ORIGINAL ARTICLE

Comparative analysis of hand dynamometer measurements across different arm positions: implications for rehabilitation and functional assessment

Mohd Arshad Bari[1ABCD], Junaid Ahmad Parrey[1ABCDE], Abdul Qayyum Khan[2ACD], Arish Ajhar[1BCD], Shivani Singh[1BCD]

[1] *Department of Physical Education, Aligarh Muslim University, India*
[2] *Department of Orthopedic Surgery, Aligarh Muslim University, India*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Grip strength is a crucial measure of human physical capability, affecting activities from daily tasks to athletic performance. Variations in arm position during grip strength measurement may influence the results, which has significant implications for both rehabilitation and functional assessment. This study explores the impact of different arm positions on grip strength to enhance understanding of human biomechanics and inform rehabilitation and sports training practices.

Material and Methods Forty right-handed male volunteers (mean age 18.27 ± 0.90 years) participated in the study. Grip strength was measured using a CAMRY Model: EH101 hand dynamometer. Measurements were taken across four arm positions: seated with elbow extension, 90-degree elbow flexion, 90-degree elbow flexion with pronation, and 90-degree elbow flexion with supination. Each position was tested three times. The highest recorded value for each position was used for analysis.

Results The dominant right hand exhibited higher grip strength across all positions compared to the non-dominant left hand. Significant differences were noted, with the greatest grip strength in the extension position. Statistical analysis using paired t-tests indicated significant differences ($p < 0.001$) between the right and left hands across all positions. Pearson correlation coefficients highlighted strong relationships between different arm positions. Multiple linear regression analysis showed significant predictors of grip strength variability based on arm position, age, and BMI.

Conclusions Arm position significantly influences grip strength performance, underscoring the importance of standardized positioning in ergonomics. Standardizing arm position can optimize performance and mitigate injury risks in activities requiring robust grip strength. These findings have practical implications for rehabilitation protocols, sports training programs, and ergonomic assessments. The results emphasize the need for consistency in grip strength evaluations to ensure accurate and reliable results.

Keywords: grip strength, arm position, biomechanics, rehabilitation, functional assessment, athletic performance.

Introduction

The foundational aspect of human physical capability, grip strength, holds pivotal significance across a spectrum of activities, from mundane tasks to athletic pursuits. The ability to exert and maintain force through the hand and fingers is influenced by various factors, with the positioning of the arm during grip exertion being a key determinant [1, 2, 3]. A recent study showed that maximal isometric grip strength is influenced by gender, handedness, posture, and population [4]. It also highlighted the need for gender-, population-, and posture-specific grip strength data for clinical and industrial applications.

Beyond its role in manual dexterity, grip strength is intricately linked to overall muscular strength, functional independence in daily activities, and certain health outcomes. As a fundamental metric for assessing muscular strength and upper extremity functionality, hand grip strength transcends diverse domains, including clinical diagnosis, physical fitness evaluation, sports performance, and occupational health [4, 5]. The importance of grip strength is accentuated in sports, where it directly influences an athlete's control, performance, and injury prevention, particularly in activities such as weightlifting, rock climbing, and martial arts [6]. Consequently, grip strength training and evaluation have become integral components in sports conditioning and injury prevention programs.

The ramifications of grip strength extend to occupational environments, particularly in jobs involving manual labor or the manipulation of heavy objects [7, 8]. Assessing and enhancing grip

doi:10.15561/26649837.2024.0504

strength play a crucial role in mitigating the risk of work-related injuries, optimizing job performance, and guiding the design of ergonomic interventions. In the medical arena, hand grip strength serves as a multifaceted indicator, evaluating an individual's ability to perform daily tasks and assessing upper extremity function. Recognizing its role as a marker of overall muscular strength, grip strength has become indispensable in evaluating health status, bone density, and body composition [8].

Measuring hand grip strength proves beneficial in assessing individuals with difficulties in daily tasks, evaluating upper extremity function integrity, and gauging the success of hand rehabilitation techniques [9, 10]. However, the influence of various factors on grip strength necessitates standardized techniques for accurate evaluation. Presently, there is a lack of consensus regarding the ideal shoulder, elbow, and wrist positions for assessing hand grip strength, highlighting the need for a standardized approach to enhance the validity of evaluations [11, 12, 13].

Despite numerous studies across various age groups and populations, significant gaps remain in the understanding of the influence of different arm positions on grip strength. Addressing these issues is crucial for improving the accuracy and reliability of grip strength assessments in clinical, occupational, and sports settings. This study explores the impact of different arm positions on grip strength to enhance understanding of human biomechanics and inform rehabilitation and sports training practices.

Materials and Methods

Participants

A total of forty male volunteers, aged 18.27 ± 0.90 years, were enrolled (Fig. 1). A thorough evaluation of medical records was performed, which included a review of diagnostic reports and participant interviews. Eligible subjects were informed about the experimental procedures, and informed consent was obtained, ensuring transparency and ethical compliance throughout the research. This study conformed to ethical guidelines and was initiated following the approval of the Research Ethical Committee at J.N. Medical College, Aligarh Muslim University (AMU), Aligarh, India (Ethical approval number: IECJNMC/943).

