of absolute power but also of the acuity of force perception (Erdağı et al., 2020). Pinch force refers to the squeezing force applied between the thumb and other fingers and is generally evaluated in three primary forms: tip pinch, key (lateral) pinch (Mathiowetz et al., 1984; Mathiowetz et al., 1985; Mathiowetz et al., 1986). The tip and key pinch types, in particular, represent the precise squeezing force between the thumb and either the index finger or other fingers (Aroona et al., 2023). The tip pinch force is applied by squeezing the tips of the thumb and index finger together, whereas the key pinch force is applied by pressing the side of the thumb against the side of the index finger. Both types of force develop based on thumb-finger tip coordination, and this coordination directly affects the fine motor control of the hand (Mathiowetz et al., 1984; Mathiowetz et al., 1986). The palmar pinch is a type of grasp in which the thumb and the tips of the index and middle fingers pinch together and is an important indicator, especially in tasks involving three-finger coordination. It has a wider surface contact than the tip and key pinch, and in some sports, this type of grasp plays a complementary role in measuring hand dexterity and finger strength (Mathiowetz et al., 1984; Mathiowetz et al., 1985).

In sports where grip strength is important, such as weightlifting, different types of grips can engage different muscle groups and biomechanical characteristics. Keogh et al. (2018) found a strong correlation between handgrip tests and thick-bar grip tests and a moderate correlation between handgrip tests and pinch-grip tests in their study of powerlifters and strongman athletes. In contrast, no significant relationship was found between pinch grip and thick-bar grip. The authors noted that these differences may stem from factors such as hand position, task specificity, and muscle activation. Therefore, evaluating grip skills using separate, sport-specific tests may contribute to more effective training program planning (Keogh et al., 2018).

In certain sports (for example, climbing, handball, wrestling, and baseball), particularly those involving intensive use of upper-extremity muscles, pinch-grip strength, the force exerted between the fingers, is significantly related to athletic performance. For example, a study of climbers showed that they exerted significantly greater force than other athletes in most of the seven pinch grips (Assmann et al., 2020).

Similarly, a study of elite handball players found that key, tip, and palmar pinch forces showed a significant positive correlation with overall grip strength, and that anthropometric measurements such as hand length, hand width, forearm circumference, and wrist circumference were also significantly related to these pinch forces (Arpaçay et al., 2024). These findings suggest that athletic performance may depend not only on overall grip strength but also on specific finger strength and structural characteristics of the hand.

The literature includes studies that examine the relationship between pinch forces and performance in sports such as climbing, handball, and wrestling; however, research evaluating the role of these force types specifically in weightlifting, particularly among female athletes, remains limited. Furthermore, the role of pinch forces in weightlifting techniques, such as the snatch and the clean and jerk, has not yet been comprehensively clarified. Therefore, research on this topic is needed.

The purpose of this study is to examine the relationship between the thumb, index-finger, and palm-pinch strength of female weightlifters and their athletic level (National Team and Turkish Olympic Training Center TOHM), physical characteristics (height, weight, BMI, training duration), and weightlifting performance (snatch and clean and jerk). The main hypothesis of the study is that National Team athletes will have higher pinch forces and that these forces will be positively related to weightlifting performance. It is also assumed that tip-pinch and key-pinch forces will be significantly related to athletes' physical characteristics.

Materials and Methods

Participants

A total of 32 female weightlifters participated in this study. Participants were divided into two groups based on their competition levels: the first group included athletes who had represented their country at international weightlifting championships as members of the national team (such as European Championships, World Championships, Olympic Games, Youth Olympic Games) (n = 16); the second group included athletes who had participated in official national and certain international tournaments within the Turkey Olympic Preparation Center (TOHM) (n = 16). All athletes in both groups had a training history of at least 2 years in Olympic-style weightlifting and trained at least 6 days per week for an average of 3 hours per day during the data collection period. Groups were distinguished based on the highest weightlifting championship level at which the athletes had competed in the past or recently; medal rankings were not used as a determining criterion for this classification.

Inclusion criteria: Having practiced Olympic-style weightlifting for at least 2 years, actively training with a license, and having participated in competitions at the specified level. Exclusion criteria are defined as follows: a history of injury to the hand, wrist, or elbow within the past 3 months; previous surgical procedures or fractures in these areas; deformities of the upper extremities; or the presence of musculoskeletal or neurological disorders.

Demographic information, anthropometric measurements (age, height, body weight, body mass index), sports history, and competition experience were collected from participants using a standard information form. Athletes' maximum snatch and clean-and-jerk data were obtained from the official websites of national and international federations.

This research was conducted in accordance with the ethical principles of the 2013 Declaration of Helsinki and was reviewed and approved by the Ethics Committee for Scientific Research in Social and Human Sciences at Necmettin Erbakan University (Approval Date: 17.10.2025, Decision No: 2025/870).

