



Sex Differences and Bilateral Asymmetry in Handgrip Strength among First-Year University Students

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ABSTRACT

Hand grip strength (HGS) is a widely recognised and robust biomarker of overall muscle health and fatigue. This study aimed to examine sex differences and bilateral asymmetry in hand grip strength among first-year university students. A cross-sectional study was conducted involving 72 new undergraduate students, consisting of 37 males and 35 females. Handgrip strength was measured using a Takei digital handgrip dynamometer, with three trials performed for each hand. The mean value was used for analysis. The results showed that male participants had higher hand grip strength than females. The mean of right-hand grip strength in males was 35.47 ± 5.7 kg, while the mean of left-hand grip strength was 31.45 ± 5.8 kg. In female participants, the mean of right-hand grip strength was 21.12 ± 3.4 kg, while the mean of left-hand grip strength was 19.0 ± 3.7 kg. The paired sample t-test indicated significant differences between right and left handgrip strength in both males and females ($p < 0.001$). The analysis revealed a large effect size (Cohen's value of 0.908), demonstrating a substantial difference between the two hands. These findings provide baseline data regarding handgrip strength characteristics in young adults and may contribute to future research in health assessment, ergonomics, rehabilitation, and sports science.

ARTICLE INFO

Article History:

Submitted/Received April 2026

First Revised June 2026

Accepted August 2026

Publication Date September 2026

Keyword:

dynamometer, hand dominance, hand grip strength, university students

INTRODUCTION

A fundamental component of physical fitness is muscular strength, which plays a crucial role in maintaining functional human capacity and overall health. Handgrip strength is one of the most commonly used indicators to assess muscle strength. Handgrip strength measurement is widely used in clinical practice, rehabilitation, sports science, and epidemiological research because it is simple, reliable, and noninvasive. Previous studies have shown that handgrip strength is strongly associated with several health outcomes, including nutritional status, functional ability, and the risk of morbidity and mortality (Bohannon et al., 2019; Celis-Morales et al., 2018; Xue et al., 2025).

Previous studies have reported that handgrip strength is significantly associated with anthropometric measures such as body mass index (BMI), waist circumference, and hip circumference, whereas age shows a negative relationship with handgrip strength (Leong et al., 2016). However, no significant association has been found between fasting blood glucose and handgrip strength (Alvina et al., 2025). Although handgrip strength is widely used as an indicator of muscle function, its associations with health outcomes are not always consistent. Ngestiningsih et al. (2020) found no significant relationship between body mass index, handgrip strength, and frailty status in elderly women, indicating that other factors may play a more important role.

Handgrip strength is typically measured using a handgrip dynamometer and is considered a practical indicator of overall muscular strength. Due to its ease of measurement and high reliability, it has been widely used in studies involving different populations, such as preschool students, children, young adults, athletes, and older adults (Mahmoud et al., 2020; Alqahtani et al., 2023; Boy et al., 2022; Ellyas et al., 2023; Kamarul & Ahmad, 2006; Efstathiou et al., 2016; Ellyas et al., 2023; Akinyemi et al., 2025). In addition to reflecting limb muscle strength, handgrip strength can also provide insights into neuromuscular function and physical performance (Wind, 2010).

One factor that may influence handgrip strength is hand dominance. Hand dominance refers to the preferential use of one hand over the other to perform daily activities such as writing, eating, or manipulating objects. Because the dominant hand is used more frequently, it generally develops greater muscle strength and coordination compared to the non-dominant hand (Zadoń et al., 2025). However, the difference in grip strength between dominant and non-dominant hands is not always consistent across populations. Several factors, such as age, sex, physical activity level, occupational demands, and lifestyle habits may influence the magnitude of this difference (Zadoń et al., 2025; Dodds et al., 2014; Kamarul & Ahmad, 2006). In young adults, particularly university students, handgrip strength may also be influenced by daily academic activities, physical exercise, and technological device use. Therefore, investigating hand dominance in handgrip strength within this population may provide valuable insights into neuromuscular characteristics during early adulthood.