Inclusion Criteria. The inclusion criteria for participants in this study were meticulously defined to ensure the reliability and validity of the findings. Eligible participants had to be right-handed, with the right hand serving as their dominant hand. They needed to be capable of independently performing grip force measurements in four specified arm positions. Additionally, participants were required to be in good physical and mental health, free from any conditions that could impair their performance or the study's outcomes, such as limb deficiencies, limb deformities, or depression.

*Exclusion Criteria***.** The exclusion criteria for this study were established to eliminate potential confounding factors that could affect grip strength assessment. Participants were excluded if they had any neurologic or orthopedic conditions impacting grip strength. Those with a history of pathology or trauma to the upper extremity or neck region were also excluded. Additionally, individuals with ongoing injuries, illnesses, or pain affecting the upper limbs or any part of the body that could influence grip strength assessment were not considered for participation.

Outcome measure

The primary outcome measure was grip strength, quantified using a CAMRY Model: EH101 hand dynamometer, ISO 9001 certified by SGS, with a maximum bearing strength of 90kg/198lb. The dynamometer underwent professional calibration according to the manufacturer's specifications to ensure accuracy and consistency throughout the study.

Procedure

Preparation and Participant Briefing. Upon approval from the Research Ethical Committee at JN Medical College, AMU, Aligarh, and securing informed consent from each participant, the following preparatory steps were undertaken:

- *Demographic Data Collection.* Each participant's age, height, weight, and BMI were recorded using a stadiometer and an Omron weighing machine (MODEL HBF-212-IN).
- *Orientation Session.* Participants were briefed on the study's objectives, procedures, and the importance of accurate performance during grip strength measurements.

Grip Strength Measurement Setup. The hand dynamometer (CAMRY Model: EH101) was calibrated according to the manufacturer's specifications to ensure accuracy. Each participant's hand size was measured, and the dynamometer was adjusted to fit appropriately, ensuring that the device handle was positioned at the second knuckle.

Measurement Protocol. Grip strength was measured in four different arm positions for both hands (Fig. 2). Each measurement was performed three times per position, with a 30-second rest interval between trials to minimize fatigue effects. The highest value from the three trials was recorded as the maximal grip strength.

1. *Seated with Elbow Extension.*
    - *Positioning.* Participants sat on an armless straight-backed chair with shoulders in a neutral position and arms by their sides. The elbow of the tested arm was fully extended.
    - *Measurement.* Participants exerted maximum force on the dynamometer for 1 second upon demand.

