

Analysis of Factors Influencing Hand Grip Strength and Acute Effect of Grip Strength Test on Blood Pressure in Young Adults

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ABSTRACT

Introduction: Isometric Hand Grip (IHG) strength measurement is extensively used in many areas of medicine and sport science as a functional test of overall strength. By testing the IHG strength, maximum isometric strength of the hand and forearm muscles can be estimated. Weak hand grip strength is a key component of sarcopenia and is associated with subsequent disability and mortality.

Aim: To evaluate the role of handedness, gender, ethnicity, Body Mass Index (BMI) on hand grip strength and to examine the acute effect of grip strength test on blood pressure in young adults.

Materials and Methods: This cross-sectional study was done between November 2018-November 2019 on normal healthy participants (n=83; average age 20.24±0.21 years) representing various ethnicities. Participants' demographic data was collected and their IHG strength was determined in both dominant and non dominant hand. Blood pressure was recorded before and after the IHG strength test. A correlation analysis was performed to

determine the association between resting blood pressure/BMI with IHG strength.

Results: A total of 83 subjects of different ethnicities and both male and female genders were included in the study. The IHG strength was not influenced by handedness in both the sexes. Amongst males, IHG strength was found to be slightly higher in the Arab population as compared to South-asian and Emirati. A lower IHG strength was observed in females compared to males in every ethnicity studied. Moderate positive correlation was found between IHG strength with BMI (dominant hand IHG strength vs BMI: $r=0.34$; p -value <0.001 , non dominant hand IHG strength vs BMI: $r=0.35$; p -value <0.001) and with Systolic Blood Pressure (SBP) ($r=0.55$; p -value ≤ 0.0001) (SBP). Both the SBP and Diastolic Blood Pressures (DBP) were observed to be reduced after IHG strength test.

Conclusion: Handedness did not influence IHG strength, but, ethnicity mildly and gender significantly influenced it. Blood pressure was reduced by IHG test. The IHG strength was positively correlated with BMI and SBP.

Keywords: Body mass index, Ethnicity, Handedness, Muscle

INTRODUCTION

Isometric Hand Grip (IHG) strength measurement is extensively used in many areas of medicine and sport science as a functional test of overall strength [1]. Grip strength is also used as an indicator of general health [2], nutritional status [3], and has been recently suggested as a risk-stratifying method for all-cause death [4-7]. Widespread use of the IHG strength results from its practical utility and feasibility, such as availability and high reliability of the measurements [8]. Moreover, evaluating IHG strength using a hand-held dynamometer is non invasive, inexpensive, and simple to implement [9,10].

Exercise, in which contraction chiefly causes a change in the tension of the muscle with slight change in the length, is considered as isometric or static. This phenomenon is seen during lifting or pushing heavy weights and contracting muscles against fixed objects, in contrast to isotonic or dynamic exercises in which contraction of the skeletal muscle causes a change in the length of muscle, such as during running, swimming, etc. By testing the IHG strength, maximum isometric strength of the hand and forearm muscles can be estimated. Weak hand grip strength is a key component of sarcopenia and is associated with subsequent disability and mortality [11]. Hand grip strength has been found to be associated with several factors such as demographics, body construct, socioeconomic variables and physical and psychosocial variables [12]. A study has also investigated whether hand length and individual training status affect hand grip strength [13]. The influence of the dynamometer's handle position on grip strength has been evaluated in school children [14]. In addition, whether there is a difference in grip strength between the preferred and non preferred hand in developing children has also been studied [15]. The reference values for IHG strength between 35-70 years

of age in Middle Eastern population was reported [7]. However, a comprehensive evaluation of various factors determining IHG strength in different ethnic groups has not been well documented. Additionally, there are no reported reference values for this population outside 35-70 years of range. This has to be read along with the recent report, which suggest an immediate need for region-specific cut points for hand grip strength in developing regions [16].

The IHG training is reported to reduce blood pressure in hypertensive patients [17,18]. Hence, the American Heart Association had classified IHG training as a potential therapy for these patients. Nonetheless, they recommend further research to prove the efficacy of such clinical implementations (Level of Evidence C) [19]. Studies which analysed the acute effects of isometric exercise observed increased [20,21], maintained [22], or decreased [23] blood pressure after exercise. These observed discrepancies could be attributed to variations in exercise protocols (which used different volumes and intensities) followed in these studies. Hence, a better understanding of cardiovascular response to a single short IHG session is relevant even in normotensive individuals as it will be helpful to understand its acute effects. The current study was designed to evaluate the role of handedness, gender, and ethnicity in influencing the IHG strength in young adults. Additionally, relationship of IHG strength with BMI and blood pressure and the immediate effect of IHG strength test on blood pressure was evaluated.

