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DESCRIPTIVE STUDY OF HAND GRIP STRENGTH AND FACTORS ASSOCIATED WITH IT IN A GROUP OF YOUNG UNDERGRADUATE STUDENTS IN UNIVERSITY OF PERADENIYA, SRI LANKA WHO ARE NOT PARTICIPATING IN REGULAR PHYSICAL TRAINING

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ABSTRACT

Background: Handgrip strength (HGS) not only reflects the strength of the upper limb muscles; it also reflects the overall strength of the skeletal muscles and physical fitness. Further, it is being used as an indicator of nutritional status too. Undergraduate students have been described as having low physical fitness due to their sedentary lifestyle in many studies. Therefore, this study describes the HGS and its association with gender, hand dominance, Body Mass Index (BMI), hand and forearm anthropometries in a group of young undergraduate students of the University who do not participate in regular physical training.

Methods: This is a cross-sectional descriptive study, and was conducted among healthy first-year residential undergraduate student population (n= 524, 350 females, 174 males, mean age= 21.31 ± 0.93). Main outcome measures were HGS, gender, hand dominance, BMI, hand length, hand span, handbreadth, forearm length, forearm girth, and wrist circumference.

Results: HGS of the dominant hand of male students was 35.27 ± 5.91 kg, which is significantly higher (p< 0.05) than that of the females (19.52 ± 4.34 kg). However, it has a significant but weakly positive correlation with other variables measured except for forearm length.

Conclusion: This study has provided an insight into the association of low HGS with physical inactivity in an academically oriented group where the BMI is within the normal range and the association of higher HGS with hand dominance and male gender.

Keywords: Hand Grip Strength, Undergraduate students, Physical activity, BMI, Gender, Hand dominance.

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INTRODUCTION

Hand grip strength (HGS) is described as the force applied by the hand to hold on, to pull on, or to suspend objects in the hand. It is a reliable measurement which can be easily used to evaluate the functional integrity of the hand [1]. HGS values have been influenced by many factors such as age, gender [2, 3] BMI, hand and forearm anthropometries, and hand dominance [4].

Strength of the skeletal muscles depends on multiple factors such as body build and composition, physical activity, hormonal influence, etc. HGS reflects total muscle strength and physical fitness [5]. Therefore, it can be used as a powerful indicator of the overall strength of the body [5-7]. Sedentary people who were not actively participating in sports have demonstrated significantly lower HGS compared to physically active people that involved in regular sports activities such as cricket, hockey, tennis, basketball, handball, etc. [8]. Therefore, HGS can be used to indicate the sedentary nature of a population, and it would help to predict their potential risk of developing non communicable diseases such as myocardial infarction and stroke [9]. Further, it is important to consider the other factors that are influencing the HGS in order to have a better understanding.

A significant difference has been reported between males and females where males have had higher HGS than the females [3, 10-14]. Moreover, statistically higher HGS had been found in dominant hand than the non dominant hand in previous studies [15-17]. Further, many studies have shown a conflicting association of anthropometry with HGS [18-23]. Hand breadth had found to be the most highly correlating parameter with the HGS [18]. Furthermore, forearm girth, wrist girth, hand length, hand span [19-22] and forearm length [23] was known to have a significant correlation with the HGS.

Andrade Fernandes et al., (2014) [24] showed the importance of getting reference values for HGS for different countries because it has been proven that the different ethnicities have different HGS. In another study done by Woo et al., (2014) [25] stated a significant variation in mean values for HGS between Asian ethnic groups and between the same ethnic groups who are living in various geographic locations. So these studies emphasize the need of doing similar studies in other countries as well.

Even though many studies had been conducted in different countries to understand HGS and the association of different variables with the HGS, for the best of our knowledge, this kind of study among young adults in Sri Lanka is not available. Therefore, the study aims to describe the HGS and the factors associated with it among an academically oriented group of undergraduate students who are not regularly involved in physical exercises.

METHODOLOGY

This was a cross-sectional descriptive study which was performed in the University during 27-03-2017 to 08-05-2017.

