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EFFECT OF HAND ANTHROPOMETRY INDICES ON THE MEASUREMENT OF HAND GRIP STRENGTH USING A HANDHELD DYNAMOMETER IN YOUNG ASIAN MALES

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Abstract:
Hand grip strength is a measure of one's muscle strength of the hand and forearm. It also indicates one's general physical fitness. Hand grip strength is measured using a handheld dynamometer and this procedure can be affected by one's hand anthropometry. Hand size and shape can be affected by one's race and ethnicity and thus identifying the specific hand anthropometric measurement that would be related to hand grip strength for a particular ethnicity is important. Thus, this study investigated the relationship between different hand anthropometric measurements with hand grip strength using a handheld dynamometer in South Asian healthy young male adults. Full hand length, middle finger length, palm width and wrist thickness in 52 young male participants aged 18-25 years old were measured. Hand grip strength was measured using a handheld dynamometer. Pearson correlation coefficient was used to study the relationship of each anthropometric variable with hand grip strength. Our data showed, palm width significantly correlates with hand grip strength ($r=0.461$; $p=0.00059$). Middle finger length has a weak positive correlation ($r=0.260$; $p=0.063$), while full hand length and wrist thickness has no correlation with hand grip strength ($r=0.048$; $p=0.734$) and ($r=0.094$; $p=0.509$) respectively. Our results show that of the four anthropometry measurements of the hand used in this study, palm width has a strong association with hand grip strength, and it is a statistically significant determinant of hand grip strength in South Asian healthy male young adults. It can also be concluded that middle finger length and wrist thickness do not play a role in affecting hand grip strength.

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Keywords: hand anthropometry, hand grip strength, handheld dynamometer, young adults

1. Introduction

Hands are the most valuable assets of one's body. It is mainly used for griping, grasping and performing complex daily living activities. Muscle development of our hands allows us to perform different motor skills including gross motor skills such as crawling, climbing and lifting and fine motor skills such as writing, drawing and sewing. Hand anthropometry is the systematic measurement of hand size, shape and proportion, which can directly or indirectly reflect upon the development of the hand [1]. Hand anthropometry is related to age group, gender, race, ethnicity, body mass index, nutritional status, and sedentary behaviour. Hand grip strength (HGS) describes the power or strength exerted when grasping or gripping. Hand grip strength measures the muscle strength of the hand, forearm and upper limbs, which reflects upon one's upper limb function, muscular endurance and overall strength [1]. Hand grip strength is known to be a predictor of the physical fitness and wellness of an individual [2]. It is affected by both physical and psychological factors, such as age, body constructs, body mass index, upper extremity function status and dominant hand [3].

2. Literature review

2.1 Relationship between hand grip strength and hand anthropometry

Hand anthropometric measurements are different in each individual. Genetic, racial, ethnicity, environmental, occupation and lifestyles are factors contributing to changes in body features. The simplest way of defining hand shape is through the hand width to hand length ratio (W/L ratio). A hand shape with a higher ratio is wide and short while a lower ratio can be described as long and narrow. Karmegam et al. conducted an anthropometric study among adults of different ethnicity in Malaysia [4]. Looking only into the hand anthropometric variables, Malay males have greater hand length and forefinger tip breath than Indians and Chinese. Elbow grip length and forward grip reach while sitting also have greater values than Indians and Chinese. Therefore, body dimension and proportions are different between ethnics in Malaysian population. Different hand anthropometric variables may contribute to different grip strengths. A Malaysian study by Kamarul et al. showed the mean grip strength of the western population is one and a half times greater than Malaysian population. It was suggested that genetics are factors affecting one's hand anthropometry [5]. However, there are limited data available for Asian population and the western population data is not representative of the whole population.

Koley and Singh performed their study specifically among the right dominant hand Indian tertiary education population [6]. They studied the correlation of dominant hand grip strength with hand anthropometric variables. Both male and female students

of greater hand breadth, and forearm circumference showed greater hand grip strength [6]. Alahmari et al. conducted a study among healthy male adults in Saudi Arabia. They intended to know the relationship between age, BMI, hand anthropometric measurements with hand grip strength [7]. Among younger males, the collected data showed that larger forearm circumference and longer hand length contributed to greater hand grip strength [7]. This is because forearm muscles play an important role in generating grip force. Rostamzadeh et al. compared the hand anthropometric measurement and hand grip strength between subjects of different occupations [8]. Manual labourers have higher mean hand breath and forearm circumference than office staff [8]. In terms of hand grip strength, manual labourers are 12% stronger on average than office staff [8]. The daily repetitive task of labourers increased their muscle strength and endurance, giving them a greater forearm circumference.