Handgrip strength is widely recognized as an important indicator of muscle strength and overall health across different populations worldwide (Bohannon et al., 2019; Celis-Morales et al., 2018; Leong et al., 2016). Handgrip strength is also associated with the risk of disease as stroke and heart disease (Li et al., 2023; Gajjar et al., 2024). Previous studies conducted in Europe, the United States, and Asia have shown that handgrip strength is influenced by factors such as age, sex, and body composition (Celis-Morales et al., 2018; Wen et al., 2020).

Although numerous studies have investigated handgrip strength asymmetry worldwide, evidence among healthy young university students, particularly during the transition to university life, remains limited. The transition to university is often associated with changes in physical activity, sleep, stress, and nutrition, all of which may influence muscle function. Data concerning grip strength among the first-year university students in Indonesia are still limited. Establishing baseline information in this population is important for understanding muscle strength characteristics and may contribute to future research in health assessment, ergonomics, military science, and sports science. Therefore, this study aims to examine sex differences and bilateral asymmetry in handgrip strength among first-year university students and to investigate the influence of hand dominance on handgrip strength. Specifically, the study compared grip strength between the right and left hands and between male and female participants, as well as between dominant and non-dominant hands, to determine whether significant differences existed.

METHODS

This study employed a cross-sectional design to examine differences in handgrip strength between the right and left hands among first-year university students. The study was conducted in accordance with ethical principles.

Participants

A total of 72 new undergraduate students (37 males and 35 females) from a university in Indonesia participated in this study. All participants were healthy young adults who voluntarily agreed to take part in the study. Individuals with a history of upper-limb injury, neuromuscular disorders, or conditions that could affect hand strength were excluded. Hand dominance was determined by asking participants which hand they primarily used for daily activities such as writing, eating, and manipulating objects. Participants were then categorized as right-hand or left-hand dominant based on their responses.

Table 1. The Characteristics of The Participants

	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)
Age (years)	18.3 $\pm$ 0.9	17,9 $\pm$ 0,4
Body mass index	22.7 $\pm$ 3.8	20.5 $\pm$ 3.9
Height (cm)	169.6 $\pm$ 5.3	159.7 $\pm$ 4.6
Weight (kg)	65.4 $\pm$ 12.0	52.3 $\pm$ 10.3
Hand dominants	Right	Right

Sampling Procedures

Participants were selected using a convenience sampling method from among new undergraduate students at a university in Indonesia. A total of 72 students agreed to participate in the study. Data collection was conducted in a designated area on the university campus under controlled and standardized conditions. Prior to participation, all individuals were informed about the study procedures and provided informed consent. Participants were entirely voluntary. Assuming a moderate effect size (Cohen's $d=0.50$), a significance level of $\alpha= 0.05$, and statistical power of 80% ($1- \beta = 0.80$), the minimum required sample size was estimated to be 34 participants. The sample size of 72 participants was considered adequate

for detecting a significant difference in handgrip strength between the dominant and non-dominant hands using paired-sample t-tests.

Materials and Apparatus

A Takei digital handgrip dynamometer, model TTK5401 (Takei Scientific Instruments Co., Ltd., Niigata, Japan), was the primary instrument used in this study. It is a widely accepted and reliable tool for measuring handgrip strength and is commonly used to assess muscular strength in research and clinical settings. Measurements were recorded in kilograms (kg), with an accuracy of +0,5 kg and measurement range of 5.0-100.0 kg. The dynamometer was used to record maximum isometric strength of the hand and forearm muscles, with results expressed in kilograms (kg). The instrument was checked and calibrated according to the manufacturer's guidelines prior to data collection. Three trials were performed for each hand, with a rest interval between trials to minimize the effects of fatigue, and the mean value of the three measurements was used for statistical analysis. No additional questionnaire or custom-developed instrument was used in this study. Hand dominance was determined through a simple self-report question regarding the preferred hand used in daily activities such as writing and eating.