Measurements

Anthropometric and Dtrength Measurements

Prior to data collection, all measurement procedures were tested, potential implementation issues were identified, and necessary adjustments were made. As part of the anthropometric measurements, height was measured using a stadiometer (Seca 274, Hamburg, Germany) to an accuracy of ±0.1 cm while

participants stood barefoot and upright. Body weight was recorded using a digital weighing scale (Tanita DC-430MA, Tokyo, Japan) with an accuracy of ±0.1 kg. Body mass index (BMI) was calculated as body weight (kg) divided by height $(m)^2$. Additionally, data on age, years of training, height, weight, BMI, and hand dominance were collected using a standard assessment form.

Upper extremity dominance was determined by asking participants which hand they preferred to use for writing and physically demanding tasks in daily life. All participants reported their right hand as dominant.

The study's basic physical assessments include force measurements of tip pinch (TP), key pinch (KP), and palmar pinch (PL). Force measurements were performed using a calibrated hydraulic pinch dynamometer (Jamar® Hydraulic Pinch Gauge, USA). Participants were seated during the measurement; their shoulders were adducted and neutrally rotated, their elbows flexed to 90°, and their forearms in a neutral position. This test position was applied using the method recommended by the American Society of Hand Therapists, and detailed by Mathiowetz and colleagues (Mathiowetz et al., 1985). Three repetitions were performed for each pinch type, and the highest value was used in the analysis. All measurements were performed by the same researcher to ensure intra-rater reliability.

Pinch Strength Measurement

Participants' TP, KP, and PL pinch grip strength were assessed using a calibrated hydraulic pinch dynamometer (Jamar® Hydraulic Pinch Gauge, USA). During measurements, participants were positioned in a standard seated position with the shoulders adducted and neutrally rotated, the elbows flexed at 90°, and the forearms and wrists in neutral positions. This test position was applied in accordance with the recommendations of the American Society of Hand Therapists (ASHT) and with the standard protocols defined by Mathiowetz and colleagues (1984, 1985) (Mathiowetz et al., 1984, Mathiowetz et al., 1985).

TP was defined as the grip in which the thumb tip touches the index fingertip. KP was defined as the grip in which the pad of the thumb touches the radial surface of the middle phalanx of the index finger. PL was defined as a three-finger grip in which the tips of the thumb, index, and middle fingers meet. Three consecutive measurements were taken for each grip type, and the highest value was used in the analysis. The device was held in a fixed position during measurement, lightly supported by the evaluator. All measurements were performed by the same researcher. Before the measurement, each participant was given a trial run to familiarize themselves with the device. A 30-second rest period was given between measurements to minimize fatigue (Mathiowetz et al., 1984; Mathiowetz et al., 1985).

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics 25.0 (IBM Corp., Armonk, NY, USA). Differences in TP, KP, and PL forces between the NTW and TOHM groups were examined using the Mann–Whitney U test. Intra-group comparisons between the dominant and non-dominant hands for each pinch type were performed using the Wilcoxon test. Additionally, the relationships between pinch force variables (TP, KP, PL) for the right and left hands and individual characteristics (age, height, body weight, body mass index (BMI), training years (TE), and weightlifting performance (snatch, clean and jerk)) were evaluated using Spearman's correlation coefficient. The strengths of the correlations were interpreted according to Evans' (1996) classification, and analyses were performed in accordance with the statistical standards recommended for biomedical research (Mukaka, 2012; Evans, 1996). The level of statistical significance was set at $p < 0.05$.

Results

In a comparison between NTW and TOHM athletes, the NTW group exhibited significantly greater age ($p < 0.001$) and training experience (TE) ($p = 0.007$).

Among the performance variables, Max Snatch ($p = 0.005$) and Max Clean & Jerk ($p = 0.007$) were significantly higher in the NTW group than in the TOHM group.

Among the pinch strength variables, KP Right ($p = 0.012$), TP Right ($p = 0.025$), TP Left ($p < 0.001$), PL Right ($p = 0.030$), and PL Left ($p < 0.001$) were significantly higher in the NTW group. However, no significant difference was observed in KP Left ($p = 0.231$) between the groups.

No statistically significant differences were found between the two groups for height ($p = 0.602$), body weight ($p = 0.298$), and BMI ($p = 0.352$). These findings are presented in Table 1.