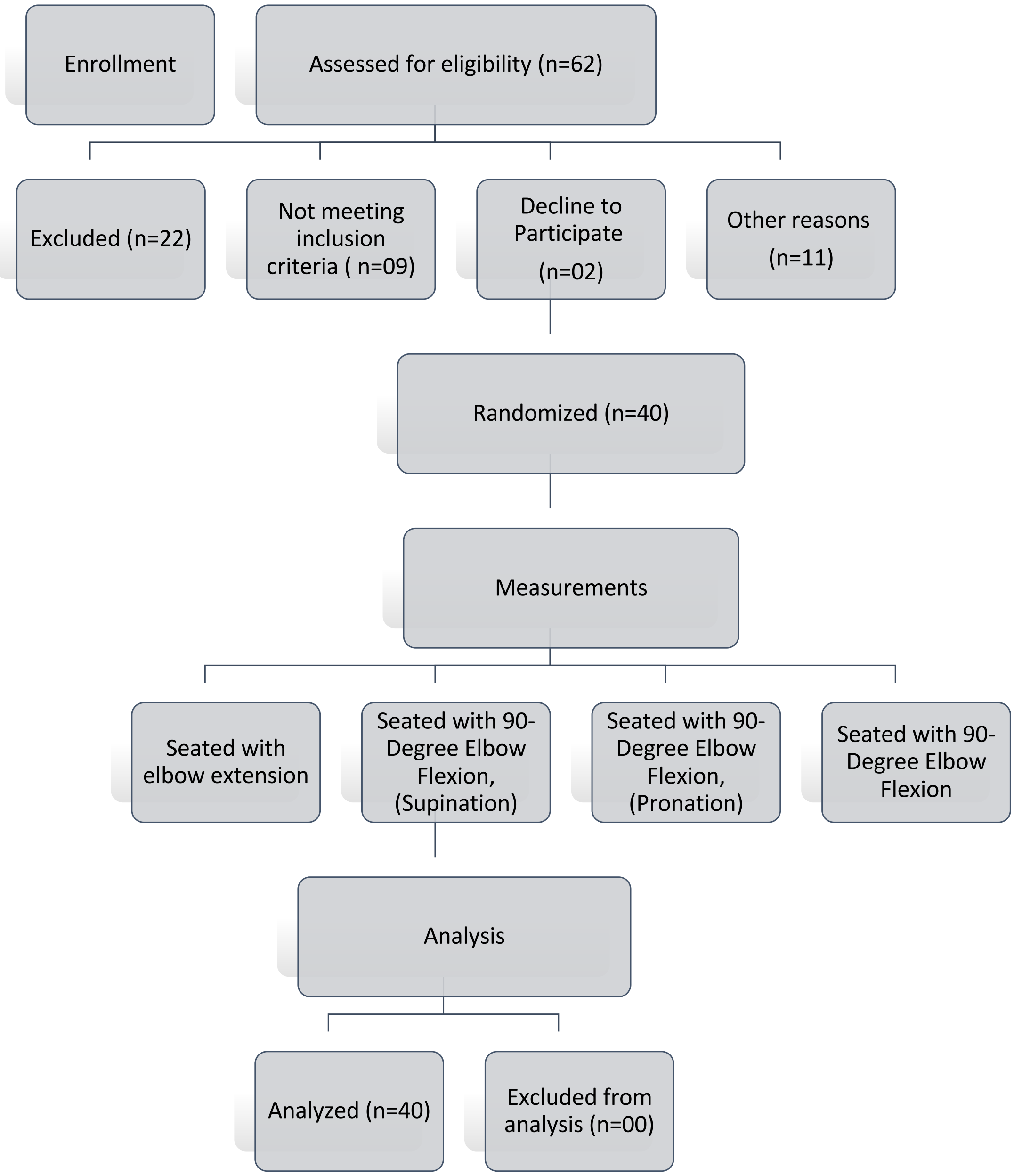

Figure 1. Flowchart showing the number of participants assessed for eligibility, randomized and analyzed during the study.

Figure 2. Four distinct arm positions

2. *Seated with 90-Degree Elbow Flexion.*
   - *Positioning.* Participants sat with shoulders in a neutral position and arms by their sides. The elbow of the tested arm was flexed at a 90-degree angle.
   - *Measurement.* Participants exerted maximum force on the dynamometer for 1 second upon demand.
3. *Seated with 90-Degree Elbow Flexion, Pronation.*
   - *Positioning.* Participants sat with shoulders in a neutral position and arms by their sides. The elbow of the tested arm was flexed at 90 degrees with the palm facing downwards.
   - *Measurement.* Participants exerted maximum force on the dynamometer for 1 second upon demand.
4. *Seated with 90-Degree Elbow Flexion, Supination.*
   - *Positioning.* Participants sat with shoulders in a neutral position and arms by their sides. The elbow of the tested arm was flexed at 90 degrees with the palm facing upwards.
   - *Measurement.* Participants exerted maximum force on the dynamometer for 1 second upon demand.

Measurement Guidelines.

- *Standardization.* The sequence of the four grip strength test positions was consistent for all participants.
- *Acclimatization.* Participants were allowed to perform submaximal efforts during initial attempts to familiarize themselves with the dynamometer and testing procedure.
- *Instruction.* Clear instructions and demonstrations were provided to ensure participants understood the correct technique and exerted maximal effort during each trial.

Data Recording and Quality Control.

- *Data Logging.* Grip strength values for each trial were logged immediately after measurement.
- *Error Minimization.* To reduce measurement error, participants were monitored closely to ensure they maintained the specified arm positions and exerted effort consistently across trials.

By implementing this systematic and standardized approach, the study aimed to capture reliable and valid grip strength data across different arm positions, contributing to a robust comparative analysis.

Statistical Analysis

Statistical analysis was performed using SPSS 23.0 to analyze variables such as age, weight, height, BMI, dominant hand, and grip strength across four distinct arm positions. Descriptive statistics were first computed to summarize participant demographics and baseline characteristics alongside grip strength measurements in each position. A paired t-test was then employed to evaluate significant differences in grip strength between the various arm positions within participants, assessing whether differences observed were statistically significant. Additionally, the Pearson correlation coefficient was calculated to examine relationships between grip strength measurements across different positions, aiming to elucidate any linear associations. A significance level of $p < 0.05$ was adopted to determine statistical significance, ensuring robust interpretation of findings. This approach underscored the study's methodological rigor and provided comprehensive insights into how varying arm positions affect grip strength, bolstering the validity and reliability of the results.

Results

The participants, forty young adults, have an average age of 18.27 years, a mean weight of 62.61 kg, and an average height of 159.30 cm (Tabl. 1). Their BMI values range from 19.08 to 31.22, with an average of 24.67, suggesting that most participants are within a healthy weight range, predominantly falling into normal to slightly overweight categories. This detailed anthropometric data ensures a representative sample, providing a solid basis for examining grip strength variations across different arm positions and hand dominances.

