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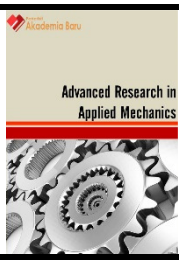

Relationship between demographic characteristics and hand grip measurement of students in UTMKL

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ABSTRACT

Biomechanical motion analysis is concerned with the investigation of movement of a subject. In particular, this project is interested in the movement found in nature, in biological systems such as human pinch and human grip. The motion is to be investigated with a view of analyzing the mechanical aspects of it, such as grip rate and force values in Newton and kilograms using a Digital Pinch/Grip Analyser. The hand grip strength (HGS) is an important test used to measure deficiency in hand muscle power, assessment of surgical treatments and rehabilitation evaluation. The aim of this study was to examine the relationship between demographic characteristics on HGS of UTMKL students. Besides, this study also observes the relation of some anthropometric variables such as weight, height, body mass index (BMI) and hand circumferences with the HGS. Overall, 30 participants participated in this study. Data were collected for demographic variables, medical history, and lifestyle behavior. Maximum dominant hand grip strength (DHGS) in male was at the age of 23 (mean= 276.446N) and 26 years (mean=276.1N) and for female in age 22 (mean=166.1778N). The mean difference in DHGS between both genders was statistically significant ($p<0.05$). The mean difference in DHGS between each side was statistically significant ($p<0.05$) in the right-hand dominant group, but not in the left-hand dominant group. The dominant hand is stronger than the non- dominant. Right-hand dominance is stronger than left-hand dominance. Besides, DHGS differed significantly across ethnicity and residential area. The DHGS also has positive correlations with age and height in male and with all measurements (age, height, weight, BMI, hand circumferences) for female. Our study has shown the relationship between HGS with demographic and anthropometric data.

Keywords:
Hand grip strength, UTMKL population-based study, Anthropometric, Demographic, Dominant hand grip

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strength, Hand pinch strength,
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1. Introduction

Earlier approaches of human detection were done based on temporal changes that will allow 3-D movement analysis. Reflective markers are placed on the subject at well-defined anatomical landmarks in a specific pattern. From this information the temporal pattern of body and segment orientations in joint angles and joint moments can be derived. In combination, muscle coordination is evaluated by measurement activities (electromyography). Nowadays, a Kinect device, developed by Microsoft can be used for skeletal detection [1]. As for hand gestures, there are two methods to estimate the movement of the hands. The first method is using the sensor glove that allows hands to move in free space but hands are restricted by the glove [2]. The second method is using computer vision techniques or range scanner. Hands must be placed in a defined area or space so that the hands can be captures in the image. The latter method is much simpler and practical. There are two distinct patterns of prehensile movements termed power grip and precision grip. Three types of precision grips commonly used in everyday activities are tip pinch, palmar pinch and key pinch. Power grip and precision grip are often combined in functional activities. For example, tying a shoe lace involves power grip on the ulnar side of the hand and precision handling on the radial side of the hand.

The study of the strength of the hand has received attention from ergonomics researchers, physical therapist and physicians. The hand grip strength (HGS) is a term used by strength athletes associate to the force that can be generated by their hands and muscular strength. It is the result of forceful flexion (the action of bending) of all finger joints, thumbs, and wrists with the maximum voluntary force [3-4]. This test is considered an easy, economic and non-invasive that measures overall muscle power fairly accurately and provide practical information on muscle, bone, nerve or joint disorders. The baseline of normal grip strength was obtained from the test on a group of healthy persons as it is compulsory to know the normal to appreciate the abnormal [4-6].

Hand grip strength is considered as a predictor of general health status. The movement of our hand is controlled by a complex interaction of muscles, nerves, joints, and bones that allow the hand to move and perform any tasks. If there is any problem with the muscles or nerves controlling it, this may lead to hand weakness such as weak grip. Furthermore, the flexibility of our hand is associated with the joints, therefore, joint diseases may affect the movement of our hand. The hand grip strength has become a common clinical evaluation for numerous neuromuscular disorders, injuries or disabilities of the hand or problems related to the central nervous system. It is also included in several motor ability tests for children and it is significant in understanding the physical development of adolescents. Besides, this test also can be used as an indicator for nutritional status and is related to normal bone mineral densities in postmenopausal women. The hand grip strength test also is useful when assessing the result of the surgical treatments [4-8].

