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Original Research Article

IMPACT OF HAND ANTHROPOMETRY ON GRIP STRENGTH AND AUTONOMIC REACTIVITY IN YOUNG ADULTS

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ABSTRACT

Background: A crucial indicator of musculoskeletal health, functional ability and general physiological resilience is hand grip strength (HGS). Although there is ample evidence of gender differences in grip strength little is known about the connection between hand dimensions, autonomic stress responses, and pain perception. By examining sex-based differences in hand anthropometry, HGS and physiological reactions to cold stress this study provides a greater understanding of how these factors are related to one another.

Materials and Methods: In this cross-sectional study 200 healthy persons between the ages of 18 and 24 (100 men and 100 women) took part. Vernier callipers were used to measure hand length and breadth and a JAMAR Hydraulic Hand Dynamometer was used to measure HGS. Using blood pressure, pain threshold and pain tolerance measurements, the Cold Pressor Test (CPT) assessed autonomic reactivity and pain perception. Pearson correlation and independent t-tests were used in the statistical analyses significance was defined at $p < 0.05$.

Results: In accordance with their bigger hand dimensions males had a greater HGS (38.2 ± 4.5 kg) than females (31.2 ± 3.8 kg). Males had higher systolic blood pressure increases (+35.3 mmHg vs. +18.7 mmHg in females) and stronger pain tolerance (29.2 ± 5.0 s vs. 18.5 ± 4.3 s) according to CPT responses. Females showed a considerably lower pain threshold suggesting heightened susceptibility to stress caused by cold.

Conclusion: These results support the idea that gender specific variations in hand form and autonomic responses shape HGS as a multifactorial biomarker. The study emphasises the necessity of taking sex into account while conducting ergonomic treatments stress tests and physical performance evaluations.

Key Words: Hand Anthropometry, Grip Strength, Autonomic Reactivity.

INTRODUCTION

Hand grip strength (HGS) is an important sign of muscle health, body strength and overall fitness. It is strongly linked to heart health, metabolism and even lifespan.[1] Because it is easy to measure and does not require any complex tools, HGS is widely used to understand how male and female bodies differ in strength, muscle mass and how they respond to stress.[2] Many studies have shown that men generally have stronger grip strength than women mostly due to differences in muscle size, hormones and body structure. However not much is known about how hand size, stress reactions and pain tolerance work together in these differences.[3]

The Cold Pressor Test (CPT) is a well-known test that checks how the nervous system reacts to pain and cold stress. It is often used to study how the heart and blood pressure respond to stress and how well a person tolerates pain.[4] At the same time hand size measurements like hand length, hand breadth and hand index are believed to affect grip strength and their role in stress response is still not fully understood.[5]

This study looks at how males and females differ in hand strength, hand size and how their bodies react to cold stress. By measuring grip strength, hand dimensions and how the heart and body react during CPT, this study helps us better understand the link between hand structure, stress tolerance and physical performance. The findings will also help in setting better health standards and improving medical advice for both men and women.

MATERIALS AND METHODS

Recruited from nearby universities, 200 healthy persons (100 men and 100 women) between the ages of 18 and 24 participated in this cross-sectional study. Participants were given information about the study and then gave their signed informed permission. People without a history of cardiovascular, metabolic or neuromuscular disorders were included people with hand injuries, surgeries, chronic pain or drug use that impairs muscle performance were not.

A JAMAR Hydraulic Hand Dynamometer (USA) was used to measure HGS. The participants squeezed the dynamometer as hard as they could while sitting with their elbows bent at a 90-degree angle. The greatest reading in kilogrammes was noted after three attempts per hand were completed with 30-second rest periods.

Sliding Vernier callipers with a precision of ±0.01 cm were used to measure the hand's dimensions. Hand breadth was measured from the second to the fifth metacarpal while hand length was measured from the distal wrist crease to the middle fingertip. The formula for the hand index was (Hand Breadth ÷ Hand Length) × 100. Two measurements of each were made, and the average was noted. Autonomic responses were assessed using the Cold Pressor Test (CPT). For a maximum of 60 seconds, participants submerged their dominant hand up to the wrist in 4°C water. Prior to and following immersion, blood pressure (BP) was measured. Pain tolerance was the entire amount of time before withdrawal, while pain threshold was the amount of time before the initial discomfort.