Procedures

The study employed a cross-sectional design to examine differences in handgrip strength between dominant and non-dominant hands among university students. The independent variable was hand dominance, while the dependent variable was handgrip strength.

Before testing, participants were given instructions on the proper procedure for performing the test. The testing was performed according to the muscle strength procedures manual of the National Health and Nutrition Examination Survey (NHANES). All participants completed the same measurement procedure; therefore, no experimental grouping or random assignment was applied. However, comparisons were made between conditions (right and left hands) and between groups (male and female participants).

Measurements were conducted with participants in a standing position, with the arm positioned comfortably alongside the body and the elbow slightly flexed. Participants were instructed to squeeze the dynamometer with maximum effort for approximately 3-5 seconds. Each participant performed the test with both the dominant and non-dominant hands. Three trials were conducted for each hand, and the highest value recorded from the trials was used for analysis. A short rest period approximately 60 seconds was provided between trials to minimize muscle fatigue. Handgrip strength values were recorded in kilograms (kg).

All participants provided informed consent before participation, and their involvement in the study was voluntary.

Design or Data Analysis

The data collected in this study were analysed using descriptive and inferential statistical methods. Descriptive statistics were used to summarize participant characteristics and handgrip strength measurements. The mean and standard deviation were calculated for right- and left-hand grip strength in the dominant and non-dominant hands. A paired sample t-test was performed to determine whether significant differences existed in handgrip strength between the right and left hands. The magnitude of the differences was further assessed using Cohen's d effect size. Statistical significance was set at $p < 0.05$. Data analysis was conducted using statistical software.

RESULTS

The characteristics of the participants used in this study are presented in Table 1. The mean age of male participants was 18.3 ± 0.9 years, while female participants had a slightly lower mean age of 17.9 ± 0.4 years. In terms of body mass index (BMI), males had a higher average BMI than females. However, both groups were within the normal BMI range.

The results of this study showed differences in handgrip strength between the right and left hands in both male and female participants. Based on the measurements, male participants demonstrated greater handgrip strength than female participants. The average handgrip strength in males was 35.47 ± 5.7 kg for the right hand and 31.45 ± 5.8 kg for the left hand. In contrast, female participants showed lower values, with average handgrip strength of approximately 21.12 ± 3.4 kg for the right hand and 19.0 ± 3.7 kg for the left hand (Figure 1 and Table 2). Overall, right handgrip strength was greater than left handgrip strength, with a difference of 3.1 kg.

Paired sample t-tests revealed significant differences between right and left handgrip strength in both males ($t = 6.074$, $p < 0.001$) and females ($t = 5.522$, $p < 0.001$). Independent sample t-tests also showed that males had significantly higher handgrip strength than females for both the right hand ($t = 12.947$, $p < 0.001$) and the left hand ($t = 10.808$, $p < 0.001$).

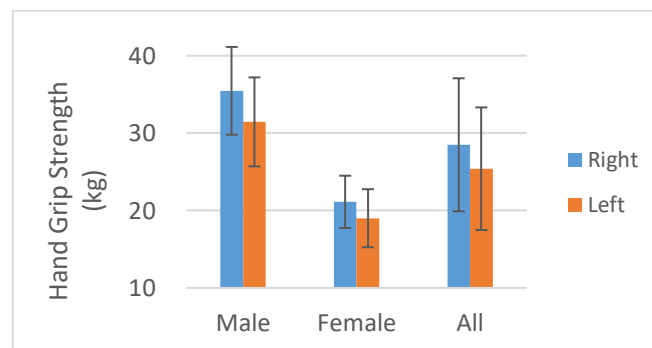


Figure 1. Comparison of Handgrip Strength between Male and Female Participants for The Right and Left Hands

The overall mean grip strength across all participants was 28.5 kg for the right hand, and 25.4 kg for the left hand. The calculated hand asymmetry index indicated that the right hand was approximately 12.1% stronger than the left hand. The effect size analysis showed a large effect (Cohen's $d = 0.908$), indicating a substantial difference between the two hands. This finding has important implications for fields such as ergonomics, rehabilitation, and sports science, where hand strength asymmetry may influence performance, injury risk, and recovery strategies. Future studies should explore whether this asymmetry has real-world implications for task performance or injury risk.