Fallahi and Jadidian investigated the effect of hand dimensions and grip strength among athletes who participate in grasp and grip sports [9]. The measurement of middle finger length, palm width and wrist circumference differed between athletes and non-athletes [9]. Higher hand grip strength is observed in athletes, supporting the correlation between these factors [9]. Longer fingers and larger hand breath allow greater coverage on the object, thus more energy exerted and giving a stronger grip power. Ruiz et al. studied the optimal grip span required to obtain maximum hand grip strength among teenagers [10]. For both genders, the hand span and hand grip strength are correlated, and their hand grip strength is influenced by the measurement of the hand span [10]. A larger middle hand span (middle finger to thumb) also produces higher hand grip strength than other fingers [10]. Teenagers have smaller hand grip strength due to smaller hand spans compared to adults. Therefore, hand span affects the maximum hand grip strength.

Thus, it can be concluded that hand anthropometry plays a significant role in determining hand grip strength. With the lack of data available from Southeast Asia, this study aims to identify specific anthropometric measurements that have a relationship with hand grip strength in the local population in Malaysia.

3. Material and Methods

3.1 Subjects

Fifty-two healthy male volunteers were recruited by advertisement, with written informed consent, explanation and briefing regarding the study. The inclusion criteria are males aged 18-25 years, with normal BMI, without any medical illness and having the right hand as the dominant hand. The exclusion criteria are subjects who had recent hand injury or surgery, hand deformity or neck strain. The population and sample size of fifty was calculated to determine a minimum correlation coefficient of 0.4, with a power of 80% and alpha of 0.05 [19].

3.2 Anthropometric measurements

Four anthropometric variables of the hand were measured (Figure 1), which are [1]:

1) Full Hand Length (measured from the midline of the distal crease of the wrist to the tip of the middle finger)
2) Middle Finger Length (measured from the tip of the middle finger to the crease of the metacarpophalangeal joint)
3) Hand Width (measured from the radial side of the second metacarpal joint to the ulnar side of the fifth metacarpal joint)
4) Wrist Thickness (which is the sagittal diameter of the wrist at the crease of the proximal wrist)

The full hand length (FHL) and middle finger length (MFL) were measured using a flexible measuring tape, while palm width (PW) and wrist thickness (WT) were measured using a vernier caliper. All measurements were recorded in cm.

3.3 Hand grip strength measurement

A handgrip dynamometer was used to measure hand grip strength. Participants were seated upright, with their feet on the floor and back supported. Both their elbows were placed by the sides, and the right hand bended to right angles (90°). Their hands were placed as neutral wrist position, a straight alignment with the forearm, and without any flexion or extension. The dynamometer handle was adjusted so that the base of the dynamometer was positioned with the rest on the first metacarpal (heel of palm), and the handle rested on the middle of the four fingers prior to testing [20]. This procedure was repeated three times and the average of the recording was calculated. The results were recorded as kilograms(kg) shown on the digital display of the dynamometer to the nearest 0.1 kg.

3.4 Statistical analysis

The data was expressed as means($\bar{x}$) and standard deviation (σ). Pearson correlation coefficient was used to study the relationship between hand anthropometry and hand grip strength. If the P value was lesser than 0.05, the result was considered statistically significant.

4. Results and Discussion

A total of 52 participants qualified for the study with a mean age of 20.62 ± 1.36 years. Basic anthropometry measurements such as height, body weight and BMI were measured (Table 1). All participants were right-handed. Hand anthropometry measurements and hand grip strength data are provided in Table 2.

Regression analysis and ANOVA were performed for each hand anthropometric variable vs hand grip strength (Figure 2). Full hand length and wrist thickness have an R-value of 0.048 and 0.094 (p=0.73 and p=0.51 respectively) showing that there is no relationship between full hand length and wrist thickness with hand grip strength.

Middle finger length has a slightly higher R value (0.260) showing a weak relationship between middle finger length and hand grip strength ($p=0.06$). Palm width has R-value of 0.46 indicating a positive correlation between palm width and hand grip strength ($p<0.01$).