Table 2 shows significant differences in grip strength between the dominant right hand and the non-dominant left hand across various arm positions. The right hand consistently demonstrates higher grip strength, underscoring the dominance effect. This statistically significant difference highlights the importance of considering hand dominance in grip strength evaluations. Additionally, grip strength varies with arm position, with both hands showing their highest strength in extension and the lowest in supination. These findings indicate that arm position significantly impacts grip strength measurements. To ensure accurate and meaningful assessments, it is essential to standardize arm position and consider hand dominance.

Table 3 shows the paired sample t-test results comparing grip strength between the dominant right hand and the non-dominant left hand across various arm positions. The results reveal significant mean differences, with the right hand consistently exhibiting higher grip strength. This dominance effect is evident across all tested positions, highlighting the substantial impact of hand dominance on grip strength. Notably, the disparity in grip strength is most pronounced in pronation and least pronounced in flexion, suggesting that the degree of strength difference varies with arm position. These findings emphasize the need to account for hand dominance when assessing and interpreting grip strength in both clinical and

Table 1. Anthropometrics of the Participants

Anthropometric Measurements	N	Minimum	Maximum	Mean	SD
Age (y)	40	17.00	20.00	18.27	0.90
Weight (kg)	40	49.00	76.00	62.61	6.88
Height (cm)	40	152.00	180.00	159.30	5.69
BMI*	40	19.08	31.22	24.67	2.43

Note. M, Mean; SD, Standard deviation; PCT, percentile values. *Calculated as weight in kilograms divided by height in meters squared.

Table 2. Grip Strength (in Kg) in Various Conditions among Different Hands

Arm Position						
N	Arm	Extension	Flexion	Pronation	Supination	P-value
		M ± SD	M ± SD	M ±SD	M ± SD	
40	Right *	40.96 ± 4.54	38.96 ±6.17	38.42 ±4.44	37.05 ±4.60	<0.001
40	Left	36.14 ±3.96	34.82 ± 3.51	32.96 ±3.08	32.09 ±3.89	<0.001

Note: The data is represented as M (SD); *Means the right hand is dominant.

Table 3. Paired Sample t-Test Results for Mean Differences in Right and Left Arm Positions

Comparison	N	Mean Difference	Mean Difference	t-value	p-value
Right Extension -Left Extension	40	4.82	2.90	10.50	0.000 <0.05
Right Flexion -Left Flexion	40	4.14	5.40	4.85	0.000 <0.05
Right Pronation -Left Pronation	40	5.45	3.55	9.70	0.000 <0.05
Right Supination -Left Supination	40	4.96	3.04	10.32	0.000 <0.05

Table 4. Correlation results between different positions

Variable	Age	Weight	Height	RE	RF	RP	RS	LE	LF	LP	LS
Age	1	0.475*	0.153	-0.056	-0.037	0.155*	0.081	0.073	0.062	0.189*	0.070
Weight		1	0.465*	0.186	0.028*	0.141	0.219*	0.182	0.286*	0.283	0.066*
Height			1	0.239	0.019	-0.027*	0.152	0.168	0.222	0.056*	0.030
RE				1	0.596	0.821	0.818	0.775	0.724	0.552	0.681
RF					1	0.602	0.543	0.557*	0.491	0.401	0.533
RP						1	0.852	0.723*	0.702	0.605	0.771
RS							1	0.686*	0.675	0.652	0.757
LE								1	0.861	0.682	0.712
LF									1	0.769	0.697
LP										1	0.754
LS											1

Note. RE - right extension, RF - right flexion, RP - right pronation, Rs - right supination, Le - left extension, LF - left flexion, LP - left pronation, Ls - left supination; *Indicates a significant correlation at the level of 0.001.

research contexts.

Table 4 provides correlation coefficients between age, weight, height, and grip strength across various arm positions for both the dominant right hand and the non-dominant left hand, with significant correlations at the 0.001 level marked with an asterisk (*). The analysis reveals several key trends. Age shows a positive correlation with weight and modest positive correlations with grip strength in the pronation position for both hands. However, it has weak negative correlations with grip strength in the extension and flexion positions of the right hand, suggesting a slight decrease in grip strength in these positions with age within this young adult sample. Weight is strongly correlated with height and significantly positively correlated with grip strength in various positions for both hands, indicating that heavier individuals generally exhibit higher grip strength across most arm positions. Height shows significant positive correlations with grip strength in several positions for both hands, suggesting that taller individuals tend to have greater grip strength. However, there are weak negative correlations with grip strength in the right flexion and right pronation positions. For the dominant right hand, there are strong correlations between different grip strength positions, indicating consistency in performance across various arm positions. Similar patterns are observed for the non-dominant left hand, demonstrating robust internal consistency in grip strength measures. These findings underscore the importance of considering anthropometric factors such as age, weight, and height when assessing grip strength. The consistency of grip strength performance across different positions within each hand highlights the reliability of these measurements, which is crucial for ensuring accurate and meaningful evaluations in both clinical and research settings.