MATERIALS AND METHODS

This cross sectional study was performed among the 'University' student population at Ras Al Khaimah Medical and Health Sciences University from November 2018-November 2019. Eighty-three, normal

healthy participants (Average age 20.24 ± 0.21 years) representing various ethnicities were recruited after obtaining their written informed consent. All procedures used in the study were approved by the Institutional Research and Ethics Committee (REC-065-2018-UG-M dated 22.11.2018). All participants enrolled into the study voluntarily agreed to take part in the study and signed an informed consent form before any study procedure in compliance with the Declaration of Helsinki.

Inclusion criteria: South Asian, Emiratis, and Arabs ethnicity students of both male and female genders, were included in the study.

Exclusion criteria: People with any history of injury of the upper limbs, fatigue, motor neuron diseases, use of drugs that affect the Central Nervous System (CNS), hand pain and/or arthritis were excluded from the study.

Sample size calculation: The calculated sample size for one-way analysis of variance test was determined to be 30 per ethnic group. Convenience sampling was followed in the present study.

Study Procedure

Each participant was invited to the physiology laboratory for the hand grip strength test after obtaining their informed consent. The participant was seated comfortably and requested to fill a form regarding his/her demographic details, dominant hand, general physical activity, details of hypertension (if any)/hypertensive family members, and any upper limb injury. After taking the participant's consent, his/her height, weight and basal blood pressure were recorded. Participants BMI was calculated and they were categorised according to the International Classification of adult BMI values- normal (BMI-18.5-24.9), overweight (BMI- 25.0-29.9), and obesity (BMI-30.0 and above). The participant was then asked to sit and relax to prepare for the IHG strength test. Each volunteer was given a brief explanation of the procedure of IHG test following which the test was conducted.

A hand dynamometer (SS25LA, BIOPAC Systems, CA, USA) connected to a desktop installed with Biopac Student Lab Software (BIOPAC Systems, version 4.0; CA, USA) was used for performing the IHG strength test. During the procedure, each participant was instructed to hold the dynamometer in the dominant hand with the arm at a right angle and the elbow by the side of the body. For proper grip, participants were asked to place the palm across the shorter bar and wrap fingers to center the force. They were then asked to squeeze the dynamometer with maximum isometric effort, which was maintained for about three seconds. Three consecutive recordings were done with an interval of three seconds between each test. They were also told to avoid any other body movement during the test. The best clench force generated was recorded and saved for further analysis. The test was first performed on

the dominant hand, immediately after this; blood pressure of the participant was recorded using a digital blood pressure monitor (Omron, Kyoto, Japan). Hand grip test was then repeated on the other hand and blood pressure was determined again.

STATISTICAL ANALYSIS

Descriptive statistics of the various outcome measures were represented as Mean \pm SD. To determine the mean difference on grip strength among various groups, one-way or/and repeated measures of ANOVA and Tukey's tests were used. Pearson's correlation coefficient test was used to measure the strength of association of hand grip with BMI/blood pressure. GraphPad Prism software (version 5.0) was used to analyse the data.

RESULTS

The mean age, height, weight and BMI of the participants (all ethnic group data pooled) were 20.2 ± 0.2 years, 166.8 ± 1.0 cm, 71.1 ± 1.9 kg and 25.3 ± 0.5 kg/m² respectively. The basal blood pressure was also measured and the mean values were 119.9 ± 1.6 mmHg, 69.8 ± 0.9 mmHg for SBP and DBP, respectively. The participant's characteristics and various other parameters were stratified by ethnicity and are represented [Table/Fig-1].

IHG strength in dominant (DH) vs non dominant hand (NDH):

There was no significant influence of handedness on IHG strength test among males and females. Mean IHG strength value for males was ~ 40 kg when tested for dominant and non dominant hand [Table/Fig-2a]. In females also, the mean IHG strength value was comparable when tested on both dominant and non dominant hands [Table/Fig-2b]. However, the mean IHG strength value was significantly lesser in females compared to males. Comparison of the pooled IHG strength data revealed no difference between dominant and non dominant hand irrespective of the gender. Although the mean IHG strength value (28.32 ± 1.3) for non dominant hand was not as much as for dominant hand (29.78 ± 1.3 kg), this difference was observed to be statistically insignificant [Table/Fig-2c].