Inclusion / Exclusion criteria

A total of 650 students were assessed for eligibility. Of them, 50 students were excluded from the study. There were 27 students who did not meet the inclusion criteria with 19 having any trauma, pathology, or pain in the upper limb, neck or back region while eight having regular physical training. Also, sixteen students declined to participate, while seven students were unable to participate. Out of 600 students who met the inclusion criteria, 524 undergraduates were recruited by randomization.

Participants

Out of 524 students, 350 were females, and 174 were males. The majority (74%) of the students in this population were Sinhalese, and they represented all the districts of Sri Lanka. The age of the students was between 20-23 years (21.31 ± 0.93).

The target population included the academically oriented young adult population who were not participating in regular physical training. This study was conducted among undergraduate students of University, and the sample was drawn from the healthy first-year residential student population. Ethical clearance was obtained from the Faculty before the data collection (no: AHS/ERC/2017/053).

Randomization and Intervention

Using a creative research survey system [26] a minimum sample size of 524 was obtained. Male and female first-year undergraduate students who fulfilled the inclusion criteria were selected using a simple randomized sampling method. Random number generator was used for randomization. Subjects that were included were explained about the nature of the study in the language best understood by them. Written informed consent was obtained from the subjects who were willing to participate in the study, and it was duly signed by each subject. The consent form and all the other identifiers of each participant were kept secure and confidential without access to anyone other than the research team.

Data related to the registration number, age, sex, ethnicity, district, and hand dominance was collected in the initial encounter by an investigator and was recorded on a data-sheet. Each measurement was measured by a separate investigator who recorded the same measurement in all subjects. Both arms were chosen for all measurements. Males and females were measured separately by investigators of the same sex. All of the participants were given five minutes of independent warm-up, and then they were instructed to squeeze the dynamometer as tightly as possible, using the musculature of the hand. Participant had performed three maximum attempts for each measurement for both dominant and non-dominant hands. Results were recorded as kilograms. The average value was recorded and considered as an individual value. One minute rest was given between each attempt, and hand was altered to reduce the fatigue effects [27]. No, any verbal or visual encouragement was given during testing. All measurements were taken at the same time of the day (4-6 pm) since it has been shown that the circadian rhythm has an influence on the HGS with a minimum around 6:00 hr and a maximum around 18:00 hr [28].

Outcome measures

Measurements including standing height [29], weight [30], hand length, breadth, span, forearm girth [20], forearm length [31], grip strength [32] were taken using standard methods and standard equipment by trained investigators. The HGS of both right and left hands was measured by using the Smedley hand grip dynamometer utilizing the protocol of the American Society of Hand Therapists (ASHT) [32]. As per ASHT recommendation, each subject was seated upright against the back of the chair with feet flat on the floor, shoulder adducted and neutrally rotated, elbow 90° flexed, wrist position (0°-30° extension of the wrist, 0°-15° ulnar deviation) that enabled the subjects to self-select a position of wrist comfort.

Statistical analysis

Data were analyzed using the Minitab 16.0 version (Minitab Inc., USA). Standard descriptive statistics (Mean, SD, min, max) were obtained for all the derived and directly measured variables. Paired t-test was performed to compare the means between dominant and non-dominant hand anthropometries and HGS. Pooled t-test was performed to identify the difference between all the measured anthropometries and HGS between males and females. Pearson correlation was used to examine the association between predictor and response variables. Multiple linear regression analysis was used to generate an equation to describe the statistical relationship between one or more predictor variables and the response variable. $P \leq 0.05$ was selected as the significant level.

RESULTS

Descriptive statistics for the variables measured are shown in Table 1 and 2.

Table 1: Descriptive statistics for all the variables measured in female and male participants