Table 5 presents findings from a multiple linear regression analysis investigating the impacts of arm postures, age, and BMI on grip strength. Significant differences were observed between right extension and right flexion, indicating a relationship in grip strength between these positions. However, other posture comparisons like right flexion versus right supination did not show significant differences, suggesting weaker associations between grip strength and these postures. Age and BMI were found to have no significant influence on grip strength in this study, indicating that within this sample, variations in these factors do not reliably predict differences in grip strength. The wide confidence intervals and p-values above 0.05 in several comparisons underscore the variability in grip strength data and highlight the complexities involved in predicting grip strength based solely on the variables assessed (Fig. 3). These insights emphasize the need for comprehensive assessments considering multiple factors in both clinical practice and research to ensure accurate evaluations of grip strength across diverse populations.

The following regression equations describe the relationships between various arm postures (predictor variables) and grip strength (dependent variable), derived from the multiple linear regression analysis. Grip Strength represents the predicted grip strength, while RE, RF, RS, and RP denote the grip strengths in right extension, right flexion, right supination, and right pronation, respectively. The term ε represents the error or residual term:

Model 1: Right Extension (RE) vs. Right Flexion (RF): $\text{Grip Strength} = 0.555 \times (RE - RF) + \varepsilon$

This equation signifies the effect of changing grip strength from right extension to right flexion, considering the coefficient 0.555.

Model 2: Right Flexion (RF) vs. Right Supination (RS): $\text{Grip Strength} = -22.851 \times (RF - RS) + \varepsilon$ It illustrates

Table 5. Results of the Multiple Linear Regression Analysis

Name of predictor variable (Posture)	B	95%ci	P value
RE Vs RF	0.555	(-1.099, 0.011)	0.046
RF Vs RS	-22.851	(-602.541, 556.839)	0.587
RE Vs RS	54.694	(-524.996, 634.384)	0.587
RE Vs RP	156.763	(-728.763, 415.237)	0.832
RF Vs RP	-366.085	(-1060.474, 328.304)	0.269
RS Vs RP	-211.457	(-793.626, 370.712)	0.434
Age	0.588	(-1.369, 2.545)	0.560
BMI	2.937	(-5.488, 11.362)	0.510

Note. RE - right extension, RF - right flexion, RP - right pronation, Rs - right supination

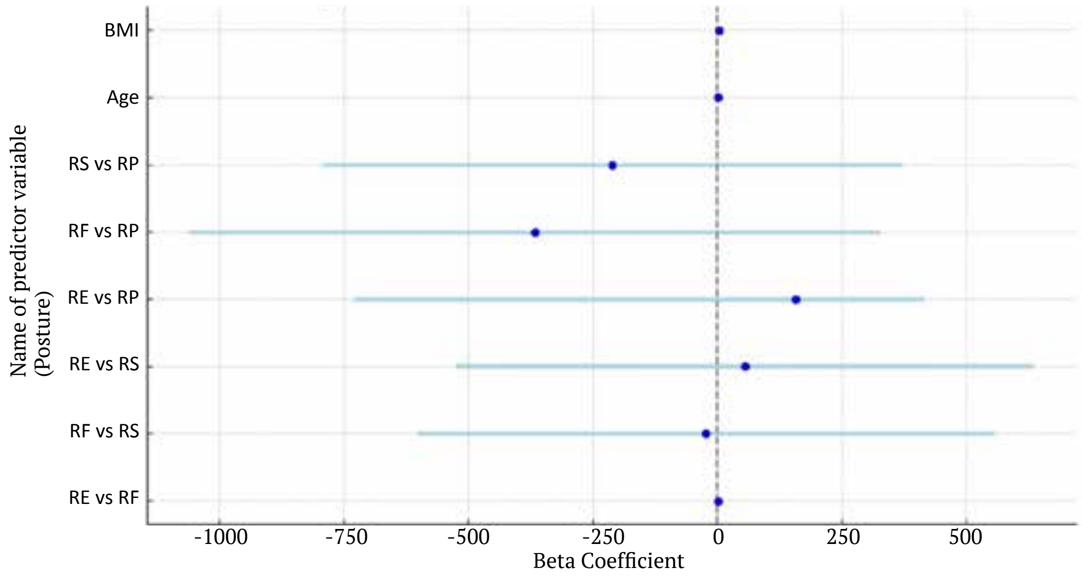

Figure 3. Regression coefficients (β) and their 95% confidence intervals. The vertical line at β=0 serves as a reference point.

the impact on grip strength when transitioning between right flexion and right supination, with a coefficient of -22.851.

Model 3: Right Extension (RE) vs. Right Supination (RS):Grip Strength=54.694 × (RE−RS) +ε

This equation shows how grip strength changes from right extension to right supination, adjusted by the coefficient 54.694.

Model 4: Right Extension (RE) vs. Right Pronation (RP):Grip Strength=156.763×(RE−RP)+ε

Describes the relationship between grip strength in right extension and right pronation, influenced by the coefficient 156.763.