Table 1. Comparison of Demographic, Anthropometric, Performance, and Pinch Strength Variables between National Team and TOHM Female Weightlifters

Variables	NTW (n=16)		TOHM (n=16)		p Value*
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	
Age (years)	20.41 ± 2.95	19.75 (2.80)	17.18 ± 0.88	17.10 (1.90)	**<0.001**
Height (cm)	162.08 ± 8.77	163.50 (14.20)	160.92 ± 5.68	161.70 (10.50)	0.602
Body weight (kg)	70.41 ± 20.82	67.40 (26.80)	62.15 ± 10.89	61.10 (11.30)	0.298
BMI (kg/m²)	26.31 ± 5.91	24.50 (9.40)	23.89 ± 3.12	23.40 (3.20)	0.352
TE (years)	7.38 ± 3.22	7.15 (3.60)	4.32 ± 1.75	3.60 (2.60)	**0.007**
Max Snatch (kg)	84.08 ± 11.27	86.50 (21.10)	71.42 ± 6.71	71.00 (9.80)	**0.005**
Max Clean&Jerk (kg)	102.65 ± 14.63	101.50 (28.80)	86.75 ± 8.05	86.20 (9.50)	**0.007**
KP Right (kg)	8.49 ± 1.25	9.05 (0.70)	7.35 ± 1.27	7.40 (1.70)	**0.012**
KP Left (kg)	8.22 ± 1.46	8.70 (2.90)	7.68 ± 1.18	7.85 (2.20)	0.231
TP Right (kg)	7.13 ± 1.91	7.05 (3.50)	5.51 ± 1.20	5.40 (1.70)	**0.025**
TP Left (kg)	6.79 ± 1.49	6.30 (5.80)	4.92 ± 1.15	4.95 (0.60)	**<0.001**
PL Right (kg)	6.32 ± 1.58	6.40 (2.60)	5.17 ± 1.04	5.10 (1.60)	**0.030**
PL Left (kg)	6.50 ± 1.33	6.35 (2.00)	4.78 ± 0.76	4.70 (0.90)	**<0.001**

Data are presented as mean ± standard deviation (SD) and median (interquartile range, IQR). TE: Training experience; BW: Body weight; BMI: Body mass index; KP: Key pinch; TP: Tip pinch; PL: Palmar pinch. TOHM: Turkish Olympic Preparation Center.; NTW: National Team Weightlifters; *Mann-Whitney U test was applied.

Comparisons of right- and left-hand pinch strengths within each group (NTW and TOHM) are presented in Table 2. In NTW athletes, No statistically significant differences were found between right and left hands for KP ($p = 0.259$), TP ($p = 0.203$), and PL ($p = 0.118$) measurements.

Similarly, no statistically significant differences were observed between the right and left hands for KP ($p = 0.165$), TP ($p = 0.749$), and PL ($p = 0.159$) measurements in TOHM athletes. Data related to these findings are presented in Table 2.

Table 2. Comparison of right and left hand pinch strength in National Team and TOHM female weightlifters

Variables	Right (n=16)		Left (n=16)		p Value*
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	
NTW KP (kg)	8.49 ± 1.25	9.05 (0.70)	8.22 ± 1.46	8.70 (2.90)	0.259

TOHM KP (kg)	7.35 ± 1.27	7.40 (1.70)	7.68 ± 1.18	7.85 (2.20)	0.165
NTW TP (kg)	7.13 ± 1.91	7.05 (3.50)	6.79 ± 1.49	6.30 (5.80)	0.203
TOHM TP (kg)	5.51 ± 1.20	5.40 (1.70)	4.92 ± 1.15	4.95 (0.60)	0.749
NTW PL (kg)	6.32 ± 1.58	6.40 (2.60)	6.50 ± 1.33	6.35 (2.00)	0.118
TOHM PL (kg)	5.17 ± 1.04	5.10 (1.60)	4.78 ± 0.76	4.70 (0.90)	0.159

Data are presented as mean ± standard deviation (Mean ± SD) and median (interquartile range) [Median (IQR)]. KP: Key pinch; TP: Tip pinch; PL: Palmar pinch; TOHM: Turkish Olympic Preparation Center; NTW: National Team Weightlifters; *Wilcoxon test was applied.

Correlation Findings for the NTW Group

In the NTW group, positive correlations were observed between various pinch strength variables and age, height, body weight, BMI, training experience (TE), Max Snatch, and Max Clean & Jerk.

Age showed moderate correlations with KP Right (r = 0.482), KP Left (r = 0.441), and TP Left (r = 0.439), but a strong correlation with TP Right (r = 0.629). Strong correlations were also found with PL Right (r = 0.592) and PL Left (r = 0.662). Height exhibited weak-to-moderate correlations with all pinch strength variables, ranging from r = 0.391 to r = 0.493. Body weight (BW) was weakly correlated with TP Left (r = 0.356), moderately correlated with KP Right (r = 0.422), KP Left (r = 0.498), TP Right (r = 0.439), and PL Right (r = 0.403), and strongly correlated with PL Left (r = 0.589). BMI demonstrated weak correlations with TP Left (r = 0.238) and PL Right (r = 0.327), and moderate correlations with KP Right (r = 0.574), KP Left (r = 0.552), TP Right (r = 0.398), and PL Left (r = 0.501). Training Experience (TE) correlated moderately with KP Right (r = 0.381), KP Left (r = 0.489), TP Right (r = 0.561), and TP Left (r = 0.439); it correlated strongly with PL Right (r = 0.581) and PL Left (r = 0.672). Max Snatch showed very weak positive correlations with KP Right (r = 0.289), KP Left (r = 0.191), PL Right (r = 0.132), and PL Left (r = 0.309), and a negligible negative correlation with TP Left (r = -0.081). Max Clean and Jerk showed weak correlations with KP Right (r = 0.328), KP Left (r = 0.263), TP Right (r = 0.271), and PL Right (r = 0.243); it showed a moderate correlation with PL Left (r = 0.429), whereas TP Left had a negligible negative correlation (r = –0.026).