Parameter	Males (n= 174)	Females (n= 350)	P value
	Mean ± SD	Mean ± SD	
Height (m)	1.70 ± 0.06	1.55 ± 0.05	<0.001*
Weight (kg)	60.24 ± 10.63	48.59 ± 8.93	<0.001*
BMI (kg/m ²)	20.84 ± 3.37	20.10 ± 3.40	0.02*
D.H. Length (cm)	18.84 ± 1.01	17.03 ± 0.80	<0.001*
D.H. Breadth (cm)	8.50 ± 0.41	7.43 ± 0.35	<0.001*
D.H. Span (cm)	20.68 ± 1.52	18.14 ± 1.15	<0.001*
ND.H. Length (cm)	18.80 ± 0.93	17.08 ± 0.80	<0.001*
ND.H. Breadth (cm)	8.44 ± 0.44	7.40 ± 0.36	<0.001*
ND.H. Span (cm)	21.11 ± 1.45	18.49 ± 1.22	<0.001*
D.W. Girth (cm)	16.33 ± 0.88	14.40 ± 0.84	<0.001*
D.F. Length (cm)	21.88 ± 1.58	20.22 ± 1.24	<0.001*
D.F. Girth (cm)	25.83 ± 2.04	22.13 ± 1.86	<0.001*
ND.W. Girth (cm)	16.22 ss ± 0.87	14.35 ± 0.88	<0.001*
ND.F. Length (cm)	21.98 ± 1.53	20.16 ± 1.20	<0.001*
ND.F. Girth (cm)	25.37 ± 2.05	21.86 ± 1.88	<0.001*

n= total number, BMI= Body Mass index, D.H= Dominant

Hand, ND.H= Non-Dominant Hand, D.W= Dominant Wrist, D.F= Dominant Forearm, ND.W= Non-Dominant Wrist, ND.F= Non-Dominant Forearm *

*Statistically significant p value

Table 2: Descriptive statistics for measured HGS in female and male participants

Parameter	Males (n= 174)	Females (n= 350)	P value
	Mean ±SD	Mean ± SD	
DHGS (kg)	35.27± 5.91	19.52± 4.34	<0.001*
NDHGS (kg)	33.25± 5.92	17.92± 4.02	<0.001*

DHGS= Dominant Hand Grip Strength, NDHGS= Non Dominant Hand Grip Strength statistically

*Significant p value

This illustrates that there is a significant difference ($p < 0.05$) in mean values of height, weight, BMI, dominant and non-dominant anthropometric measurements tested and HGS values between males and females. Therefore all the tests were performed separately for each gender. All the measured parameters were significantly higher in males than in females. Mean differences for variables measured in females and males in dominant and non-dominant hands are shown in Table 3.

Table 3: Mean differences for variables measured in females and males in both hands

	Females (n= 350)		Males (n= 174)	
	Paired difference		Paired difference	
	Mean ± SD	P value	Mean ± SD	P value
D.H. Length-ND.H. Length	-0.05 ± 0.35	0.004*	0.03 ± 0.43	>0.05
D.H. Breadth-ND.H. Breadth	0.04 ± 0.23	<0.001*	0.05 ± 0.28	0.01*
D.H. Span- ND.H. Span	-0.35 ± 0.70	<0.001*	-0.43 ± 0.97	<0.001*
D.W. Girth- ND.W. Girth	0.05 ± 0.34	0.004*	0.10 ± 0.36	<0.001*
D.F. Length- ND.F. Length	0.04 ± 0.67	>0.05	-0.10 ± 0.81	>0.05
D.F. Girth- ND.F. Girth	0.27 ± 0.55	<0.001*	0.45 ± 0.67	<0.001*
DHGS- NDHGS	1.60 ± 2.52	<0.001*	2.02 ± 3.31	<0.001*

n= total number, D.H= dominant Hand, ND.H= non-dominant hand, D.W= Dominant Wrist, ND.W= Non-dominant wrist, D.F= Dominant Forearm, ND.F= Non-dominant Forearm, DHGS= Dominant Hand Grip Strength, NDHGS= Non-Dominant Hand Grip Strength

*statistically significant p value.

According to that, there is a significant difference ($p < 0.05$) between dominant and non-dominant anthropometric measurements and the HGS mean values except for hand and forearm lengths in males and for forearm length in females. Except for hand length and span, all the other parameters were significantly higher in dominant hands in females. In contrast, all the parameters except hand span and forearm length were substantially higher in dominant hands in males. The associations of HGS with all other

variables tested are represented in Table 4.