There are a lot of methods and device for measuring hand grip strength, but the most popular device is using a dynamometer. The hand-held dynamometer is a simple and economical tool that is reliable in evaluating grip strength. The hand grip strength is usually measured in kilograms (kg) or newton (N) [7-9]. Each person has different hand strength. There are a lot of factors that leads to this difference. A lot of studies have been done to evaluate the factors affecting hand grip strength which can be divided into demographic [4,8,10] and anthropometric [3-14]. As an example, in most cases, a more muscular person will have higher hand strength. The young adults have stronger grip

compared to the older person. Therefore, there are various factors that affect the hand grip strength, such as age, gender, body size including height, weight and body mass index (BMI), physical activities, types of work, ethnicities, and consumption of foods. Hand dominant also has a correlation with hand grip strength. Grip strength was mostly reported to be higher in the dominant hand of right-handed subjects, however, no significant differences reported for left-handed people [3-14].

Other than the factors mentioned above, there is a lot more than can be taken into consideration. The posture and wrist and forearm position also affect the hand grip strength. There is a difference in grip strength in different posture due to change in length of the muscles. Furthermore, psychological factor and fatigue rate are also associated with diminished grip strength [15-17]. There are a lot of published normative data for hand grip strength from many countries especially Western countries. The Western normative data are not suitable to be applied to Asians. In the Asian population particularly Malaysian, there are not many studies of the normal grip strength [6,8]. Therefore, our objective is to examine the relationship between demographic characteristics on hand grip strength of Universiti Teknologi Malaysia Kuala Lumpur (UTMKL) students. Besides, we also observe the relation of some anthropometric variables such as weight, height, BMI and hand circumferences with the hand grip strength.

2. Methodology

2.1. Data collection

This study was conducted in Universiti Teknologi Malaysia Kuala Lumpur (UTMKL). All healthy subjects aged 18 to 30 years old were invited to participate in this study. A total of 30 subjects consist of 15 males and 15 females participated in the study. The consent form, registration and medical history forms were obtained from all the participants. The previous injuries, particularly related to hand, recent illness, family history, allergies and lifestyle, including smoking and alcohol consumption were recorded in the registration and medical history form [18-19]. Subjects with upper limb injury or deformity or dysfunction of the elbow joint and surgery related to hand within the last three months were not included in this study. Identity (ID) number was given for each subject. Since it will be anonymous, we will have to identify them with an ID number. This study received ethical approval from the university.

In brief, the demographic and some anthropometric data such as gender, ethnicity and residential area, age, height, weight and hand dominant were obtained from the form given. Body mass index (BMI) was calculated as body weight measured in kilogram (kg) divided by the square of the body height measured in meters (m). Wrist (a), forearm (b), and upper arm (c) circumferences for dominant hand were obtained using a measuring tape in centimetres (cm). The points of our measurement are as in Fig. 1. Subjects were in standing position and the measurement was taken with the shoulder in adduction as in Fig. 2.

Hand grip strength was taken in Newton (N) and measured using a digital grip/ pinch analyzer from MIE Medical Research Ltd. as in Fig. 3. The measurement procedures and protocol were referred to NIHR Southampton Biomedical Research Centre Procedure [20]. The measurement was taken with participants seated on the chair with the elbow flexed to right angles, a neutral wrist position and the forearm lying on an armrest. This was to ensure that their hand free to squeeze the handles. Their feet were ensured to be flat on the floor and they did not leave the ground during the test. The participants need to hold the grip analyzer handles 2 cm down from the red indicator line without support as in Fig. 3 (a). The mean of three trials of grip strength for each hand was recorded. They were asked to perform three trials for five seconds, allowing a two seconds rest between measurements for both hands. The five seconds rest was given to change hands. To minimize the

effects of fatigue, the participants were advised to grip their maximum as quick as possible. The position of the subject during the measurement of the hand grip strength was shown in Fig. 3 (b). The dominant hand grip strength (DHGS) of the participants was used for the comparison.