Correlation Findings for the TOHM Group

In the TOHM group, various positive and negative correlations were observed between different types of pinch strength and age, height, body weight, BMI, training experience (TE), Max Snatch, and Max Clean & Jerk. Age showed moderate positive correlations with KP Left (r = 0.602), KP Right (r = 0.421), and PL Right (r = 0.333), and a very weak positive correlation with PL Left (r = 0.110). A very weak negative correlation was found for TP Left (r = –0.182). Height showed a weak positive correlation with KP Left (r = 0.432) and a very weak positive correlation with TP Left (r = 0.097). Negative correlations were observed for TP Right (r = –0.559, moderate), PL Left (r = –0.392, weak), PL Right (r = –0.321, weak), and KP Right (r = –0.019, very weak), respectively. Body weight showed moderate positive correlations with KP Left (r = 0.462) and TP Left (r = 0.362), whereas KP Right (r = 0.007), PL Right (r = 0.112), and PL Left (r = –0.021) showed very weak associations. TP Right had a very weak negative correlation (r = –0.089). BMI showed weak positive correlations with KP Right (r = 0.211) and PL Right (r = 0.203); moderate positive correlations with KP Left (r = 0.519) and TP Left (r = 0.408); and very weak positive correlations with TP Right (r = 0.132) and PL Left (r = 0.018). Training Experience (TE) was strongly positively correlated with KP Right (r = 0.608), weakly correlated with KP Left (r = 0.354), and very weakly correlated with TP Left (r = 0.029), PL Right (r = 0.089), and PL Left (r = 0.032). A very weak negative correlation was observed for TP Right (r = -0.046). Max Snatch showed weak positive correlations with TP Right (r = 0.282), TP Left (r = 0.356), and PL Right (r = 0.378). Very weak correlations were observed for KP Right (r = 0.092), KP Left (r =

0.364), and PL Left (r = 0.071). Max Clean and Jerk showed moderate positive correlations with KP Left (r = 0.541), TP Left (r = 0.429), and PL Right (r = 0.531); weak correlations with KP Right (r = 0.271) and TP Right (r = 0.316); and a very weak correlation with PL Left (r = 0.112).

Table 3. Correlations between pinch strength and demographic/performance variables in National Team and TOHM female weightlifters

Variable NTW (n=16)	**KP (Right)**	**KP (Left)**	**TP (Right)**	**TP (Left)**	**PL (Right)**	**PL (Left)**
Age (years)	0.482	0.441	0.629	0.439	0.592	0.662
Height (cm)	0.436	0.445	0.401	0.392	0.391	0.493
BW (kg)	0.422	0.498	0.439	0.356	0.403	0.589
BMI (kg/m²)	0.574	0.552	0.398	0.238	0.327	0.501
TE (years)	0.381	0.489	0.561	0.439	0.581	0.672
Max Snatch (kg)	0.289	0.191	0.142	-0.081	0.132	0.309
Max Clean & Jerk (kg)	0.328	0.263	0.271	-0.026	0.243	0.429
Variable TOHM (n=16)	**KP (Right)**	**KP (Left)**	**TP (Right)**	**TP (Left)**	**PL (Right)**	**PL (Left)**
Age years)	0.421	0.602	0.289	-0.182	0.333	0.110
Height (cm)	-0.019	0.432	-0.559	0.097	-0.321	-0.392
BW (kg)	0.007	0.462	-0.089	0.362	0.112	-0.021
BMI (kg/m²)	0.211	0.519	0.132	0.408	0.203	0.018
TE (years)	0.608	0.354	-0.046	0.029	0.089	0.032
Max Snatch (kg)	0.092	0.364	0.282	0.356	0.378	0.071
Max Clean & Jerk (kg)	0.271	0.541	0.316	0.429	0.531	0.112

Spearman's correlation coefficients are shown. BW: Body weight; BMI: Body mass index; TE: Training experience; KP: Key pinch; TP: Tip pinch; PL: Palmar pinch; TOHM: Turkish Olympic Preparation Center; NTW: National Team Weightlifters.

Discussion

The aim of this study was to examine the relationships among pinch strength, performance, and demographic variables in elite female weightlifters and to compare two groups with different training backgrounds. The findings indicated that national team athletes were statistically significantly older, had more training experience, and had higher key performance indicators (max snatch and max clean and jerk) than TOHM athletes.