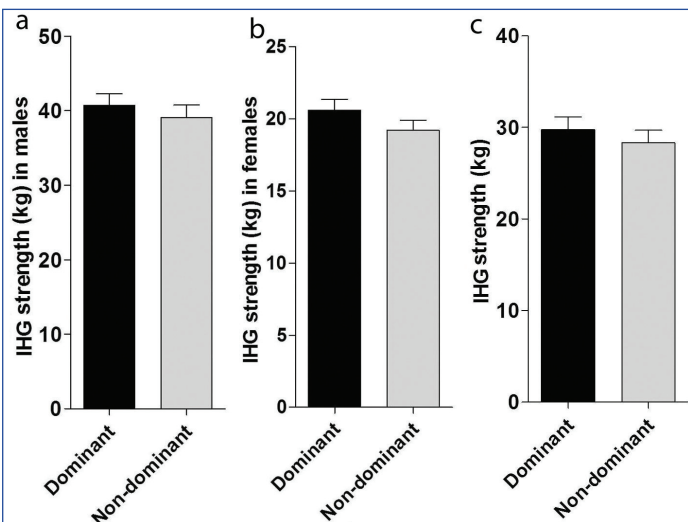
IHG strength in different ethnic populations:

Even though the IHG strength values were slightly different among the different ethnic groups, this difference did not appear to be statistically significant for the dominant hand in both males [Table/Fig-3a] and females [Table/Fig-3b]. One-way analysis of variance (ANOVA) test revealed no significant differences of the mean values of IHG strength among different ethnicities. The same pattern was evident for the non dominant hand as well (males; [Table/Fig-3c], females; [Table/Fig-3d]). However, IHG strength values in the Arab group was observed to be higher compared to the other ethnic groups studied, but this difference was not statistically significant.