Model 5: Right Flexion (RF) vs. Right Pronation (RP):Grip Strength=−366.085×(RF−RP)+ε

Indicates how grip strength varies from right flexion to right pronation, accounting for the coefficient -366.085.

Model 6: Right Supination (RS) vs. Right Pronation (RP):Grip Strength=−211.457×(RS−RP)+ε

Shows the impact on grip strength when transitioning between right supination and right pronation, with the coefficient -211.457.

Regression models equations summarize the relationships between different arm postures (predictor variables) and grip strength (dependent variable) based on the regression coefficients (β) obtained from the analysis. They provide a quantitative understanding of how changes in grip strength in one posture relative to another are expected, given the coefficients derived from the regression analysis.

Discussion

This study aimed to investigate variations in grip strength across different arm positions and hand dominances among young adults. The findings contribute valuable insights into how anthropometric factors and hand dominance impact grip strength, with implications for clinical and research applications.

Anthropometric data (Table 1) indicated that participants generally maintained a healthy weight, with a mean BMI of 24.67, characteristic of typical young adults and ensuring sample representativeness. Age, weight, and height variations were controlled to create a homogeneous group, reducing potential confounding effects on grip strength measurements.

Significant variations in grip strength across different sitting arm positions were observed, with the highest strength recorded during elbow extension for both hands and a noticeable decline in the supination position. This aligns with biomechanical principles attributing force production to muscle length-tension relationships and joint mechanics. [14, 15, 16]. These results are pertinent to clinical assessments, ergonomic interventions, and athletic training programs [14]. The study also identified substantial variations in grip strength across different sitting arm positions (extension, flexion, pronation, and supination). Grip strength was highest during elbow extension for both dominant and non-dominant hands, with a notable decrease observed in the supination position [15]. This aligns with existing literature underscoring the influence of muscle length-tension relationships and joint mechanics on force production [16].

The results of the study further confirmed substantial grip strength disparities between the right and left hands across all tested arm positions, underscoring the varying influence of hand dominance on grip strength due to differential muscle engagement and mechanical advantage in each position. The largest difference was observed during pronation, while the smallest was noted in flexion. These findings indicate that hand dominance exerts a varying influence on grip strength across different arm positions, likely due to differential muscle engagement and mechanical advantage inherent in each position. This phenomenon of hand dominance effect is well-documented in literature, attributed to habitual use and superior muscle conditioning of the dominant hand in daily activities [17]. The substantial disparity in grip strength between hands underscores the importance of considering hand dominance in clinical assessments and rehabilitation protocols [18].

Correlation analysis revealed significant relationships between age, weight, height, and grip strength. Weight showed a strong positive correlation with grip strength across most arm positions, suggesting that individuals with higher body weight tend to exhibit greater grip strength. Height also demonstrated positive correlations with grip strength, albeit to a lesser extent. These findings align with biomechanical principles indicating that larger body size generally contributes to increased muscle mass and strength. Notably, age exhibited a modest positive correlation with grip strength in the pronation position, but a weak negative correlation in extension and flexion positions, indicating a potential peak and subsequent decline in grip strength during young adulthood [19]. Grip strength typically declines with age due to muscle mass and musculoskeletal strength loss.

Our study introduced a novel arm posture – sitting with arms in supination – to assess its impact on grip strength compared to sitting with the elbow fully extended. Contrary to expectations, the supinated posture did not yield greater grip strength, likely due to reduced engagement of forearm muscles crucial for grip strength and gravitational effects [20].

The strong positive correlation observed across various arm postures highlights the integrated nature of muscle groups involved in grip strength. This suggests that alternative postures could be considered when the standard posture is impractical, with regression coefficients aiding in clinical applications [21].

Multiple linear regression analysis provided nuanced insights into factors influencing grip strength, including arm posture, age, and BMI. Our models confirmed age, weight, and BMI as significant predictors of grip strength, consistent with previous research [22]. Specifically, sitting with the elbow fully extended consistently resulted in higher grip strength values, supporting its standardization in clinical settings for accurate muscle strength assessment [22].

Interaction terms in our models revealed that age and posture significantly influence grip strength, suggesting older adults may experience varied grip strength outcomes based on posture during measurement. This aligns with prior research emphasizing standardized posture for reliable grip strength assessments [23, 24]. Diagnostic tests validated the robustness of our regression models, showing normality in residual plots and absence of multicollinearity among predictors (VIF values). These measures affirm the reliability of our analyses and the validity of our findings. Our findings are corroborated by previous studies showing maximum grip strength with fully extended elbows [25], underscoring the importance of posture in grip strength measurement. The inclusion of BMI as a predictor aligns with literature linking higher BMI to greater grip strength, highlighting the relevance of body composition in muscle strength assessments [22, 25].

The significance of these findings extends to their potential clinical and practical applications. Standardizing grip strength measurements in the sitting position with a fully extended elbow could enhance the accuracy of assessments, particularly crucial for diagnosing conditions like sarcopenia. Early and precise detection can significantly influence patient outcomes and resource allocation in medical settings [22].

