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Hand grip strength: Age and gender stratified normative data in Anatolian population

Melih Unal[1], Ozkan Kose[1], Hasan Onur Arik[2], Ferhat Guler[1], Baver Acar[1], Halil Yalcin Yuksel[1]

ABSTRACT

Objective: The purpose of this study is twofold; first we aimed to provide age and gender specific normative hand grip strength (HGS) data in Anatolian adult population and secondly we aimed to determine the effects of gender and hand dominance on HGS.

Patients and Methods: The study included 1359 adult healthy subjects, aged 18-90 years. A calibrated hydraulic hand dynamometer was used for the HGS measurements in accordance with current standardized instructions. The HGSs on sides, age, gender, and dexterity were recorded and statistically analyzed.

Results: The subjects were 712 males and 647 females with a mean age of 41.8±15.9 years and 46.9±16.1 years, respectively. Left hand dominance was determined in 67 subjects. Male subjects were stronger than female subjects in each age stratified group (p: 0.001). HGS showed a significant decline as the age of the subjects increased (r=-0.463, p=0.0001 dominant hand, r=-0.472, p=0.0001 non-dominant hand). The dominant hand was stronger than the non-dominant hand (p=0.0001). The mean difference between the dominant and non-dominant hand was 8.5% (SD: 13.1, median 7.6%). The mean strength ratio between the dominant and non-dominant hand was 1.07±0.12 for males and 1.09±0.13 for females.

Conclusions: This study is the largest study to present normative values of HGS in an Anatolian population. These findings can be used as a reference for future studies in an Anatolian population. HGS was seen to be higher in males and to decrease proportionally with age. The dominant hand is on average 8% stronger than the non-dominant hand in both genders and all age groups.

Key words: *Hand, grip strength, normative data, Turkish, Anatolian*

Introduction

The hand is a sophisticated musculoskeletal organ that can perform a variety of precise as well as forceful movements. It is hard to measure all functional aspects of the hand, although hand grip strength (HGS) is a widely used objective measure that provides quantitative evidence of the hand functions and its integrity as a whole [1]. HGS is the result of forceful flexion of all finger joints with the maximum voluntary force that the subject is able to exert under normal biokinetic conditions [2].

HGS measurements can be used for a variety of purposes such as comparison of the outcomes of various surgical procedures or treatment methods in the

Author affiliations : *[1]Department Orthopaedics and Traumatology, Antalya Education and Research Hospital, Antalya, Turkey [2]Deparment of Hand Surgery, Hacettepe University, Ankara, Turkey*
Correspondence : *Ozkan Kose, MD, Department Orthopaedics and Traumatology, Antalya Education and Research Hospital, Antalya, Turkey*
e-mail: drozkankose@hotmail.com
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upper extremity, monitoring the progression of a disease affecting hand functions and assessment of working capacity [1]. In order to evaluate a particular HGS measurement and make a judgment whether an individual is impaired or not, physicians should be aware of the normal reference values in healthy subjects. In case of unilateral traumatic injuries, the contralateral normal hand can be used as a reference baseline HGS for assessment of the involved side [3]. However, several authors have claimed that dominant and non-dominant HGS are not equal to each other [4-7]. Furthermore, in cases with bilateral involvement or injury, it is difficult to assess whether HGS is within the normal range as there is no reference point. Therefore, surgeons need to know the normative data to avoid faulty assessments.

It has been shown that HGS is affected by several factors such as age, gender, body mass index, laterality, dominance, and occupation of the subject, chronic systemic diseases, and even ethnicity [8-10]. Several studies have reported normative data of HGS from different populations with great variations [2,3,11-37] (Table 1). To the best of our knowledge, there has been one previous study which has aimed to present age and gender stratified normative HGS in a Turkish population; however, in this previous study a number of participants are small, particularly when analyzed in stratified age groups [37]. The purpose of this study was to provide age and gender specific normative HGS data in a large sample Turkish adult population.