Table 4: Correlation between HGS and variables measured

	Males (n=174)		Females (n=350)	
	DHGS	NDHGS	DHGS	NDHGS
	r	r	r	r
Height	0.09	0.166*	0.01	0.07
Weight	0.303***	0.290***	0.186***	0.188***
BMI	0.286***	0.243***	0.210***	0.188***
D.H. length	0.140*		0.107*	
D.H. breadth	0.309***		0.264***	
D.H. span	0.19**		0.199***	
D.W. girth	0.323***		0.183***	
D.F. length	-0.12		0.03	
D.F. girth	0.432***		0.228***	
ND.H. length		0.187*		0.187***
ND.H. breadth		0.343***		0.299***
ND.H. span		0.19**		0.183***
ND.W. girth		0.330***		0.190***
ND.F. length		0.01		0.02
ND.F. girth		0.383***		0.228***

DHGS= Dominant Hand Grip Strength, NDHGS= Non-dominant Hand Grip Strength, D.H= Dominant Hand, ND.H= Non-dominant Hand, D.F= Dominant Forearm, ND.F= Non-dominant Forearm, D.W= Dominant Wrist, ND.W= Non-dominant wrist

*Correlation was significant at 0.05 level

**Correlation was significant at 0.01 level

*** Correlation was significant at 0.001 level

All the measured predictor variables were significantly correlated ($P < 0.05$) with the HGS and with each other in both genders except for forearm length and height of the participant ($P > 0.05$). Hand breadth was the most highly correlated anthropometric measurement with the HGS in females ($r = 0.264$ and $r = 0.299$ in dominant and non-dominant hands, respectively) whereas it was forearm girth in males ($r = 0.432$ and $r = 0.383$ in dominant and non-dominant hands respectively). The most weakly correlated variable in females was forearm length ($r = 0.028$ and $r = 0.023$ in dominant and non-dominant hands, respectively). In males, the dominant forearm length had a negative association with dominant HGS. The least correlating parameter was hand length ($r = 0.140$) for the dominant hand, and it was forearm length ($r = 0.011$) for the non-dominant hand. The most highly correlating variables with HGS are shown in Figure 1 for females and males.

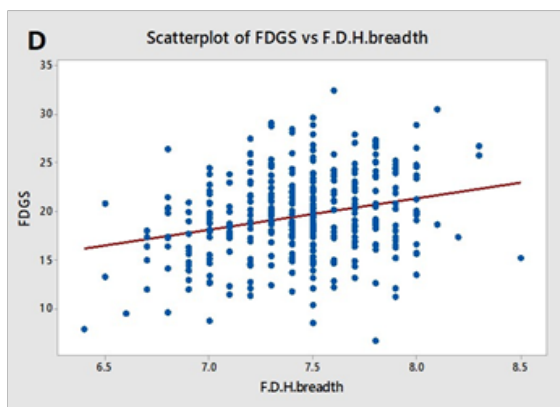
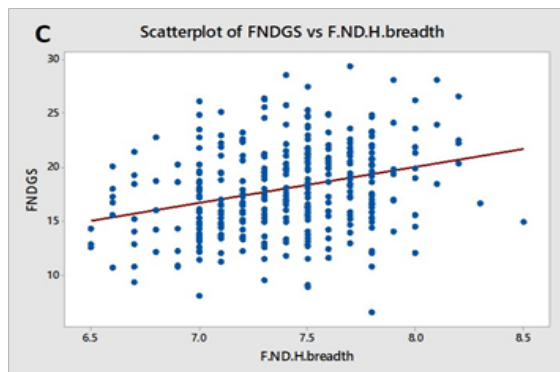
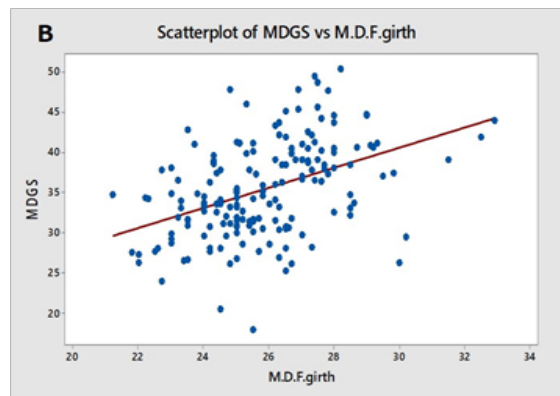
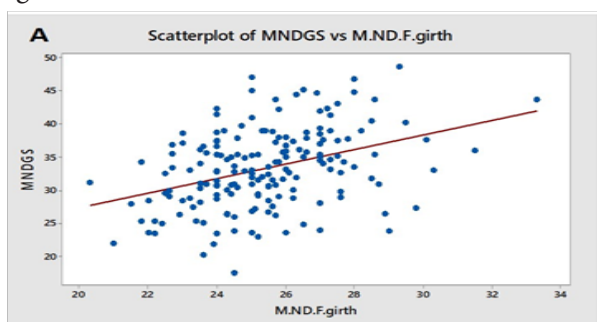