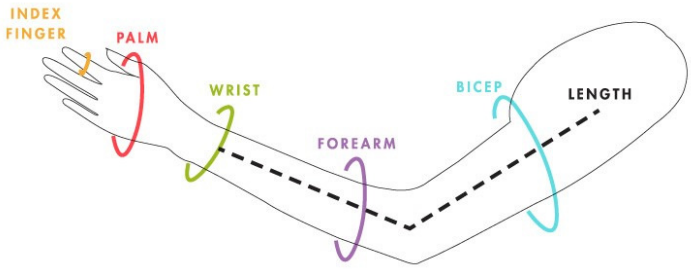

Fig. 1. Measurements of wrist, forearm and upper arm (bicep). Adopted from [19]

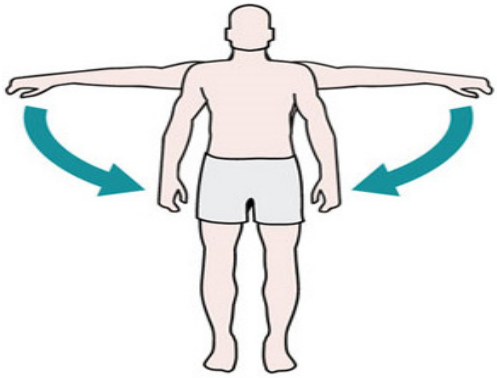

Fig. 2. Shoulder in adduction position. Adopted from [20]

(a) (b)

Fig. 3. (a) Digital grip / pinch analyser from MIE Medical Research Ltd. [21] and (b) position of the subject during the hand grip strength measurement

2.2. Data Analysis

All statistical analysis was performed using the Clinical Analysis Software (CAS) for MIE's Digital Analyser Products and Microsoft Excel. First, the characteristics of the participants were summarized using descriptive statistics including frequencies, percentages, means and standard deviations (SD). The One-way ANOVA test was used to observe the associations between the dominant hand grip

strength with the demographic variables such as ethnicity and residential area [5,8,13]. The significant difference in dominant hand grip strength between male and female populations and the difference between right-hand and left-hand dominant strength was analyzed using the independent T-test [3,7,10-12]. The Pearson's correlation coefficients were applied to establish the correlations of the dominant hand grip strength with age, height, weight, BMI and wrist, forearm and upper arm circumference [3,5-7,9-11]. A $p \leq 0.05$ probability level was used to indicate significance in all of the statistical analyses.

3. Results and discussion

Overall, 30 participants (15 males, 15 females) aged 18 to 30 years (mean, 21.97 years) participated in this study. The characteristics of the study population of UTMKL students are shown in Table 1. Out of the participants 26 (86.67%) were right-hand dominant, 2 (6.66%) were left-hand dominant and the other 2 (6.67%) was ambidextrous. So far ethnicity was concerned, the maximum frequency (30%) were from Chinese followed by Malay (26.67%), Borneo (20%), Indian (16.67%) and others which are African and Turkish (6.67%). As per residential area, most participants live in an urban area (36.7%). Next are the suburban and rural area (33.3% and 30% respectively). There was a significant difference in dominant hand grip strength (DHGS) between both ethnicity and residential area (one-way ANOVA test, p-value is almost zero). The mean value of the dominant hand grip strength for the characteristics was shown in Table 2.

The dominant hand grip strengths of Malaysian subjects were weaker compared to the African subject. However, this 'African' subject account for only 3.33% (n=1) of all participants, and may not truly represent all other Africans in UTMKL. The highest dominant hand grip strength is reported in subjects from the rural area. Physical activities in the rural area are mostly from occupations and daily activities. Most of the rural participants have a history of farming, fishing, other manual labor and it is also common for them to walk to the market, to work or other social activities [10, 24-25]. Such a lifestyle may explain the difference in the dominant hand grip strength between the residential areas that we observed in the study.

Mean dominant hand grip strength peaked between 23 and 26 years in male (mean=276. 446N and mean=276.1N respectively) and in 22 years (mean= 166.1778N) in the female. The results are tabulated in Table 3. Using the Pearson test, a positive correlation was observed between dominant hand grip strength and age in both genders, male and female (r= 0.34356, r= 0.396513 respectively). Although there was a positive correlation between dominant hand grip strength and gender, but, there was not a statistically significant correlation between them for both male and female ($p>0.05$).

The literature has consistently found that males are stronger than females. This is because females commonly have lesser muscle strength than males. Generally, males have greater muscle bulk and this result in greater strength [24-27]. Hence, this study showed higher readings in dominant hand grip strength of males (mean= 249.9993 N) than females (mean= 153.2553 N) as in Table 4. The mean difference in the dominant hand grip strength between both genders was statistically significant (independent T-test, $p<0.05$).