Patients and Methods

The study included adults aged between 18 and 90 years. The research was carried out according to the principles of the Declaration of Helsinki and informed consent was obtained from each volunteer after explaining the objectives and methods of the study. The data collection and measurements were performed by the same author and the participants were patients and their companions who were admitted to our hospital. All participants were screened to exclude those with upper limb conditions and a thorough physical examination was made. Subjects with a history of upper limb injury, previous surgical operation, congenital or neuromuscular disease, or abnormality of the upper limb and those with a history of chronic inflammatory joint disease (such as rheumatoid arthritis) that may affect the grip strength were excluded from the study. All subjects were otherwise healthy.

A calibrated hydraulic hand dynamometer (Baseline®, Fabrication Enterprises, Inc., Irvington, USA) was used for the grip strength measurements (Figure 1). All measurements were made in accordance with standardized instructions of the American Society for Surgery of the Hand and the American Society of Hand Therapists [38]. The device handle was adjusted for each subject, to fit onto the palm with the fingers in flexion at the proximal and distal interphalangeal joints with the thumb in 90º abduction. The subjects were seated upright with the shoulder in adduction and neutrally rotated, the elbow flexed at 90º, the forearm in a neutral position, and the wrist positioned between 0º and 30º dorsiflexion and 0º and 15 º ulnar deviations. HGS was measured in kilograms. The subjects were instructed to grasp the handle for 5 seconds and 3 readings were taken alternatively for each hand, starting with the dominant hand. One minute of rest was provided between each measurement to overcome muscle fatigue.

The mean value of the three tests was used as the resultant value for analysis. The grip strength measurements on each body side, age, gender, and dexterity were recorded. The dominant extremity was confirmed with the Edinburgh handedness inventory in patients who were not aware of their dominant extremity [39].

Statistical Analysis

The whole study group was first divided into two groups according to gender, and then each gender was stratified into 10-year age groups from 18 to 70 years and over. Continuous variables were stated as mean and standard deviation and categorical variables as number (n) and percentage (%). Statistical comparison of grip

Table 1. Previous studies of HGS in different ethnic populations (abbreviations: D: dominant, ND: non-dominant, SD: standard deviation, R: right hand, and L: left hand).