Practically, these findings offer several applications. For clinicians, understanding how arm position affects grip strength facilitates more precise assessments of hand function and strength. Standardizing arm posture during measurement improves evaluation reliability and aids in tracking rehabilitation progress.

For ergonomists, the results inform the design of tools and workstations to optimize grip strength and minimize musculoskeletal injury risks in manual labor tasks.

In sports science, insights from this study can enhance grip strength training and conditioning programs. Athletes in sports requiring substantial grip strength, such as rock climbing, weightlifting, and martial arts, can benefit from tailored training protocols that consider optimal arm positions to improve grip performance and reduce injury potential.

Practical Implications

This study emphasizes the critical role of hand dominance and arm position in the assessment of grip strength. Clinicians and researchers should carefully consider these factors to ensure precise and meaningful evaluations of grip strength. For example, rehabilitation programs can benefit from customizing exercises aimed at improving grip strength, especially for the non-dominant hand and specific arm positions. Furthermore, the significant correlations observed within different arm positions underscore the importance of employing consistent measurement techniques to maintain data reliability.

Limitations

While providing insights into grip strength among young adults, this study is limited by a small, homogeneous sample, hindering generalizability across diverse populations. The cross-sectional design prevents tracking grip strength changes over time or assessing long-term effects of hand dominance and arm position on muscle development. It also overlooks confounding variables like physical activity levels, occupational demands, and hand injuries, which could influence grip strength. Moreover, reliance on self-reported dominant hand data introduces potential misclassification bias. Future research should address these limitations with larger, diverse samples, longitudinal studies, and broader variable considerations to enhance understanding of grip strength determinants across populations.

Conclusions

Our study has strong evidence endorsing standardized postures for grip strength measurements and underscores the significance of incorporating factors like age, gender, and BMI in these evaluations. We recommend adopting consistent body positions for grip strength assessments during screening and supplementary diagnosis of muscle loss in clinical and research settings. Future research should delve into how these variables interact and their implications for refining methodologies in diagnosing and managing conditions such as sarcopenia, advancing clinical practice.

Acknowledgements

The authors are grateful to the Aligarh Muslim University, Aligarh (U.P.) India 202002.

Competing interests

The authors declare no competing interests.

References

1. Smets MPH, Potvin JR, Keir PJ. Constrained handgrip force decreases upper extremity muscle activation and arm strength. *Ergonomics*, 2009;52(9): 1144–1152. https://doi.org/10.1080/00140130902919113
2. Balogun J, Akomolafe C, Amusa L. Grip strength: Effects of testing posture and elbow position. *Arch Phys Med Rehabil*. 1991;72(5):280-3. https://doi.org/10.1016/0003-9993(91)90147-Q
3. Richards LG, Olson B, Palmiter-Thomas P. How Forearm Position Affects Grip Strength. *The American Journal of Occupational Therapy*, 1996;50(2): 133–138. https://doi.org/10.5014/ajot.50.2.133
4. Lee KS, Hwang J. Investigation of grip strength by various body postures and gender in Korean adults. *Work*, 2019;62(1): 117–123. https://doi.org/10.3233/WOR-182846
5. Alahmari KA, Silvian SP, Reddy RS, Kakaraparthi VN, Ahmad I, Alam MM. Hand grip strength determination for healthy males in Saudi Arabia: A study of the relationship with age, body mass index, hand length and forearm circumference using a hand-held dynamometer. *Journal of International Medical Research*, 2017;45(2): 540–548. https://doi.org/10.1177/0300060516688976
6. Richards LG. Posture effects on grip strength. *Archives of Physical Medicine and Rehabilitation*, 1997;78(10): 1154–1156. https://doi.org/10.1016/S0003-9993(97)90143-X
7. Kong YK, Seo MT, Kang HS. Evaluation of total grip strength and individual finger forces on opposing (A-type) handles among Koreans. *Ergonomics*, 2014;57(1): 108–115. https://doi.org/10.1080/00140139.2013.851284
8. Kattel BP, Fredericks TK, Fernandez JE, Lee DC. The effect of upper-extremity posture on maximum grip strength. *International Journal of Industrial Ergonomics*, 1996;18(5–6): 423–429. https://doi.org/10.1016/0169-8141(95)00105-0
9. Ha YC, Hwang SC, Song SY, Lee C, Park KS, Yoo JI. Hand grip strength measurement in different epidemiologic studies using various methods for diagnosis of sarcopenia: a systematic review. *European Geriatric Medicine*, 2018;9(3): 277–288. https://doi.org/10.1007/s41999-018-0050-6
10. Watanabe T, Owashi K, Kanauchi Y, Mura N, Takahara M, Ogino T. The Short-Term Reliability of Grip Strength Measurement and the Effects of Posture and Grip Span. *The Journal of Hand Surgery*, 2005;30(3): 603–609. https://doi.org/10.1016/j.jhsa.2004.12.007
11. Shyam Kumar AJ, Parmar V, Ahmed S, Kar S, Harper WM. A study of grip endurance and strengh in different elbow positions. *Journal of Orthopaedics and Traumatology*, 2008;9(4): 209–211. https://doi.org/10.1007/s10195-008-0020-8
12. Desrosiers J, Bravo G, Hébert R, Mercier L. Impact of Elbow Position on Grip Strength of Elderly Men. *Journal of Hand Therapy*, 1995;8(1): 27–30. https://doi.org/10.1016/S0894-1130(12)80153-0
13. Oxford KL. Elbow Positioning for Maximum Grip Performance. *Journal of Hand Therapy*, 2000;13(1): 33–36. https://doi.org/10.1016/S0894-1130(00)80050-2
14. Jain R, Meena ML, Sain MK, Dangayach GS. Impact of posture and upper-limb muscle activity on grip strength. *International Journal of Occupational Safety and Ergonomics*, 2019;25(4): 614–620. https://doi.org/10.1080/10803548.2018.1501972
15. Kamarul T, Ahmad T, Loh W. Hand Grip Strength in the Adult Malaysian Population. *Journal of Orthopaedic Surgery*, 2006;14(2): 172–177. https://doi.org/10.1177/230949900601400213