4.1 The association between palm width (PW) and hand grip strength (HGS)

A study by Nicolay C. W. and Walker A. L. (2005) summarized that palm width, palm length, forearm length and forearm circumference were strongly positively correlated with maximum hand grip strength in participants aged 18-33 years old [21]. Among these anthropometric variables, palm width is most strongly correlated to hand grip strength for all genders. They also found out that males have a stronger hand grip compared to females. Koley S. and Kumaar S. B. (2012) investigated the hand grip strength of female workers in India, specifically only on the right dominant hand [22]. The result shows a strong correlation between palmar width (palm width) and right-hand grip strength [22]. Koley and Singh (2009) concluded in their study among Indian Collegiate population that the male right dominant hand's anthropometric variables are highly and significantly correlated to hand grip strength [6]. Forearm length, hand breadth (palm width), hand length, upper arm circumference, and forearm circumference has a p-value of <0.001 [6]. Günther et al. (2008) studied the hand grip strength in healthy Caucasian adults and observed that hand width (palm width), hand length, forearm circumference and length have a positive correlation with hand grip strength [23]. This correlation is strong only when the anthropometric variables are measured together, and weak when it is measured separately. Therefore, they hypothesize that hand grip strength is influenced by different anthropometric variables [23]. These studies confirm our study's finding that palm width has a strong and statistically significant correlation with hand grip strength.

4.2 The association between middle finger length (MFL) and hand grip strength (HGS)

In Nicolay C. W. and Walker A. L.'s (2005) study, they found out that finger length has a weak positive correlation with maximum grip force [21]. They hypothesize that finger length does not directly correlate to hand grip strength. A longer finger may contribute to a better and firmer grip on the dynamometer, but it does not indicate greater overall strength. Abaraogu et al. (2017) concluded that middle finger length showed a significant positive correlation ($p<0.001$) with hand grip strength for both dominant and non-dominant hands. They found out that a longer middle finger provides more surface variables, which is required for grasping an object [24]. The study by Wen et al. (2020) also shows a weak positive correlation between middle finger length and hand grip strength among children aged 5-13 years old in NanJing, China [1]. They suggested that rapid growth and development in young children affect the inconsistency of results. In contrast, Fallahi and Jadidian et al. (2011) study the effect of hand anthropometries on hand grip strength among male athletes and non-athletes [9]. They concluded that finger length measurements were different in both groups and middle finger length is not significant in hand grip strength. There was no correlation between middle finger length

and hand grip strength. Our findings show a weak positive correlation between middle finger length and hand grip strength. As hypothesized by Nicolay et al. and Abaraogu et al. study, this weak association could be due to the firmer grip provided by the longer middle finger, rather than anthropometric factor of middle finger length.

4.3 The association between full hand length (FHL) and hand grip strength (HGS)

Pizzigalli et al. (2017) conducted a study among Italian female national basketball players and concluded that there is no significant correlation between hand length and hand grip strength [25]. Wichelhaus et al. (2018) mentioned in their study that hand length was proven to significantly influence hand strength. In their correlation coefficient results, hand length influences the manugraphy system. The difference in result is due to the different dynamometer used. Our study uses a hand grip dynamometer, while Wichelhaus et. al.'s study uses Jamar dynamometer [26]. Alahmari et al. (2017) concluded that a longer hand length and larger forearm circumference contribute to stronger hand grip strength among adult males in Saudi Arabia [7]. This positive and significant correlation may be due to the inclusion of different age group (42.55±15.45 years) and different BMI (27.52±5.08 Kg/m^2) [7]. Age may be a factor affecting the association between full hand length and hand grip strength. Jürimäe et al. (2008) performed a study among pre-puberty children to examine the relationship of hand grip strength with various hand anthropometric variables [27]. It was concluded that the midstylion-dactylion length (full hand length) is correlated with hand grip strength. This observation is because the study was done among children. Bone gain may affect the muscle and physical growth of a child. Sartorio et al. (2002) reported that a progressive age-dependent increase of hand grip strength in males and females was strongly associated with the increase in muscle mass during child puberty growth [28]. Ethnicity can also be a factor as shown by Bhat A. et al. (2021). They conducted a study to investigate the variation between anthropometric measurements among different ethnicity and gender, hand length has a positive correlation with hand grip strength and pinch strength [29]. A significant correlation was observed because of the inclusion of different ethnicities such as Iranians, Africans, Dutch and Polish [29]. In our study, we looked at young adult males and the majority of them were of South Asian ethnicity. We found that there was no correlation between full hand length and hand grip strength.