Figure 1: Relationship between variables and handgrip strength in both males and females. MNDGS= Male Non-dominant Grip Strength, M.ND.F. girth= Male Non-dominant Forearm girth, MDGS= Male Dominant Grip Strength, M.D.F. girth= Male Dominant Forearm girth, FNDGS= Female Non-dominant Grip Strength, F.ND.H. breadth = Female Non-dominant hand breadth A. Relationship between NDHGS and ND.F. Girth in males B. Relationship between DHGS and D.F. Girth in males C. Relationship between NDHGS and ND.H. Breadth in females D. Relationship between DHGS and D.H. Breadth in females.

* Statistically significant p-value

Multiple linear regression analysis

The regression equations developed for males and females, and both dominant and non-dominant hands are shown below in Table 5.

Table 5: Multiple Linear Regression Analysis for estimation of hand grip strength

Gender	Hand	Regression equations	R ²	R ² (adjusted)	p-value
Female	Dominant	DHGS= -9.37 + (2.734 D.H. Breadth) + (0.472 D.H. Span)	8.38%	7.85%	<0.001*
	Non-dominant	NDHGS= -6.82 + (3.349 ND.H. Breadth)	8.95%	8.69%	<0.001*
Male	Dominant	DHGS= 2.99 + (1.250 D.F. Girth)	18.63%	18.16%	<0.001*
	Non-dominant	NDHGS= -11.18 + (2.80 ND.H. breadth) + (0.819 ND.F. Girth)	18.04%	17.08%	<0.001*

DHGS= Dominant Hand Grip Strength, NDHGS= Non-dominant Hand Grip Strength, D.H= Dominant Hand, ND.H= Non-dominant Hand, D.F= Dominant Forearm, ND.F= Non-dominant Forearm

* Statistically significant p-value

DISCUSSION

The present study describes the HGS and factors associated with it among an academically oriented group of undergraduate students of the University of Peradeniya who are not participating in regular physical training.

A study similar to that of the present one was conducted by Maynard & Triyanti (2016) [33] on sedentary undergraduate students in Jakarta, Indonesia. The study was conducted using 47 male and 47 female college students who were classified as sedentary according to a physical activity questionnaire. Their mean HGS values for dominant hand among both males and females were similar to that of our study (35.99 ± 6.37 and 21.89 ± 4.89 for males and females respectively). They too had used the Smedley dynamometer and the standard ASHT protocol.

Further, Mullerpatan et al., (2013) [34] have described HGS among 1005 (413-males, 592-females) healthy, sedentary adults in various states of India aged 18-30 years and had found approximately similar HGS values for both males (33.67 ± 7.2 kg) and females (19.51 ± 3.9 kg). HGS was measured using standard Jamar hand-held dynamometer in standing position. Kim et al., (2018) [35] have established normative HGS values for the Korean population. They also have found higher HGS values for both males (42.5 ± 0.5 kg) and females (25.9 ± 0.3 kg) for 20-24 age group using hand-held Takei dynamometer in the standing position.

Furthermore, Brazilian men had shown much higher mean HGS in both dominant and non-dominant sides (48.8 ± 8.9 , 47.3 ± 8.8 for dominant and non-dominant hands respectively) [24] for 20-24 years age group. Two hundred twenty-three healthy subjects were randomly selected for this specific age group from the state of Minas Gerais, Brazil. Jamar hand dynamometer and standard ASHT positions had been used for the measurement of HGS.

A study was done by Steiber et al. (2016) also have found higher HGS values for healthy German population (20-24 age group) for both males (49.1 kg) and females (30.2 kg) [36]. They too, had used the Smedley dynamometer.