Table 1
Demographic and clinical characteristics of the study population

Variables	Value
Gender:	
Male- n (%)	15 (50)
Female- n (%)	15 (50)
Age:	
Total- mean (SD), years	21.96667 (2.12511)
Female- mean (SD), years	21.2 (1.567528)
Male- mean (SD), years	22.73333 (2.374467)
Ethnicity:	
Malay -n (%)	8 (26.67)
Chinese- n (%)	9 (30)
Indian- n (%)	5 (16.67)
Borneo- n (%)	6 (20)
Others- n (%)	2 (6.67)
Residential Area:	
Rural- n (%)	9 (30)
Suburban- n (%)	10 (33.3)
Urban- n (%)	11 (36.7)
Height:	
Male- mean (SD), m	1.711333 (0.060222)
Female- mean (SD), m	1.579333 (0.051474)
Weight:	
Male-mean (SD), kg	68 (8.742344)
Female- mean (SD), kg	52.73333 (8.91601)
BMI:	
Male-mean (SD), kg/m^2	23.15066 (2.090475)
Female- mean (SD), kg/m^2	21.14009 (3.311381)
BMI Range:	
Underweight- n (%)	5 (16.67)
Normal- n (%)	20 (66.66)
Overweight- n (%)	5 (16.67)
Dominant Hand:	
Right hand dominant- n (%)	26 (86.67)
Left hand dominant- n (%)	2 (6.66)
Ambidextrous (both) - n (%)	2 (6.66)
Hand Circumference:	
Male:	
Wrist- mean (SD), cm	16.4 (0.736788)
Forearm- mean (SD), cm	24.8 (2.042408)
Upper arm- mean (SD), cm	26.73333 (1.869556)
Female:	
Wrist- mean (SD), cm	15.0 (1.195229)
Forearm- mean (SD), cm	21.73333 (2.374467)
Upper arm- mean (SD), cm	25.2 (3.098387)
Dominant Hand Grip Strength:	
Male- mean (SD), N	249.9993 (72.14971)
Female- mean (SD), N	153.2553 (55.35553)

A lot of studies on hand grip strength reveal that right-hand dominant person has approximately 10% stronger than the non- dominant hand [28-29]. Most people are right-hand dominant and they use their right hand more, and hence it gets significantly more exercise. This creates more motor recruitment, larger muscle fibers, and higher hand strength. Earlier studies made no difference

between right- and left-handed person, hence they assumed that the 10% hand strength difference in favor of the dominant hand found in right-handed persons was true regardless of hand dominance. Later studies, shown the result that left-hand dominant people are either having no considerable strength difference between hands or left-hand dominant people whose right hand (non-dominant) was slightly stronger than the left hand (dominant) [7, 28-29].

Table 2
Mean of DHGS for ethnicities and residential areas

Characteristics	Mean of DHGS (N)
Ethnicity:	
Malay	220.1063
Chinese	191.2133
Indian	190.178
Borneo	199.6883
Others:	
African	269.18
Turkish	148.85
Residential Area:	
Rural	209.029
Suburban	205.9309
Urban	188.1433

Table 3
Mean DHGS for male and female presented in ascending age group

Male			Female		
Age (years)	N	Mean DHGS (N)	Age (years)	N	Mean DHGS (N)
18	1	148.9	18	2	130.485
21	1	201.43	19	1	117.54
22	6	245.3683	21	2	96.4
23	5	276.446*	22	9	166.1778*
26	1	276.1*			
28	1	269.2			

Table 4
Comparison of dominants hand grip strength in males and females

Gender	N	Mean DHGS (N)	STD. Deviation	t-value	p-value
Female	15	153.2553	55.35553	-4.12023	0.000304
Male	15	249.9993	72.14971		

In our study, the dominant hand is stronger than the non-dominant hand for both groups as in Table 5. The right hand dominant (mean= 199.6619N) is stronger than left hand dominant (mean=147.83N). The mean difference in DHGS between each side was statistically significant (independent T-test, $p<0.05$) in the right-hand dominant group, but not in the left-hand dominant group. However, as only two left-hand dominant participants were studied, thus the power of the statistical analysis is weak.