Table 2. The Mean and Standard Deviation for Male and Female New University Students

Handgrip Strength	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)	All (Mean $\pm$ SD)
Right Hand (kg)	35.47 $\pm$ 5.7	21.12 $\pm$ 3.4	28.49 $\pm$ 8.6
Left Hand (kg)	31.45 $\pm$ 5.8	19 $\pm$ 3.7	25.4 $\pm$ 7.9

Figure 2 illustrates the relationship between handgrip strength (kg) and body mass index (BMI) among university students for both the right and left hands. The yellow markers indicate right-handgrip strength, whereas the brown markers represent left-handgrip strength. Linear trendlines are included for both hands, with coefficients of determination of $R^2 = 0.1509$ for the right hand and $R^2 = 0.0982$ for the left hand.

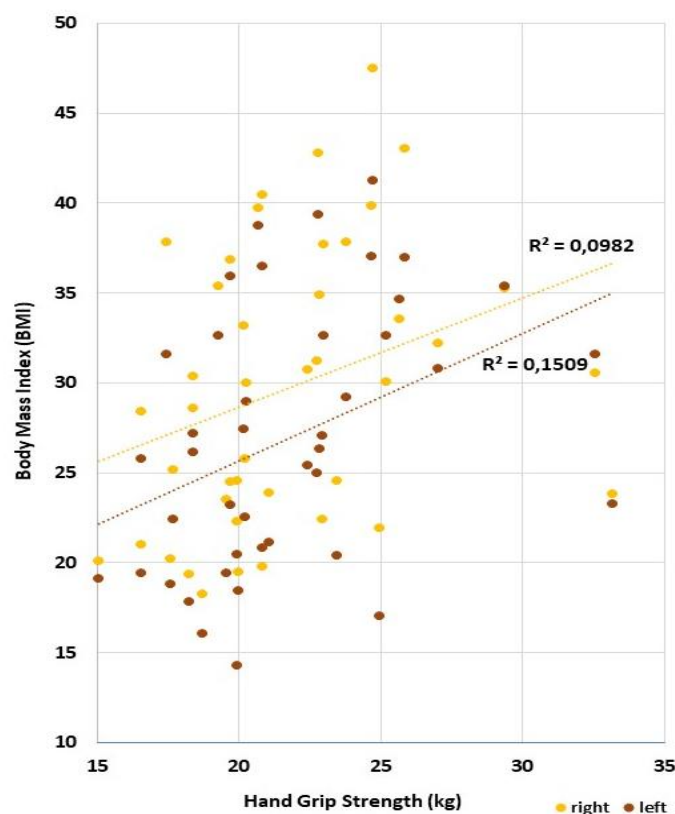


Figure 2. Relationship between Right and Left Handgrip Strength and Body Mass Index (BMI) in University Students

Table 3. Results of Kolmogorov-Smirnov Normality Test

Gender	Hand Side	N	Test Statistic	p-value
Male	Right Hand	37	0.071	0.200*
	Left Hand	37	0.088	0.200*
Female	Right Hand	35	0.134	0.114*
	Left Hand	35	0.044	0.200*

Note: The test distribution was normal. * Lilliefors significance correction. Data were considered normally distributed when the *p-value* was > 0.05 .