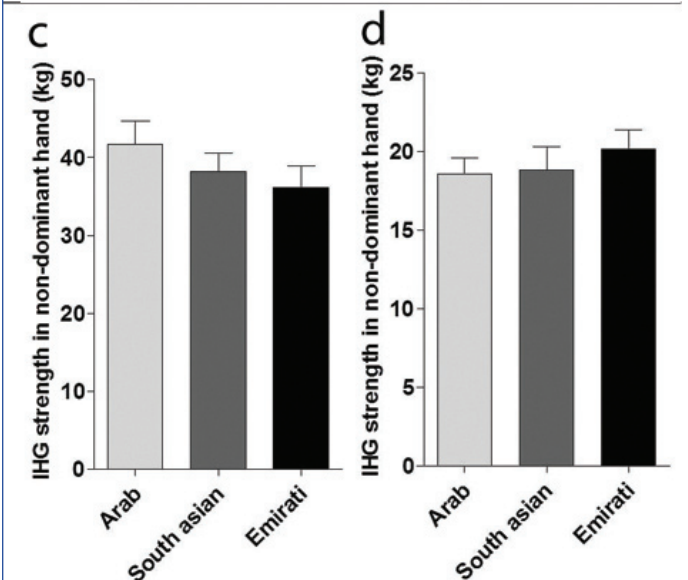
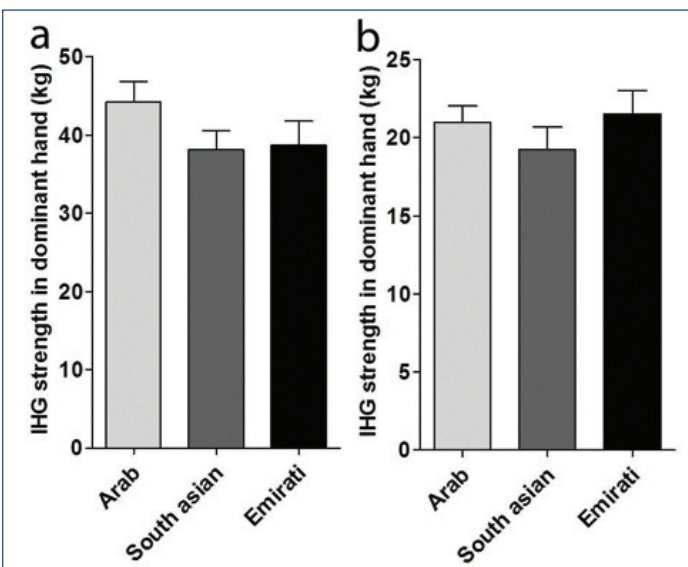
Ethnicity	Arab		South Asian		Emirati		
	Men	Women	Men	Women	Men	Women	
Age (Years)	19.67 \pm 0.28	19.47 \pm 0.35	20.47 \pm 0.42	20.67 \pm 0.47	21.38 \pm 1.37	20.33 \pm 0.41	
IHG strength (kg)	Dominant hand	44.25 \pm 2.56	20.96 \pm 1.07	38.16 \pm 2.40	19.23 \pm 1.46	38.68 \pm 3.10	21.54 \pm 1.47
	Non dominant hand	41.65 \pm 2.99	18.57 \pm 1.02	38.19 \pm 2.36	18.85 \pm 1.44	36.12 \pm 2.78	20.17 \pm 1.21
Blood pressure (mmHg)	Resting SBP	129.9 \pm 3.26	110.5 \pm 2.47	129.4 \pm 4.48	109.7 \pm 1.94	133.5 \pm 5.11	112.5 \pm 2.36
	Resting DBP	70.87 \pm 2.59	66.27 \pm 1.69	73.27 \pm 2.69	66.93 \pm 1.47	75.25 \pm 3.92	69.27 \pm 1.62
	SBP after IHG test on DH	127.7 \pm 3.61	108.7 \pm 1.92	127.1 \pm 3.84	107.1 \pm 2.67	134.3 \pm 4.32	111.3 \pm 3.39
	DBP after IHG test on DH	66.73 \pm 2.06	65.07 \pm 1.48	72.60 \pm 2.54	66.53 \pm 1.68	71.50 \pm 2.83	66.36 \pm 1.68
	SBP after IHG test on NDH	126.8 \pm 3.28	107.9 \pm 2.43	126.5 \pm 3.42	107.3 \pm 2.18	126.9 \pm 4.96	113.7 \pm 2.26
	DBP after IHG test on NDH	66.80 \pm 1.69	62.93 \pm 1.89	71.87 \pm 3.23	65.67 \pm 2.04	74.50 \pm 2.27	67.53 \pm 1.67
Height (cm)	176.5 \pm 1.90	160.5 \pm 0.96	172.4 \pm 1.26	160.0 \pm 1.68	172.8 \pm 3.25	161.5 \pm 1.58	
Weight (kg)	84.19 \pm 4.21	54.87 \pm 2.27	77.55 \pm 4.21	68.73 \pm 3.32	85.38 \pm 7.59	62.73 \pm 2.19	
BMI (kg/m ²)	26.93 \pm 1.13	21.20 \pm 0.79	26.07 \pm 1.38	26.79 \pm 1.20	28.26 \pm 1.63	24.07 \pm 0.86	

[Table/Fig-1]: Participants characteristics and other parameters stratified by ethnicity.

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; IHG: Isometric hand grip; DH: Dominant Hand; NDH: Non dominant hand; BMI: Body mass index