4.4 The association between wrist thickness (WT) and hand grip strength (HGS)

Wen et al. (2020) found out that the wrist thickness of boys is larger than girls in most age groups before puberty, but girls' hand shape was greater after puberty [1]. From the correlation analysis of wrist thickness and hand grip strength for both hands, the results show a significant weak correlation. The wrist thickness measurements increased with each age level. They hypothesize that the difference in puberty age affects the correlation result. The increase in testosterone and oestrogen production results in an increase in muscle mass. There are limited papers that measure wrist thickness and study its correlation with hand grip strength. Most of the studies measure wrist circumference.

Shahida et al. (2015), Bhat A. et al. (2021), Fallahi and Jadidian et al. (2011) and Nicolay et al. (2005) concluded in their study that wrist circumference has a positive correlation with hand grip strength [30, 26, 9, 21]. Li et al. (2010) studies the correlation between different anthropometric variables and maximal grip strength (MGS). The Pearson correlation coefficients between wrist circumference and hand grip strength using different dynamometers were calculated. The result shows that r values for both dominant and non-dominant hands were higher than 0.6 in all dynamometers, and p values were <0.001, showing that there is a significant positive relationship between these two aspects [31]. In our study, we used wrist thickness and our findings show no correlation with hand grip strength.

4.5 Limitations

There were some limitations in this study. This study only recruited male participants with the right hand as the dominant hand. Female participants and those left-handed are not studied may have positive correlation results. Secondly, the physical activity of the participants was not considered. Participants who do the gym or exercise regularly will have higher muscle mass. Studies show that higher muscle mass will contribute to higher hand grip strength. Thirdly, due to the restriction of the age group, most of the participants are tertiary education students. The population of other age and occupational groups, especially those that require strong physical fitness were not evaluated. In future studies, the inclusion of different gender, age group and hand dominance should be done, for better comparison and evaluation among South Asian population. The inclusion of body fat should be considered because participants with normal BMI may have a high body and visceral fat percentages and are at risk of diseases. Body and visceral fat percentages are more precise for health determination. Other than that, muscle mass and sport participations can be included for a better correlational study.

5. Conclusion

In conclusion, in our study, we found that there was a positive and strong statistical correlation between palm width and hand grip strength in young males of South Asian ethnicity. There was a weak correlation between middle finger length and hand grip strength. There was no correlation between full hand length and wrist thickness with hand grip strength.

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Conflict of interest statement

The authors declare no conflicts of interest.

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Alysia Koh Xin Wey a Bachelor of Pharmacy student with interests in the field of human performance physiology. She conducted this research project as part of her undergraduate dissertation.

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Appendix: Figures and Tables