A systemic review done by Leal et al. (2010) had shown that the mechanical dynamometers, including Harpenden and Smedley, were the second most used dynamometer following Jamar dynamometer to assess the HGS [37]. In clinical practice and research, ASHT protocol has been

used widely in the evaluation of HGS. Association of HGS with gender, hand dominance, BMI, hand, and forearm anthropometries too were assessed in this study.

HGS recorded for males and females, and the dominant hand and non-dominant hand of the current study population has shown values lower than what was reported in many studies. These differences may suggest the involvement of different genetic and environmental factors associated with these diverse populations. Factors such as different body anthropometries observed for ethnic difference, geographic location, cultural status, lifestyle habits, including nutrition, pattern of physical activities can play an important role.

Academically oriented individuals mostly spend a lifestyle characterized by low physical activities. In the present study, despite their sedentary lifestyles, BMI has not reflected a marked variation in body composition. Therefore HGS would be a good indicator of the sedentary nature of individuals as it reflects the changes before BMI, which is commonly used to assess the body composition. Other than the low physical activity, inadequate calorie intake too can cause lower muscle strength [38]. Therefore both underweight and overweight categories also can have low HGS due to weakness in the muscle strength, although the power of the muscle is in the normal range.

BMI was in the normal range in the present study. Therefore, HGS showed only a weak positive correlation with BMI (Males; r values 0.286 & 0.243, Females; r values 0.210 & 0.188 for dominant and non-dominant hands respectively). Therefore it is vital to interpret HGS values with the results of body composition to understand an underline cause of low HGS. In the present population, the mean BMI was in the normal range (Females- 20.10 ± 3.40 , Males- 20.84 ± 3.37) and the HGS is low, which indicates the association between the sedentary nature of lifestyle and HGS.

Further, our study too indicated that there is a significant gender influence for HGS, which is described by other researchers also [3, 12, 14]. This decreased grip strength in females is identified to be attributed to the high prevalence of frailty in their old age [39]. As frailty can cause adverse health effects such as the increased risk of falls, disability, and even mortality [40], this is a matter of great concern. A significant difference of HGS between dominant and

non-dominant hands that is seen in the present study was described by other researchers too [15, 16, 17]. However, other factors such as hand and forearm anthropometries have not shown a stronger relationship although there was a significant correlation with them except forearm length that has not shown a relationship. Thus these internal factors have a little influence in improving the grip strength while the strength of the muscle that is determined by sex, hand dominance, physical activities and nutritional status has greater control over it. Thus HGS may be used to reflect the state of physical activities and nutritional status of an individual.

CONCLUSION

This study has provided an insight into the association of low HGS with reduced physical activity that is inclining towards a sedentary lifestyle in an academically oriented group where the BMI is within the normal range. Further, it has shown that male gender and hand dominance are responsible for higher HGS, while other internal factors such as limb anthropometries have a weak association. Therefore, an increase in the HGS would provide an indication of involvement in the physical activity when the BMI is unable to show such changes. As reduced physical activity level is associated with the development of non-communicable diseases later in life, it is essential to study this matter at the clinical level to identify whether this population is at such risk.

Limitations

This study is not a community-based study and is based on a healthy student population. Thus, the findings can only be generalized to similar academically oriented young people but not to all young adults in the general population.

Future directions

Similar studies should be performed for the general young adult population in Sri Lanka as there is limited data available on HGS. Also, it will be interesting to study HGS for various ethnic groups.