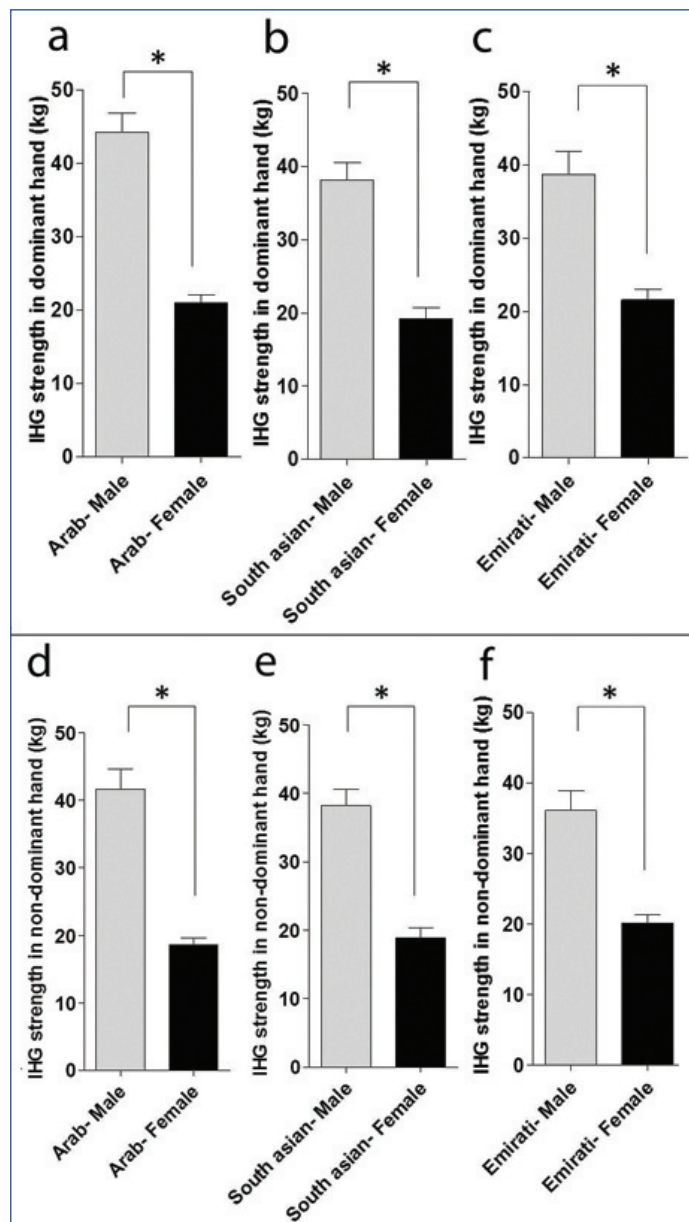


[Table/Fig-2]: IHG strength in dominant and non dominant hands in males (a), females (b) and in both the genders data pooled (c).



[Table/Fig-3]: IHG strength in different ethnic groups. IHG strength of dominant (a) and non dominant hands (c) in males of different ethnic populations. IHG strength of dominant (b) and non dominant hands (d) in females of different ethnic groups.

differences in IHG strength values of dominant and non dominant hands in Arab male vs female [Table/Fig-4a] and d; $p \leq 0.0001$), south Asian male vs female [Table/Fig-4b and e]; $p \leq 0.0001$), and Emirati male vs female [Table/Fig-4c] and f; $p \leq 0.0001$).

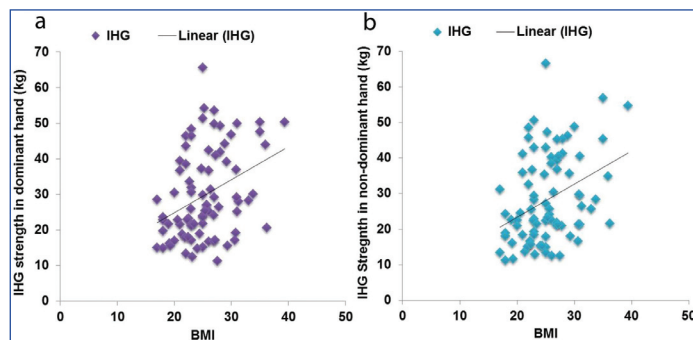


[Table/Fig-4]: IHG strength of both the genders in different ethnic groups. IHG strength of dominant hand (a, b, c) and non dominant hand (d, e, f) in different ethnic groups.

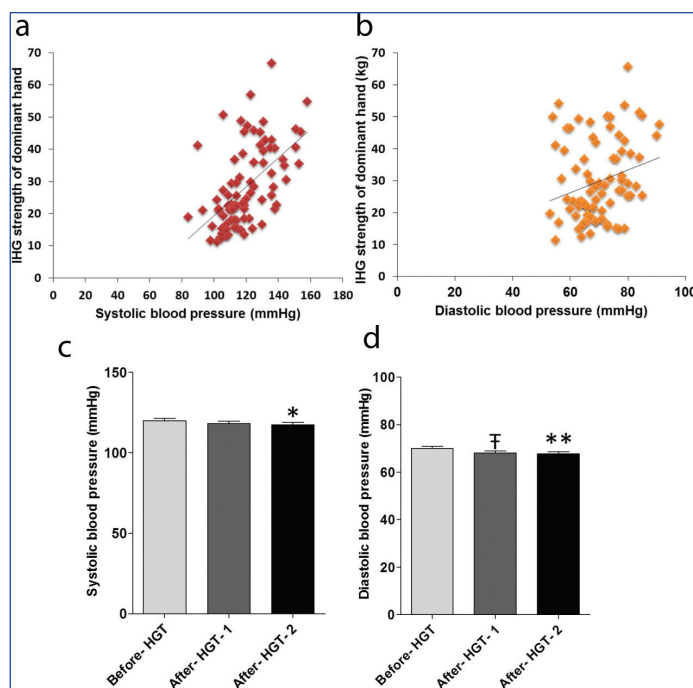
IHG strength's relationship with BMI: In order to understand the relationship between IHG strength and BMI, a correlation analysis was carried out between IHG strength values and BMI. Two correlations were performed. First, IHG strength values of dominant hand vs BMI. Second, IHG strength values of non dominant hand vs BMI. As depicted in [Table/Fig-5a,b], a positive correlation was observed between IHG strength and BMI (dominant hand IHG strength vs BMI: $r=0.34$; $p < 0.001$, non dominant hand IHG strength vs BMI: $r=0.35$; $p < 0.001$). From the results below, it is evident that the IHG strength moderately correlates with BMI values.