Table 4. Paired Samples Test of Right Handgrip Strength and Left Handgrip Strength

Comparison	Mean Difference	SE Difference	t	df	p-value
Pair 1: Male (Right Hand – Left Hand)	4.02	0.66	6.07	36	<0.001
Pair 2: Female (Right Hand – Left Hand)	2.11	0.38	5.52	34	<0.001

Table 5. Independent Samples Test of Handgrip Strength between Male and Female Participants

Comparison	Mean Difference	SE Difference	t	df	p-value
Pair 1: Right Hand (Male-Female)	14.35	1.11	12.95	70	<0.001
Pair 2: Left Hand (Male-Female)	12.45	1.15	10.81	70	<0.001

DISCUSSION

The present study investigated sex differences and bilateral asymmetry in handgrip strength among first-year university students. The findings revealed that male students demonstrated substantially greater handgrip strength than female students in both hands. Overall, the right hand exhibited greater grip strength than the left hand in both groups. This pattern indicates that the dominant hand, which is typically the right hand for most individuals, tends to generate greater muscular force compared to the non-dominant hand. Additionally, the difference between right and left handgrip strength was slightly larger in male participants compared to female participants.

These findings also highlight a clear difference in grip strength between males and females. Male participants showed considerably higher grip strength values than female participants in both hands. This difference may reflect variations in muscle mass and other physical characteristics between males and females. All participants in this study reported right-hand dominance. This finding is consistent with previous studies reporting that the dominant hand tends to be stronger due to more frequent use in daily activities (Zadoń et al., 2025). Repeated use of the dominant hand in activities such as writing, lifting objects, and manipulating tools may contribute to greater neuromuscular adaptation and muscle development. This result is consistent with earlier research indicating that males typically have greater muscle mass and upper-body strength than females (Wind, 2010; Massy-Westropp et al., 2011). Hormonal differences, body composition, and greater skeletal muscle mass in males are often cited as contributing factors to these differences. These biological differences may contribute to greater force-generating capacity in males, particularly in upper body strength. The right hand exhibited higher grip strength values than the left hand in both sexes, indicating the presence of bilateral asymmetry in handgrip performance.

Another observation from this study is the relatively small but consistent difference between the dominant and non-dominant hands. Although the right hand was stronger, the difference between the hands was not particularly large. This may be because first-year university students often use both hands for various daily activities, including typing, carrying objects, and using digital devices, which may contribute to more balanced hand use.

In terms of the relationship between body mass index and handgrip strength, the findings show a positive but weak relationship. As handgrip strength increase, BMI tends to increase slightly; however, the low R² values (less than 0.2) indicate that BMI explains only a small proportion of the variability in handgrip strength. These findings indicate that although BMI may have some association with muscle strength, it is not a strong predictor of handgrip strength in young adults. This finding is consistent with previous studies (Leong et al., 2016).

Therefore, relying solely on BMI to assess muscular fitness may be insufficient, and additional measures should be considered.

Overall, the results of this study support the existence of both sex differences and bilateral asymmetry in handgrip strength among first year university students. Male students exhibited significantly greater grip strength than female students, while the right hand consistently produced greater force than the left hand. These findings support the concept that hand dominance influences handgrip strength. The dominant hand tends to produce greater force compared to the non-dominant hand, and males generally demonstrate higher grip strength than females. These findings provide useful baseline data on handgrip strength characteristics among first-year university students and may inform future studies in health assessment, ergonomics, and sports science.

CONCLUSION

This study examined sex differences and bilateral asymmetry in handgrip strength among first-year university students. The results showed that the right hand generally demonstrated greater grip strength than the left hand in both male and female participants, indicating the presence of bilateral asymmetry. In addition, male students exhibited greater handgrip strength than female students in both hands. However, the difference between the hands was relatively small, suggesting relatively balanced hand use among first-year university students. These findings suggest that hand dominance plays a role in handgrip strength, with the dominant hand tending to produce greater muscular force because of its more frequent use in daily activities. The observed sex differences in grip strength may also be associated with variations in muscle mass and other physical characteristics between males and females.

Overall, this study provides baseline information on handgrip strength characteristics among first-year university students. Future research involving larger sample sizes and additional variables, such as physical activity level, body composition, muscle mass, hand dominance patterns, are recommended to further explore the factors influencing handgrip strength in young adults.

ACKNOWLEDGMENT

We gratefully acknowledge all participants for their voluntary involvement in this study. We also thank the Ergonomics Laboratory, Industrial Engineering Study Program, UGM, for providing the handgrip dynamometer and facilitating the data collection process.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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