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REFERENCES

- [1] Walankar P, Verma C, Mehta A. Study of Hand Grip Strength in Indian Population. *Int J Health Sci Res.* 2016; 6: 162–66.
- [2] Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Res Notes.* 2011; 4 (127): 1-5.
- [3] Kubota H & Demura S. Gender differences and laterality in maximal handgrip strength and controlled force exertion in young adults. *Health.* 2011; 3 (11): 684–88.
- [4] Koley S & Singh AP. Effect of hand dominance in grip strength in collegiate population of Amritsar, Punjab, India. *The Anthropologist.* 2010; 12 (1): 13–16.
- [5] Kärkkäinen M, Rikkinen T, Kröger H, Sirola J, Tuppurainen M, Salovaara K et al. Physical tests for patient selection for bone mineral density measurements in postmenopausal women. *Bone.* [Online] 2009; 44 (4): 660–65.
- [6] Wind AE, Takken T, Helders PJ, Engelbert RH. Is grip strength a predictor for total muscle strength in healthy children, adolescents and young adults. *Eur J Pediatr.* 2010; 169 (3): 281-87.
- [7] Trosclair D, Bellar D, Judge LW, Smith J, Mazerat N, Brignac A. Hand-grip strength as a predictor of muscular strength and endurance. *J Strength Cond Res.* 2011; 25 (S99).
- [8] Wagh PD, Birajdar G, Nagavekar M. Comparison of hand grip muscle strength in sportsmen and sedentary group. *Journal of Dental and Medical Sciences.* 2017; 16 (7): 62-5.
- [9] Leong DP, Teo KK, Rangarajan S, Lopez-Jaramillo P, Avezum A, Orlandini A et al. Prognostic value of grip strength: Findings from the Prospective Urban Rural Epidemiology (PURE) study. *The Lancet.* [Online]. 2015; 386 (9990): 266–73.
- [10] Leyk D, Gorges W, Ridder D, Wunderlich M, Rüter T, Sievert A et al. Hand-grip strength of young men, women and highly trained female athletes. *Eur J Appl Physiol.* 2007; 99: 415–21.
- [11] Luna-Heredia E, Martin-Pena G, Ruiz-Galiana J. Handgrip dynamometry in healthy adults. *Clin Nutr.* 2005; 24: 250–58.
- [12] Peters MJ, van Nes SI, Vanhoutte EK, Bakkens M, van Doorn PA, Merkies IS et al.. Revised normative values for grip strength with the Jamar dynamometer. *J Peripher Nerv Syst.* 2011; 16 (1): 47–50.
- [13] Koley S & Singh AP. An Association of Dominant Hand Grip Strength with Some Anthropometric Variables in Indian Collegiate. *Anthrop. Anz.* 2009; 67 (1) 21-8.
- [14] Oseloka IA, Bello BM, Oliver HW, Emmanuel UU, Abraham MS. Association Of Handgrip Strength With Body Mass Index Among Nigerian Students. *IOSR J Pharm and Biol Sci.* [Online]. 2014; 9 (1) ,01–07.
- [15] Incel NA, Ceceli E, Durukan PB, Erdem HR, Yorgancıoglu ZR. Grip Strength: Effect of Hand Dominance. *Singapore Med J.* 2002; 43 (5): 234–37.
- [16] Armstrong CA & Oldham JA. Comparison of Dominant and Non-Dominant Hand Strengths. *J Hand Surg Br.* [Online]. 1999; 24 (4): 421–25.
- [17] Özcan A, Tulum Z, Pinar L, Baskurt F. Comparison of Pressure Pain Threshold, Grip Strength, Dexterity and Touch Pressure of Dominant and Non-Dominant Hands within and Between Right- and Left-Handed