SPSS (version 26.0) was used to analyse the data. Pearson correlation was used to look at the association between grip strength and hand size and independent t-tests were used to compare HGS, hand dimensions and CPT responses between genders. P-values less than 0.05 were regarded as statistically significant. In addition to providing insightful information about gender differences in grip strength, hand shape and physiological reactions to stress. This standardised technique guaranteed accuracy and reproducibility.

RESULTS

Table 1: Mean Hand Grip Strength Among Study Participants

Gender	Hand Grip Strength (kg) (Mean ± SD)
Male	38.2 ± 4.5
Female	31.2 ± 3.8

The study revealed a significant difference in hand grip strength (HGS) between males and females. Males exhibited a higher mean grip strength of 38.2 ± 4.5 kg, whereas females had a mean grip strength of 31.2 ± 3.8 kg. This difference is consistent with existing literature, where male grip strength is typically 40–60% higher than females due to greater lean body mass and muscle fiber composition. The findings emphasize the importance of sex-specific reference values in assessing musculoskeletal fitness and functional capacity.

Table 2: Anthropometric Measurements of the Hand

Parameter	Male (Mean)	Female (Mean)
Hand Length (cm)	18.6–19.1	16.4–17.4
Hand Breadth (cm)	8.1–8.9	7.1–7.9
Hand Index (%)	42.1–44.3	42.2–43.5

Males had longer and broader hands compared to females, with hand length ranging between 18.6–19.1 cm in males and 16.4–17.4 cm in females. Similarly, hand breadth was 8.1–8.9 cm in males and 7.1–7.9 cm in females. The hand index was comparable between genders (42.1–44.3 in males vs. 42.2–43.5 in females), indicating proportional hand structure despite size differences. The larger hand dimensions in males may contribute to enhanced grip mechanics, supporting previous research that links hand size to grip performance and functional strength.

Table 3: Physiological Responses to Cold Pressor Test

Parameter	Male (Mean ± SD)	Female (Mean ± SD)
Systolic BP (Rest)	109.0 ± 8.0	112.0 ± 7.3
Systolic BP (CPT)	144.3 ± 9.8	130.7 ± 8.6
Diastolic BP (Rest)	70.3 ± 5.8	69.6 ± 4.9
Diastolic BP (CPT)	84.6 ± 8.0	81.8 ± 7.2

Pain Threshold (s)	26.0 ± 4.1	17.2 ± 3.8
Pain Tolerance (s)	29.2 ± 5.0	18.5 ± 4.3

The cold pressor test (CPT) induced distinct cardiovascular and pain responses in males and females. Males showed a larger increase in systolic blood pressure (SBP) during CPT, rising from 109.0 ± 8.0 mmHg at rest to 144.3 ± 9.8 mmHg, whereas females had a lesser increase from 112.0 ± 7.3 mmHg to 130.7 ± 8.6 mmHg. Similar trends were observed in diastolic blood pressure (DBP), with males experiencing a greater rise from 70.3 ± 5.8 mmHg to 84.6 ± 8.0 mmHg, while females showed a smaller increase from 69.6 ± 4.9 mmHg to 81.8 ± 7.2 mmHg.

Pain perception also varied significantly. Males demonstrated a higher pain threshold (26.0 ± 4.1 s) and pain tolerance (29.2 ± 5.0 s) compared to females (17.2 ± 3.8 s and 18.5 ± 4.3 s, respectively). These findings support prior research indicating that males generally withstand pain longer, potentially due to testosterone-mediated pain modulation and differences in autonomic nervous system responses.