These results largely support the initial hypothesis. The significantly higher tip, key, and palmar pinch strength values observed in the national team athletes suggest that these strength parameters may be positively associated with training experience and age. However, the generally weak correlations found between pinch strength and technical performance variables indicate that grip strength may not be a direct determinant of competitive performance outcomes in weightlifting.

Additionally, significant differences in favor of the national team were observed in KP Right, TP Right, TP Left, PL Right, and PL Left measurements, with all pinch strength values—except for KP Left—being significantly higher in this group. No significant differences were found between the groups in terms of height, body weight, or BMI. Furthermore, there were no significant differences in pinch strength between the right and left hands within either group. These findings suggest that specific pinch-strength profiles may be influenced by an athlete's training history and neuromuscular adaptations, rather than direct indicators of technical performance.

In this study, NTW outperformed TOHM athletes on several pinch-strength parameters. Significant group differences were observed in tip, palmar, and right-hand key pinch strengths, indicating that elite-level athletes may exhibit a more developed pinch-strength profile. Although no significant group differences were found in body weight, height, or BMI, correlation analyses revealed that these anthropometric factors were moderately associated with pinch strength among national team athletes. This aligns with previous findings in healthy individuals, in which body weight, height, and BMI were found to significantly influence pinch strength of the dominant hand (Asif et al., 2023).

Notably, a study conducted among Indonesian archers reported a significant positive correlation between both right- and left-hand pinch strengths and archery performance, suggesting that grip strength may contribute to fine motor performance and accuracy (Rusdiawan et al., 2024). Similarly, a large-scale study among healthcare workers revealed significant differences in pinch strength based on anthropometric factors such as sex and age. The mean dominant-hand pinch strength was reported as 4.23 ± 1.15 kg for women and 6.96 ± 1.58 kg for men, with women aged 35–40 showing the highest mean pinch strength (Sayadizadeh et al., 2025). These findings reinforce the notion that age and occupational hand use are important contributors to grip strength. Consistent with these studies, the current study also found moderate to strong correlations of pinch strength with age and training experience, particularly among national-level athletes.

Similarly, studies conducted in sports that involve frequent upper extremity use have reported that tip, key, and palmar pinch strengths reflect athletes' hand function and may serve as important indicators of upper limb physical capacity. In particular, a study involving elite female handball players demonstrated significant positive correlations between each of the three types of pinch strength and overall grip strength. These strength parameters, when assessed alongside hand anthropometry and body composition, were found to play a key role in shaping athletes' hand strength profiles (Kamaşak Arpaçay et al., 2024). Moreover, recent perspectives emphasize that not only quantitative measures of pinch strength but also sensory and motor control are critical components of athletic competence.

In this context, Erdağı et al. (2019) reported that although elite adolescent female weightlifters demonstrated high levels of pinch strength, their ability to perceive force intensity accurately, especially at very low (10%) and very high (70%) effort levels, was limited. This finding suggests that, beyond strength output, proprioceptive awareness and force regulation may also influence performance development.

Conversely, other studies have focused primarily on group differences based on strength levels. For instance, Assmann et al. (2021) found that recreational climbers exhibited greater grip strength across almost all pinch positions compared to non-climbers. Taken together, these findings support the notion that while training leads to improved muscular strength, sport-specific neuromuscular and sensory adaptations also play a crucial role in overall athletic performance.

In this study, no significant differences were found between the right- and left-hand pinch strength measurements in either the NTW or the TOHM group. This finding suggests that in symmetrical sports like weightlifting, which involve bilateral loading, hand strength may develop in a balanced manner. In support of this, Rusdiawan et al. (2024) evaluated right- and left-hand pinch strength separately in archers, and reported that grip strength in both hands was significantly positively correlated with performance. This underscores the importance of bilateral hand function in sports requiring symmetrical upper extremity use.

In contrast, Puh (2010) reported that, in right-handed individuals, the dominant hand exhibited significantly greater pinch strength, likely reflecting habitual unilateral use. However, Erdağı et al.

(2019) found no significant difference in strength between hands when measured under equivalent conditions, further supporting the notion that bilateral sports may promote symmetrical strength development. These findings collectively suggest that the demands of symmetrical, bilateral sports like weightlifting may lead to more evenly distributed upper limb strength profiles.

Similarly, in the study by Assmann et al. (2021), recreational climbers exhibited less pronounced strength differences between the dominant and non-dominant hands compared to non-climbers. Interestingly, in less familiar pinch positions (e.g., I/IV or I/II+III+IV), these differences were not statistically significant. Collectively, the findings of both studies suggest that in sports requiring coordinated and balanced use of both hands, bilateral strength distribution tends to develop more symmetrically.

In contrast, a large-scale study by Sayadizadeh et al. (2025) involving healthcare professionals reported that among female participants, pinch strength in the dominant hand was significantly higher than that in the non-dominant hand. This discrepancy was attributed to habitual use of the dominant hand during daily tasks, suggesting that strength symmetry may vary with occupational or functional hand-use patterns.