Table 5
Comparison of dominant hand grip strength in dominant hand and non-dominant hand

Hand Dominant	N	Mean DHGS (N)	STD. Deviation	t-value	p-value
Right-hand dominant group					
Right hand	26	199.6619	81.35778	2.074019	0.048528
Left hand		184.3077	83.27547		
Left-hand dominant group					
Right hand	2	99.655	12.45215	1.232255	0.434
Left hand		147.83	42.83653		

This study has discovered that males are generally taller, heavier, and has wider hand circumference, than the female (refer Table 1). The mean BMI for male and female were 23.15066 kg/m^2 and 21.14009 kg/m^2 respectively. Usually, BMI values of female are slightly larger than male (from age 7 to 16). As long as both, female and male are not overweight, BMI values of men are slightly larger than women (after age 18) [30]. There is relevant literature show the association of the hand grip strength with weight, height and body mass index (BMI) [9, 31-33]. The Pearson correlation coefficients test was used to see the correlation between dominant hand grip strength and anthropometric data. The results of the test are provided in Table 6.

Table 6
Correlation of anthropometric variables with DHGS

Gender	Male		Female	
Variables Correlated	**Correlation coefficient (r)**	**Significance (p)**	**Correlation coefficient (r)**	**Significance (p)**
Age vs. DHGS	0.343568	0.206937	0.396513	0.140243
Weight vs. DHGS	-0.05859	0.835663	0.300569	0.269282
Height vs. DHGS	0.102228	0.716168	0.052788	0.851398
BMI vs. DHGS	-0.17022	0.544218	0.258783	0.349381
Wrist circumference. vs. DHGS	-0.05887	0.834832	0.313546	0.252334
Forearm circumference vs. DHGS	-0.13404	0.633994	0.221107	0.426469
Upper arm circumference vs. DHGS	-0.12283	0.662838	0.32929	0.227835

In our study, there was a positive correlation between dominant hand grip strength with weight, height, and BMI in the female. As for the male, the positive correlation was found between dominant hand grip strength with height only while there was a negative correlation with weight and BMI. It can be concluded that there was correlation between the dominant hand grip strength with height, weight, and BMI, however, there was no statistically significant correlation between them for both male and female ($p>0.05$).

In the case of height, the correlation with hand grip strength could be the result of several factors. As an example, greater heights would lead to longer arms, with greater lever arm for force generation, resulting in an efficient amount of force. BMI is a statistical measure of body weight based on a person's weight and height. It does not actually measure body fat, however, it is usually used to estimate a healthy body weight based on height. The reason for the correlation between

hand grip strength with weight and BMI is difficult to explain and unclear as all levels of body weight have wide variability in strength [9, 32-33].

Apart from these established associations, hand circumference has also been proposed to be an indicator of hand grip strength. Vikram [29] stated that hand grip strength can be predicted by using hand circumference among the Malaysian population, but, predictive models for hand grip strength with hand circumference have not been so much established in this region. Most of the available literature are applicable to Western population and other regions [31-32]. From our study, there was a positive correlation between dominant hand grip strength with the wrist, forearm, and upper arm circumference in females while negative correlation was shown for all the circumferences in the male. There was no statically significant correlation between all of the circumference for both male and female ($p>0.05$).

Throughout the test, it is important to ensure that all the participants followed the right posture as described before. There are few limitations to our study. This was a small group cross-sectional study carried out in the single institute. Although our study population was small, it does provide a hint of the correlation of hand grip strength with the demographic and anthropometric parameters. However, a study with larger sample size will definitely be of a great value in predicting the correlation between hand grip strength and numerous parameters in demographic or anthropometric. The small number of left-hand dominant subjects does affect the result of the study. Hence, it is important to recruit more left-hand dominant subjects to ensure better predictability of hand grip strength. In addition, this study does not involve a wide age range and hence this also can be improved. Further, the correlation can be studied by including more demographic and anthropometric parameters such as palm length, hand size, occupation and level of physical activities, to obtain more precise relationship between them.

4. Conclusion

The normative hand grip data from the western population were unsuitable to be applied to Malaysian population as they are having larger mean grip strength (1.5 times) than Malaysian population. Hence, it is very important to have our own local normative data for reference to be used in any research or for the rehabilitation purpose. From this study, gender, hand dominant, age, ethnicity, residential area, height, weight, BMI, and hand circumference do have a correlation with hand grip strength. All the demographic and anthropometric data other than this should be all considered when establishing normal values for grip strength. The limitations of the study should be handle more deeply for the data to be used more widely in the context of Malaysia.

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