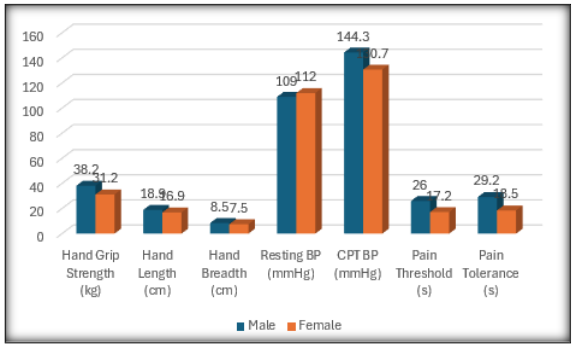

Figure 1: Comparison of Hand Grip Strength, Hand Anthropometry and Cold Pressor Test Responses Among Male and Female Participants

DISCUSSIONS

Our findings clearly show significant differences between males and females in hand grip strength (HGS), hand size and how their bodies respond to cold stress (CPT). These results match previous studies while also providing new insights into how body structure and nervous system responses are connected.

Males in our study had a much stronger grip (38.2 ± 4.5 kg) compared to females (31.2 ± 3.8 kg). This is consistent with other research, which shows men generally have 40–60% more grip strength than women across different populations.[6,7] Female grip strength in our study (67% of male strength) is similar to what has been reported in Taiwanese and Korean studies.[7,8] This suggests that sex-based differences in grip strength are common across different cultures. The reason for this difference is likely due to higher lean body mass (LBM), hormonal differences and better neuromuscular efficiency in males. Studies have shown a strong link between HGS and LBM (r = 0.88–0.89) further supporting this idea.[9]

Our study also found that males had bigger hands than females (length: 18.6–19.1 cm vs. 16.4–17.4 cm; breadth: 8.1–8.9 cm vs. 7.1–7.9 cm). This matches previous research that suggests hand size plays a big role in grip performance, where hand length and breadth together explain 45–57% of grip strength variation (r = 0.45–0.57).[10] Even though both genders had similar hand index values (42–44%), the larger hand size in males gives them a mechanical advantage, making their grip stronger.

Males and females showed different physiological responses to cold stress. Males had a greater rise in systolic blood pressure (SBP) during CPT (+35.3 mmHg) compared to females (+18.7 mmHg). This pattern is similar to other studies showing stronger sympathetic nervous system activation in males during cold stress.[11] Research using brain imaging (fMRI) also supports this males show more activity in the motor and sensory parts of the brain during CPT while females have more activation in the amygdala, which is linked to emotional processing.[12]

Males also showed higher pain tolerance (29.2 ± 5.0 s) compared to females (18.5 ± 4.3 s). This is with previous research that links testosterone to pain control suggesting hormonal differences may explain why men handle pain better.[13]

The higher grip strength in males may be an evolutionary adaptation for survival related to tasks requiring upper-body strength. However, the rise in blood pressure during CPT in males, despite their higher pain tolerance, suggests that pain perception and cardiovascular response may be controlled by different mechanisms.[14] Some studies have also linked how much a person dislikes CPT to how long they can maintain grip strength, particularly in females (r = -0.26, p = 0.040).[10] This highlights that males and females cope with stress differently.

Since female grip strength is 52–65% lower than males in all arm positions, it is important to have separate strength standards for men and women, especially when evaluating muscle health or frailty.[13] Our study also supports previous findings that higher grip strength is linked to a lower risk of hospitalization making it a useful predictor of heart and metabolic health.[11,15,16]

At the same time our CPT results suggest that standard stress tests may not work the same way for everyone. Since males have stronger BP responses, this could sometimes hide early signs of blood vessel problems.[17,18]

Although we adjusted for height and weight, future studies should look at factors like hand dominance, time of day and muscle activation using electromyography (EMG). Also hormonal studies could help understand how much grip strength

differences are controlled by muscle versus nerve function.

CONCLUSION

Our study confirms that HGS is influenced by both hand size and the body's response to stress. The large male-female differences in CPT responses suggest that men and women may have different long-term risks for heart disease. These findings highlight the need for gender-specific approaches in physical fitness, workplace ergonomics and cardiovascular health management.

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