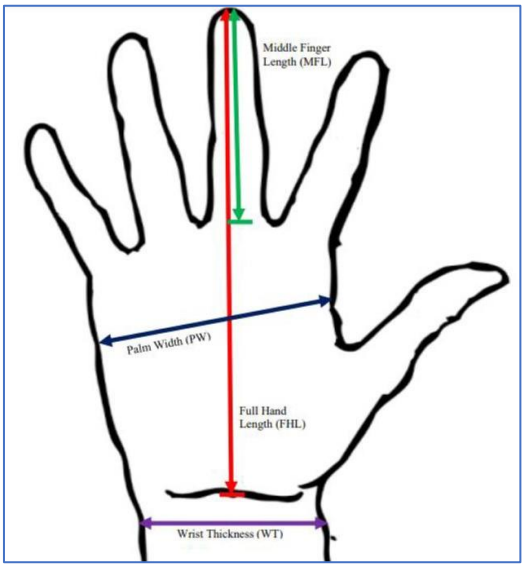

Figure 1: Anthropometric measurements of the hand

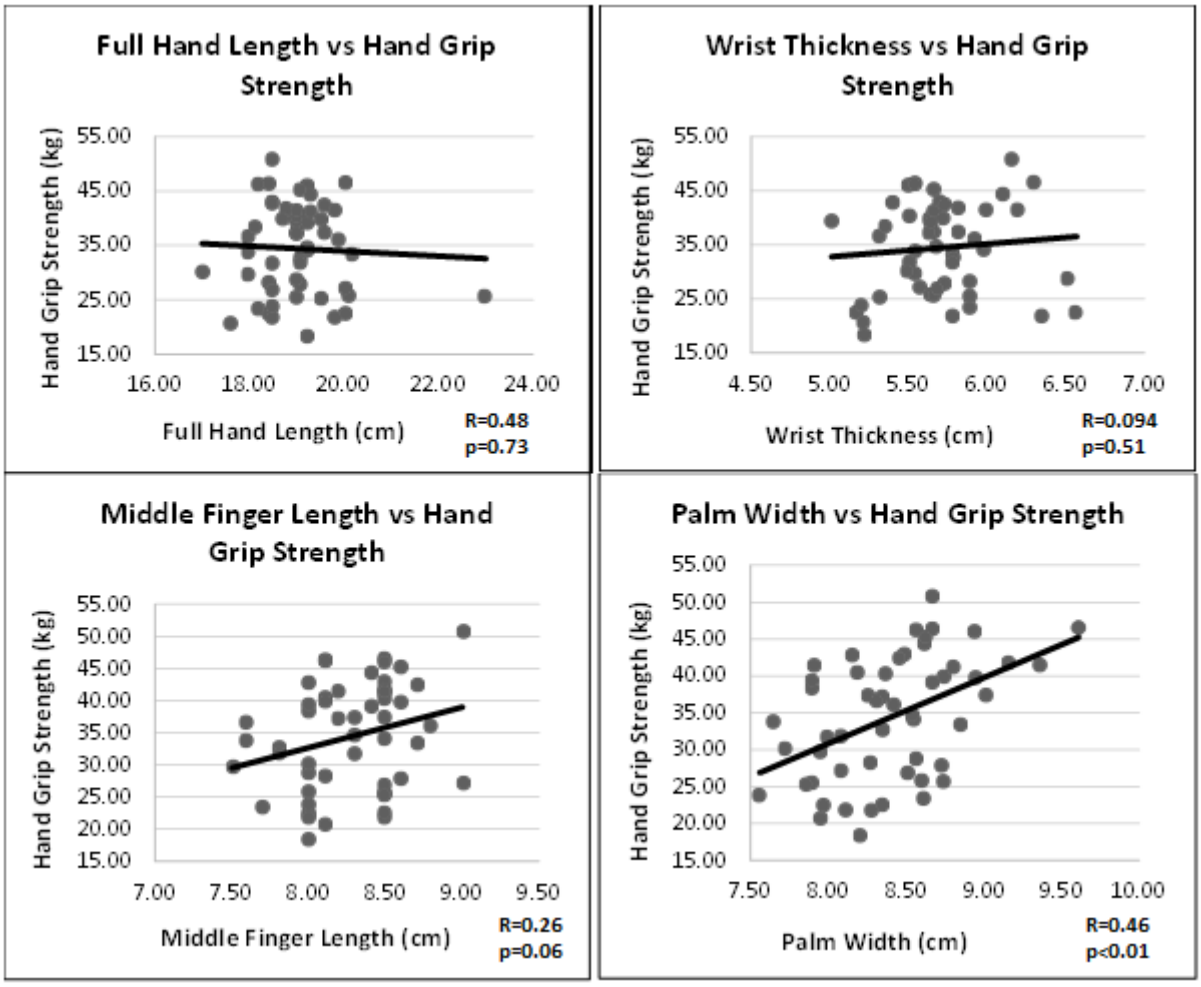

Figure 2: Correlation analysis of the four hand anthropometry parameters vs hand grip strength

Table 1: Basic anthropometric parameters of the study population

Characteristics	**Min - Max**	**Mean ± SD**
Age (years)	18 - 25	20.62 ± 1.36
Height (m)	1.63 - 1.85	1.74 ± 0.06
Weight (kg)	53.5 - 79.7	65.97 ± 7.23
BMI (kg/m2)	18.00 - 24.66	21.75 ± 1.91

Table 2: Hand anthropometry and Hand grip strength measurements of the study population

Variables	**Min - Max**	**Mean ± SD**
Full Hand Length (cm)	17.00 - 23.00	19.03 ± 0.88
Middle Finger Length (cm)	7.50 - 9.00	8.27 ± 0.34
Palm Width (cm)	7.56 - 9.61	8.40 ± 0.43
Wrist Thickness (cm)	5.01 - 6.57	5.70 ± 0.33
Hand Grip Strength (kg)	18.37 - 50.80	34.42 ± 8.35