16. Chen CY, McGee CW, Rich TL, Prudente CN, Gillick BT. Reference values of intrinsic muscle strength of the hand of adolescents and young adults. *Journal of Hand Therapy*, 2018;31(3): 348–356. https://doi.org/10.1016/j.jht.2017.05.012
17. Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Research Notes*, 2011;4(1): 127. https://doi.org/10.1186/1756-0500-4-127
18. Kong YK. The Effects of Co-ordinating Postures With Shoulder and Elbow Flexion Angles on Maximum Grip Strength and Upper-Limb Muscle Activity in Standing and Sitting Postures. *International Journal of Occupational Safety and Ergonomics*, 2014;20(4): 595–606. https://doi.org/10.1080/10803548.2014.11077077
19. Mogk J, Keir P. The effects of posture on forearm muscle loading during gripping. *Ergonomics*, 2003;46(9): 956–975. https://doi.org/10.1080/0014013031000107595
20. Di Domizio J, Keir PJ. Forearm posture and grip effects during push and pull tasks. *Ergonomics*, 2010;53(3): 336–343. https://doi.org/10.1080/00140130903389076
21. Wichelhaus A, Harms C, Neumann J, Ziegler S, Kundt G, Prommersberger KJ, et al. Parameters influencing hand grip strength measured with the manugraphy system. *BMC Musculoskeletal Disorders*, 2018;19(1): 54. https://doi.org/10.1186/s12891-018-1971-4
22. Xu Z yang, Gao D fa, Xu K, Zhou Z qi, Guo Y kun. The Effect of Posture on Maximum Grip Strength Measurements. *Journal of Clinical Densitometry*, 2021;24(4): 638–644. https://doi.org/10.1016/j.jocd.2021.01.005
23. Shyam D. Comparative analysis of elbow positions on grip strength. *J Strength Cond Res*. 2015;29(3):673-8. https://doi.org/10.1519/JSC.0000000000000748.
24. Johanne S. The influence of posture on grip strength measurements in different age groups. *J Gerontol.* 2016;71(2):234-40. https://doi.org/10.1093/geronj/gou113.
25. Kim S. Impact of elbow extension on maximum grip strength. *Phys Ther Sport.* 2018;33:69-73. https://doi.org/10.1016/j.ptsp.2018.05.005

Information about the authors:

Mohd Arshad Bari; https://orcid.org/0000-0003-2365-1300; arshadbari.bari@gmail.com; Department of Physical Education, Aligarh Muslim University; Aligarh, India.

Junaid Ahmad Parrey; (Corresponding author); https://orcid.org/0000-0002-0762-3038; ahmadjunaid232; @gmail.com; Department of Physical Education, Aligarh Muslim University; Aligarh, India.

Abdul Qayyum Khan; https://orcid.org/0000-0002-9252-5810; drabdul762@gmail.com; Department of Orthopedic Surgery, Aligarh Muslim University; Aligarh, India.

Arish Ajhar; https://orcid.org/0000-0002-7787-799X; khanarishazhar@; gmail.com; Department of Physical Education, Aligarh Muslim University; Aligarh, India.

Shivani Singh; https://orcid.org/0009-0002-1080-7302; shivanisingh@; gmail.com; Department of Physical Education, Aligarh Muslim University; Aligarh, India.

Cite this article as:

Bari MA, Parrey JA, Khan AQ, Ajhar A, Singh S. Comparative analysis of hand dynamometer measurements across different arm positions: implications for rehabilitation and functional assessment. *Pedagogy of Physical Culture and Sports,* 2024;28(5):360–369.
https://doi.org/10.15561/26649837.2024.0504

Received: 24.06.2024
Accepted: 25.07.2024; Published: 30.10.2024