In this study, several positive correlations were observed between pinch-strength parameters and individual characteristics, such as age, training experience, height, and body weight. These relationships were generally moderate to strong in the national team group, whereas they were weaker in the TOHM group. This suggests that greater age and more years of athletic experience may be associated with more pronounced development of muscular strength.

Furthermore, our findings indicate that pinch strength is influenced not only by age and training history but also by an individual's physical and structural attributes. In support of this, Takagi et al. (2019) reported a strong positive correlation between upper extremity muscle mass and lateral pinch strength in young adults. Notably, this association remained significant regardless of sex, emphasizing the critical role of muscle mass in determining hand strength and functional capacity.

Similarly, a study by Asif et al. (2023) involving healthy adults reported significant positive correlations between dominant hand pinch strength and key anthropometric variables such as age, height, and body mass index. The authors suggested that age-related increases in muscle mass and neuromuscular development may have contributed to these associations.

In another study, Rusdiawan et al. (2024) found significant positive correlations between right- and left-hand pinch strength and variables such as age and training duration in Indonesian archers. Notably, a strong correlation was reported between age and palmar pinch strength, further supporting the relationship among age, experience, and development of hand strength.

Consistent findings were also observed in the study by Sayadizadeh et al. (2025), which involved female healthcare professionals. The study identified significant positive correlations between dominant hand pinch strength and variables such as age, height, and body weight.

Collectively, these studies support the notion that pinch strength tends to increase with age and that both physical characteristics (e.g., anthropometry) and training background may influence its development.

In the same vein, a study involving elite female handball players reported significant positive associations between tip, key, and palmar pinch strengths and hand anthropometric characteristics (Kamaşak Arpaçay et al., 2024). This supports the idea that muscle strength is influenced not only by age and training experience, but also by individual structural and physical attributes.

Additionally, Puh (2010) found that pinch strength tends to increase with age, peaking between ages 25 and 44. In contrast, Erdağı et al. (2019) reported that adolescent weightlifters of lower mean age exhibited reduced ability to accurately perceive force. These findings suggest that older and more experienced athletes may demonstrate not only higher levels of strength but also more developed motor awareness. Although the athletes in the present study fall below the peak age range, the significantly greater training experience observed in the national team group indicates that sport-specific loading, in addition to age, may play a compensatory role in the development of pinch strength.

In our study, weak correlations were generally observed between pinch strength and technical performance indicators, such as Max Snatch and Clean and Jerk. These findings suggest that technical proficiency in weightlifting depends not only on grip strength but also on motor coordination, balance, movement speed, and technique optimization.

Indeed, in certain sports, pinch strength may play a more decisive role in technical performance. For example, in disciplines like archery, which require upper extremity stabilization and fine motor control, pinch grip strength has been shown to correlate significantly with performance outcomes (Rusdiawan et al., 2024).

In contrast, weightlifting involves multi-joint, explosive movements and complex coordination, in which not only the amount of force but also the ability to apply and regulate that force within a precise movement pattern are likely to be more critical than absolute grip strength. These distinctions highlight the sport-specific nature of strength-performance relationships.

Supporting this perspective, Erdağı et al. (2019) emphasized that deficiencies in the accuracy of force perception can negatively impact performance, particularly in sports that require high levels of technical precision. The authors demonstrated that even elite adolescent weightlifters with high levels of pinch strength exhibited notable limitations in their ability to accurately perceive and regulate force. Specifically, measurements taken at very low (10%) and very high (70%) intensity levels revealed inadequate control and inconsistent application of force.

These findings suggest that athletic performance may not be improved solely through increased muscular strength, but also through accurate force perception, balanced regulation, and the coordinated integration of strength within complex technical movements.

Limitations

This study has several limitations. First, the sample size is relatively small (n = 32) and includes only female athletes, which limits the generalizability of the findings across genders and different age groups. Second, pinch strength was assessed solely through static and isometric tests; no dynamic, time-dependent, or functional assessments of hand strength were included. Additionally, sensory-motor parameters such as proprioceptive sensitivity and force control were not directly measured. Assessments that address not only the magnitude of strength but also its quality and contextual application may offer stronger predictive value for athletic performance. Finally, due to the cross-sectional design of the study, causal inferences cannot be made. Future studies involving more diverse athletic populations and longitudinal research designs are needed to further explore and validate these findings.

Conclusions and Recommendations

This study examined the relationships among tip, key, and palmar pinch strength, athlete level, physical characteristics, and technical performance in elite female weightlifters. The results showed that national team athletes had significantly higher technical performance (snatch and clean & jerk) and greater

pinch-strength parameters (especially right-hand key, tip, and palmar pinches) compared with athletes in the Olympic Preparation Center (TOHM) program. These findings suggest that higher levels of pinch strength may reflect the neuromuscular adaptations associated with advanced training status.