IHG strength's relationship with resting blood pressure and acute effect of IHG strength test on blood pressure: To understand the relationship between IHG strength and blood pressure, a correlation analysis was carried out between resting blood pressure (systolic and diastolic) with IHG strength value of their dominant hand. It was evident from the results that a positive correlation exists between resting SBP with IHG strength ($r=0.55$; $p \leq 0.0001$; [Table/Fig-6a]). In contrast, the correlation was not very evident between resting DBP with IHG strength ($r=0.25$; p -value ≤ 0.026 ; [Table/Fig-6b]).

To understand the acute effect of IHG test on blood pressure, SBP and DBP were recorded immediately after each IHG strength test and these values were compared with that of the resting blood pressure. Repeated measures of ANOVA and Tukey's test revealed that both systolic [Table/Fig-6c] and diastolic [Table/Fig-6d] blood pressures were significantly decreased immediately after the IHG strength tests.



[Table/Fig-5]: IHG strength relationship with body mass index. Relationship of IHG strength of dominant (a) and non dominant hands (b) with BMI in young adults. BMI: Body mass index



[Table/Fig-6]: IHG strength and its relationship with resting systolic (a) and diastolic (b) blood pressure and acute effect of IHG strength test on systolic (c) and diastolic (d) blood pressure in young adults. HGT: Hand grip strength test

DISCUSSION

Mounting evidences indicate that IHG strength is of prognostic importance in the general population and in those with existing disease condition [24,25]. Reports regarding hand grip strength and the factors influencing it in younger populations are scarce in the United Arab Emirates (UAE) population. The results of this study demonstrate that IHG strength is slightly greater in the dominant hand compared to the non dominant hand in individuals of three ethnicities regardless of the gender. Reports suggest that handedness has an important role in determining IHG strength in the aged population. Hernández-Martínez J et al., found that, IHG strength was significantly higher in the dominant than the non dominant hand in aged population [26]. In another study, conducted on the American and Greek volunteers, it was found that grip strength of the dominant hand was higher compared to the non dominant hand for right-handed people, but was equal in both hands for left-handed people [27].

Considerable number of evidences suggests that IHG strength is influenced by geographical region and ethnicity. In the current study,

a difference was observed in IHG strength values of people from different ethnicities. However, the difference was not statistically significant. Although a variation in IHG strength is evident across different ethnicities, the potential reason for this variation is still debatable and not resolved completely. It is plausible that the genetic makeup of an ethnicity can determine the muscular makeup and thereby the muscle strength of that ethnicity. Although this is true, the significant role played by environmental factors such as diet and physical activity in influencing IHG strength cannot be ruled out. Yet, some uncertainty still remains in this matter as to which factor (ethnic and genetic vs environmental) primarily determines the grip strength. Although a moderate difference in the IHG strength values between different ethnicities was observed in this study, further studies are required to unravel the potential influence of environmental factor such as diet, which was not assessed in the current study.

As depicted in the results, we found that gender plays a significant role in determining the IHG strength across different ethnicities. This pattern is evident in the IHG strength of both dominant and non dominant hands, indicating that, sex related difference in IHG strength might be common to contralateral limbs. Further research is needed to corroborate, if this can be extrapolated to lower limb muscles of various age groups. The observed gender difference in IHG strength of young adults of various ethnicities in the current study corroborates with a few earlier reports. In a report, Leong DP et al. showed that males had higher hand grip strength compared to females across all ages [7]. Hernández-Martínez J et al., reported that Maximal Voluntary IHG Strength (MVIHS) was found to be significantly lower in older females (≥ 65 -year-old) than males [26].