- Subjects. *J Korean Med Sci.* 2004; 19 (6): 874-78.
- [18] Nicolay CW & Walker AL. Grip strength and endurance : Influences of anthropometric variation, hand dominance, and gender. *Int J Ind Ergon.* 2005; 35 (7): 605-18.
- [19] Shah UN, Sirajudeen MS, Somasekaran PK, Mohasin N, Shantaram M. The Association between Hand Grip Strength and Hand Dimensions in Healthy Indian Females. *Int J Curr Res Rev.* 2012; 4(2): 36-42.
- [20] Sirajudeen MS, Shah UN, Pillai PS, Mohasin N, Shantaram M. Correlation between Grip Strength and Physical Factors in Men. *Int J Health and Rehabil Sci.* 2012; 1(2): 58-63.
- [21] Alahmari KA, Silvian SP, Reddy RS, Kakaraparthi VN, Ahmad I, Alam MM. Hand grip strength determination for healthy males in Saudi Arabia : A study of the relationship with age , body mass index , hand length and forearm circumference using a hand-held dynamometer. *J Int Med Res.* 2017; 45(2): 540-48.
- [22] Mohan V, Shamsaimon NS, Japri MB, Yasin NE, Henry LJ, Othman IR. Fore Arm Circumference and Hand Length Predicts Maximal Hand Grip Strength among Malaysian Population. *Middle East J Sci Res.* 2014; 21(4), 634-39.
- [23] Ibegbu AO, Baita MB, Hamman WO, Emmanuel UU, Musa SA. Evaluation of the Relationship between Handgrip Strength with Some Anthropometries among Nigerian Secondary School Students. *Anthropologist.* 2014; 17(3): 921-27 .
- [24] Andrade Fernandes AD, Natali AJ, Vieira BC, Valle MAAND, Gomes Moreira D, Massy-Westropp N et al. The relationship between hand grip strength and anthropometric parameters in men. *Arch Med Deporte.* 2014; 31(3): 160-64.
- [25] Woo J, Arai H, Ng TP, Sayer AA, Wong M, Syddall H et al. Ethnic and geographic variations in muscle mass, muscle strength and physical performance measures. *Eur Geriatr Med.* 2014; 5(3), 155-64.
- [26] Survey system (2017) Sample Size Calculator - Confidence Level, Confidence Interval, Sample Size, Population Size, Relevant Population - Creative Research Systems. [Online] Available from: <http://www.survey-system.com/sscalc.htm>. [Accessed: 11 March 2017].
- [27] Trossman PB & Li PW. The effect of the duration of intertrial rest periods on isometric grip strength performance in young adults. *Occupational Therapy Journal of Research.* 1989; 9(6): 362-78.
- [28] Jasper I, Haussler A, Baur B, Marquardt C, Hermsdorfer J. Circadian variations in the kinematics of handwriting and grip strength. *Chronobiol Int.* 2009; 26(3): 576-94.
- [29] Centres for Disease Control and Prevention, 2007. Anthropometry procedures manual. National Health and nutrition examinatory survey (NHANES). [Online]. (January):102. http://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_an.pdf
- [30] WHO/Europe| Nutrition, 2017. Body Mass Index. [Online] <http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi>[Accessed: 10 July 2017].
- [31] Mohanty BB, Agrawal D, Baisakh P, Samantsinghar P, Kumar S, Chinara PK. A study of different parameters of human extremities and its relationship with human height in residents of eastern India. *Tanta Med J. [Online].* 2015; 43(1), 1-8.
- [32] Pereira HM, Menacho MDO, Takahashi RH, Cardoso JR. Hand grip strength evaluation on Tennis players using different recommendations. *Rev Bras Med Esporte;* 2011; 17(3): 184-88.
- [33] Maynard & Triyanti V. Evaluation Of The Correlation Between Hand Anthropometry And Grip Strength in Sedentary Undergraduate Students. *International Journal of Advances in Computer Science and Technology.* 2016; 5(3): 38- 46.
- [34] Mullerpatan RP, Karnik G, John R. Grip and pinch strength: Normative data for healthy Indian adults. *Hand Ther.* 2013; 18 (1): 11-16.
- [35] Kim M, Won CW, Kim M. Muscular grip strength normative values for a Korean population from the Korea National Health and Nutrition Examination Survey, 2014-2015. *PLoS One.* 2018; 13(8): 1-16.
- [36] Steiber N. Strong or weak hand grip? Normative reference values for the German population across the life course stratified by sex, age and body height. *PLoS One.* 2016; 11(10): 1-14.
- [37] Leal VO, Mafra D, Fouque D, Anjos LA. Use of hand-grip strength in the assessment of the muscle function of chronic kidney disease patients on dialysis : a systematic review. *Nephrol dial transplant.* 2010; 26: 1354-360.
- [38] Flood A, Chung A, Parker H, Kearns V, O'Sullivan TA. The use of hand grip strength as a predictor of nutrition status in hospital patients. *Clinical Nutrition.* [Online]. 2014; 33(1): 106-14. Available from:
- [39] Falsarella GR, Gasparotto LPR, Barcelos CC, Coimbra IB, Moretto MC, Pascoa MA et al. Body composition as a frailty marker for the elderly community. *Dove Press.* 2015;10: 1661-667.
- [40] Tom SE, Adachi JD, Anderson Jr FA, Boonen S, Chapurlat RD, Compston JE et al. Frailty and Fracture, Disability and Falls: A multiple country study from the global longitudinal study of Osteoporosis in women. *J Am Geriatr Soc.* 2013; 61(3): 327-34.