However, the correlations between pinch strength and technical performance indicators were generally weak. This indicates that successful weightlifting performance is shaped not only by grip strength but also by technical skill, balance, coordination, and motor control. Additionally, no significant differences were found between right- and left-hand strength in either group, supporting the notion that strength development may be symmetrical in sports involving bilateral loading, such as weightlifting.

Future research should include assessments of sensory-motor components such as proprioception and force control to provide a more comprehensive understanding of the relationship between grip strength and athletic performance. Moreover, studies with larger and more diverse samples—across different age and gender groups—will help clarify the specific role of pinch strength in various athletic populations. It is also recommended that training programs for elite athletes incorporate specific exercises targeting the hand and finger muscles to support functional performance.

Practical Applications

The findings of this study suggest that pinch strength, particularly palmar and key pinch strength, may serve as a useful indicator of performance levels among elite female weightlifters. Coaches and sports professionals are encouraged to include targeted exercises for the hand and finger muscles in training programs to improve grip-specific strength.

Additionally, the observed symmetry in hand strength supports the use of bilateral training strategies in sports such as weightlifting that require balanced use of the upper extremities. Regular assessment of pinch strength can provide coaches with a practical tool for tracking upper limb readiness and may also aid in developing individualized strategies for performance enhancement and injury prevention.

References

Arpaçay, E., Yıldırım, Y., & Koca, A. (2024). The Relationship Between Upper Extremity Anthropometric Measurements and Bioimpedance Analysis With Grip Strength in Female Elite Handball Players. Turkish Sports and Exercise Journal, 26(1), 75–82. https://doi.org/10.15314/tsed.1533392

Aroona, A., et al. (2023). Correlation between Hand Tripod Pinch Grip and Handwriting Quality impact on Academic Performance- A Narrative Review, A narrative review. Journal of Advanced Zoology. Vol: 44, Issue: 03. DOI: 10.17762/jaz.v44i3.1660

Asif, M. M., Amjad, F., Arslan, S. A., Ahmad, A., & Gilani, S. A. (2023). Influence of basic anthropometric variables on pinch strength of dominant hand in healthy individuals. Muscles, Ligaments and Tendons Journal, 13(1), 163–168. https://doi.org/10.32098/mltj.01.2023.19

Assmann, M.; Steinmetz, G.; Schilling, A.F.; Saul, D. Comparison of Grip Strength in Recreational Climbers and Non-Climbing Athletes A Cross-Sectional Study. Int. J. Environ. Res. Public Health 2021, 18, 129. https://dx.doi.org/10.3390/ijerph18010129

Erdağı, K., Yargıç, M. P., Kürklü, G. B., & Aydın, L. (2020). Accuracy of pinch force sense in elite female adolescent weightlifters. Turkish Journal of Sports Medicine, 55(2), 95–101. https://doi.org/10.5152/tjsm.2020.165

Erdağı, K. (2022). Olimpik halter eğitimi ve ağirlik antrenmanlarinda çalişan kas gruplari. Ankara: Türk Eğitim Yayinlari ISBN 978-625-7247-35-1.

Evans, J. D. (1996). Straightforward statistics for the behavioral sciences. Brooks/Cole

Garhammer, J. (1993). A review of power output studies of Olympic and powerlifting: Methodology, performance prediction, and evaluation tests. Journal of Strength and Conditioning Research, 7(2), 76–89.

Huebner, M.; Riemann, B.;Hatchett, A. Grip Strength and Sports Performance in Competitive Master Weightlifters. Int. J. Environ. Res. Public Health 2023, 20, 2033. https://doi.org/10.3390/ijerph20032033

Keogh, J. W., Burge, A., & Wright, K. (2018). Relationships between grip strength tests in male strength sport athletes. ISBS Proceedings Archive, 36(1), 730.

Mathiowetz, V., Wiemer, D. M., & Federman, S. M. (1986). Grip and pinch strength: norms for 6-to 19-year-olds. The American journal of occupational therapy, 40(10), 705-711.

Mathiowetz, V., Weber, K., Volland, G., & Kashman, N. (1984). Reliability and validity of grip and pinch strength evaluation. Journal of Hand Surgey, 9A,222-226. DOI: 10.5014/ajot.40.10.705

Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil. 1985;66(2):69–74.

Mukaka, M. M. (2012). Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Medical Journal, 24(3), 69–71.