Correlation of BMI and IHG strength was performed to understand the relationship of BMI to IHG strength. As seen from the results, a weak positive correlation was observed between BMI and IHG strength indicating a positive relationship between these two variables. However, whether an increase in one factor leads to an increase of the other requires further investigations. In other words, knowing a factor (BMI) value helps to possibly predict the other (hand grip strength value) would requires further investigation.

A correlation analysis was carried out to appraise the relationship between IHG strength and blood pressure. As depicted in the results, the relationship of the subjects' IHG strength with resting SBP was stronger than its relationship with that of DBP. Shin JY and Ha CH observed similar findings that, the relationships between SBP and heart rate, muscle endurance, power, and agility are stronger compared to the relationships between these variables to the DBP among Asian obese and normal weight middle-aged women [28].

Acute effects of isometric exercise on blood pressure have been evaluated in multiple studies. However, consensus is not seen with these reports as researchers have either observed increased [20,21], maintained [22] or decreased [23] blood pressure after the isometric exercise. In the current study, a reduction was observed in both the SBP and DBP immediately after the IHG strength test. Although this decrease was statistically significant, the clinical significance of this reduction has to be further appraised. This partially corroborates with an earlier report which demonstrated that isometric exercise can be effectively used for reducing DBP and mean arterial blood pressure at rest [29]. Evidences suggest that most of the protocols involving IHG, necessitated less time commitment to produce effective reduction in BP (~33 min/wk total) compared with other exercise modalities (for e.g., typically 150 min/week (wk) with aerobic dynamic exercise) [19]. In the current study, before recording the blood pressure, each subject underwent three trials of IHG strength test trials. Additionally, before the next measurement, another three trials were also performed on the other hand. Further careful analysis can help establish the possible mechanisms that lead to a decrease in blood pressure. Brook RD et al., suggest that, isometric exercise lead to an acute stimulation of the metaboreflex in a physiological attempt to restore muscle blood flow [19]. This and other responses may lead to a reduction in tissue

oxidative stress, improved vascular endothelial function, favorable changes in baroreflex sensitivity, as well as an autonomic balance over a long-term. Although this may be possible, available studies in this regard offer mixed findings. Therefore, the responsible mechanistic pathways have not been fully clarified [30].

Another important aspect of the current study is basically, it is the first report to provide normative value of IHG strength in normal young adults (late adolescents) of different ethnic groups of United Arab Emirates. However, future research may also provide insight on the other possible factors affecting muscle strength and endurance in this population.

Limitation(s)

The limited sample size prevented additional evaluations of how other factors may influence IHG strength, primarily the role of clinical conditions. The specific characteristics of the sample population may limit the generalisability of the results to other populations that differ in age, sex, or health status. The authors have included only male and female young adults and not studied other age groups and therefore it may not be possible for the results (primarily related to cardiovascular parameters and their underlying mechanisms) to be generalised with the other age groups for both the genders. Additionally, there is a minor methodological difference in the current study which has to be kept in mind while extrapolating these results or comparing these results with other studies. There is a difference in the choice of equipment used for measuring grip strength in the current study. There is evidence that variation in equipment and methodological approach can affect the values recorded [7]. The authors of the present study have used a hand dynamometer connected to a desktop installed with Biopac Student Lab Software, whereas the Jamar hand dynamometer is the most widely used. Nonetheless, its test-retest, inter-rater and intra-rater reliability were established. Furthermore, the study used the maximum strength values measured from three attempts tested on both dominant and non dominant hands.

CONCLUSION(S)

The IHG strength was not influenced by handedness in both the sexes. Although the IHG strength values were slightly higher in the Arab population compared to others, this difference was not significant for both the dominant and non dominant hands in either sexes. The IHG strength was significantly lesser in females of all ethnicities studied. This gender effect was evident in both the dominant and non dominant hands. A positive correlation was found between IHG strength with BMI and/resting SBP. In contrast, only a weak positive correlation was detected between IHG strength with resting DBP. Additionally, both the SBP and DBP decreased immediately after the IHG strength test. Future studies that focuses on generating IHG strength reference values for UAE population outside 35-70 years of range is required to elucidate the clinical significance of findings and to unravel the possible underlying mechanisms. Along with this, a comprehensive evaluation of various other factors determining IHG strength in different UAE ethnic groups would be worth investigating.

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