Puh, U. (2010). Age-related and sex-related differences in hand and pinch grip strength in adults. International Journal of Rehabilitation Research, 33(1), 4-11. DOI: 10.1097/MRR.0b013e328325a8ba

Rusdiawan, A., Kusuma, D. A., Ar Rasyid, M. L. S., García-Jiménez, J. V., Purnomo, M., Siantoro, G., Wismanadi, H., Lani, A., Irmawati, F., & Ningsih, Y. F. (2024). Physical capacity and performance correlation in sub-elite Indonesian archery athletes. Retos: Nuevas Tendencias en Educación Física, Deporte y Recreación, 60, 1093–1101. DOI: 10.47197/retos.v60.107017

Sayadizadeh, M., Daliri, M., Sadeghi, M., Ataei Azimi, M., Khaje Mozafari, J., & Moradi, A. (2025). Normative values of grip and pinch strength and their predictor factors: PERSIAN cohort study of healthcare staff. International Orthopaedics, 49(3), 549–557. https://doi.org/10.1007/s00264-025-06409-3

Storey, A., & Smith, H. K. (2012). Unique aspects of competitive weightlifting: Performance, training and physiology. Sports Medicine, 42(9), 769–790. DOI: 10.2165/11633000-000000000-00000

Takagi, D. (2019). Influence of upper extremity muscle mass on lateral pinch strength. International Journal of Physical Therapy & Rehabilitation, 5(150), 1–4. https://doi.org/10.15344/2455-7498/2019/150

Data Availability Declaration

Data Availability Upon Formal Request: While the primary datasets utilized in this study are not publicly accessible due to certain constraints, they are available to researchers upon a formal request. The authors have emphasized maintaining the integrity of the data and its analytical rigor. To access the datasets or seek further clarifications, kindly reach out to the corresponding author. Our aim is to foster collaborative academic efforts while upholding the highest standards of research integrity.

Author Contributions: Conceptualization, R.K. and M.E.U.; methodology, R.K., M.E.U., S.Ü., and J.F.G.-V.; investigation, R.K., M.E.U., and S.Ü.; resources, S.Ü. and R.K.; data curation, R.K., S.Ü., and M.E.U.; formal analysis, J.F.G.-V.; writing—original draft preparation, R.K. and M.E.U.; writing—review and editing, R.K., M.E.U., and J.F.G.-V.; visualization, J.F.G.-V.; supervision, R.K.

Author(s)' statements on ethics and conflict of interest

Ethics statement: Ethical approval for this study was obtained from the Ethics Committee for Scientific Research in the Social and Human Sciences at Necmettin Erbakan University, in accordance with the ethical principles of the 2013 Declaration of Helsinki (Approval Date: 17.10.2025, Decision No: 2025/870). Before participating, all individuals received detailed explanations regarding the study's aims, procedures, and scope and voluntarily provided written informed consent.

Statement of interest: The authors declare that there are no conflicts of interest related to this study.

Funding: This research received no external funding and was fully self-supported by the authors.

Acknowledgements: The author would like to sincerely thank all the Olympic-style weightlifters and their coaches for generously contributing their time and effort to this study. Appreciation is also extended to the Turkish Weightlifting Federation for facilitating access to athletes and supporting the research process through their institutional cooperation.

Biographical notes:

Rıdvan KIR: Rıdvan Kır is an Assistant Professor specializing in Olympic weightlifting, strength training, corrective exercise, and performance analysis. His research focuses on

athlete monitoring, biomechanical performance indicators, and developing evidence-based training methodologies for high-performance sport.

ScopusAuthorIdentifierNumber: 56426434900

Web of Science Researcher ID: JVE-1833-2024

GoogleScholarResearcherID:
https://scholar.google.com.tr/citations?hl=tr&user=k2w4Jx0AAAAJ

Mahmut Esat UZUN: Mahmut Esat Uzun serves as an Assistant Professor in the Coaching Education Department at Karabük University. His research focuses on exercise science, athlete development, performance training, and the application of sports technologies.

Web of Science Researcher ID: AGE-2700-2022

GoogleScholarResearcherID: 7BRyMeUAAAAJ
https://scholar.google.com/citations?user=7BRyMeUAAAAJ&hl=tr&oi=aohttps://scholar.google.com/citations?user=-cBbgB8AAAAJ&hl=tr

Juan Francisco GARCÍA-VÁZQUEZ: He is a physiotherapist and researcher specializing in human movement biomechanics, injury assessment, and rehabilitation. He holds a PhD in Biomechanics and teaches physiotherapy courses while contributing to national and international research projects in gait analysis and neuromechanics.

ScopusAuthorIdentifierNumber:57200612036
https://www.scopus.com/authid/detail.uri?authorId=57200612036

Web of Science Researcher ID: IDODK-8125-2025

GoogleScholarResearcherID:
https://scholar.google.com.tr/citations?user=DNjiTXMAAAAJ&hl=tr&oi=ao

Serap ÜNLÜ: Serap Ünlü is a physical education teacher and a 5th-level Olympic weightlifting technical director, serving as the head coach of the Turkish Women's National Weightlifting Team. She specializes in high-performance athlete development, technical coaching, and long-term training strategies for youth, elite, and national-team athletes. She also works as a weightlifting coach at the Turkish Olympic Preparation Center, contributing to the preparation of athletes for international championships.