Study #	Author	Year	Ethnicity	Number	Age (mean, range)	Side	HGS in male subjects (kg, mean±SD)	HGS in female subjects (kg, mean±SD)
1	Kamon and Goldfuss	1978	American	602	M: adults F:18-55	D	45.8±10.7	27.3±6.5
2	Mathiowetz et al.	1985	American	628	(20-94)	R L	47.3±12.8 42.2±12.5	28.4±7.7 24.4±7.1
3	Balogun et al.	1991	Nigerian	120	(7-84)	R L	27,9 25,7	15,9 14,27
4	Backman et al.	1995	Swedish	128	(17-70)	ND	48.8±5.8	29.72±4.74
5	Nevill and Holder	2000	English	2632	(16-74)	NR	49,00	29,42
6	Peolsson et al.	2001	Swedish	101	(25-64)	R L	51 50	34 32
7	Sella	2001	American	875	(19-91)	R L	31,43±12,56 30,83±12,4	17,1±7,56 15,76±7,16
8	Bao and Silverstein	2005	American	120	M:19-60 F:20-63	NR	47.9±7.8	30±6.7
9	Luna-Heredia et al.	2005	Spanish	496	17-97	D ND	39.9 35.1	25.7 22.8
10	Tsang	2005	Chinese	548	37.8 (21-70)	D ND	43,8±8,0 40,8±7,8	28,5±5,7 26,2±5,5
11	Kamarul et al.	2006	Malaysian	412	34.3 (18-65)	R L	31.09±8.9 28.09±8.2	18.6±5.7 16.8±5.5
12	Vianna et al.	2007	Brazilian	2648	(18-90)	D	36.8 ± 0.2	21.0 ± 0.18
13	Anakwe et al.	2007	English	250	42.8 (18-83)	D ND	48.6±10.96 44.8±9.81	28.5±4.6 26.6±4.9
14	Günther et al.	2008	German	769	(20-95)	R L	49±11 47±10	29±7 27 ± 7
15	Schlüssel et al.	2008	Brazilian	2050	≥20	R L	42,8 40,9	25,3 24,0
16	Mitsionis et al.	2009	Greek	232	39.8 (10.5)	R L	55.9±4.1 50.5±4.3	30.5±2.8 27.4±2.8
17	Wu et al.	2009	Taiwanese	482	47.2 (20-80)	R	46,9	29.2
18	Adedoyin et al.	2009	Nigerian	745	29.3 (20-70)	D ND	35.2±8.6 31.6±8.7	24.9±6.4 22.8±5.9
19	Werle et al.	2009	Swiss	978	51.7 (18-96)	D ND	47,2±7.9 47.1±7.8	30.3±5.2 29.6±5.1
20	Koley et al.	2010	Indian	303	21.5 (18-25)	R: D L: ND	41.31±6.0 38.14±6.2	23.82±3.71 21.03±3.49
21	Puh et al.	2010	Slovenian	199	49 (20-79)	D ND	45.5±9 44.82±3.57	28.27±5.57 26.25±5.2
22	Peters et al.	2011	Dutch	720	54.9 (20-96)	D ND	41.6 41.6	25.01 25.01
23	Aadahl et al.	2011	Danish	3471	49 (19-72)	D	49.2±8	31.1±6.1
24	Suzuki et al.	2012	Japanese	122	28 (20-46)	R: D L: ND	41.9±6.0 38.4±5.9	25.4±5.2 22.7±4.9
25	Nilsen et al.	2012	Norwegian	566	49.8 (20-94)	R	37.86±10.12	20.88±6.11
26	Shim et al.	2013	Korean	336	(13-77)	R L	42,3±7,5 40,7±7,4	26,5±4,5 24,8±4,7
27	Tveter et al.	2014	Norwegian	370	54.5 (18-90)	R L	46.8 47.5	28.5 28.8
28	Abe et al.	2016	Japanese	613	(20-89)	D	42.37±5.48	27.55±4.28
29	Eksioglu	2016	Turkish	211	33.9 (18-69)	D ND	46.41±7.5 45.02±7.4	26.3±4.7 25.1±5
30	Current study	2016	Turkish	1359	44.2 (18-90)	D ND	42.5±9.8 39.9±9.5	26.1±6.6 24.1±6.4

Figure 1. Hand dynamometer.

strength was made using Student's t-test for paired and independent samples, respectively. A parametric correlation coefficient (Pearson r) was used to analyze the relationship between the variables. A value of $p<0.05$ was accepted as statistically significant.

Results

The study subjects were 712 (52.4%) males with a mean age of 41.8±15.9 years (range, 18-90 years) and 647 (47.6%) females with a mean age of 46.9±16.1 years (range, 19-87 years). The main characteristics of the population are presented in Table 2.

Age and gender stratified normative grip strength data are presented in Table 3. The mean HGS of each age group in both genders was statistically different (p: 0.0001 for both genders) (Figure 2). HGS showed a significant decline (negative correlation) as the age of the subjects increased (r=-0.463, p=0.0001 dominant hand, r=-0.472, p=0.0001 non-dominant hand).

The dominant hand was stronger than the non-dominant hand (p=0.0001 in both genders and all age groups). The mean difference between the dominant and non-dominant hand was 8.5% (SD: 13.1, range:-47.3% to 74.0%, median 7.6%). In 21% of the subjects, the non-dominant hand was stronger, in 2.5% of the subjects both hands were equal, and in 73.5% of the subjects the dominant hand was stronger. In both left-handed and right-handed subjects dominant hand was stronger (8.0% versus 8.5%, respectively, p=0.750). The mean strength ratio between the dominant and non-dominant hand was 1.07±0.12 for males and 1.09±0.13 for females.

Table 2. Demographic and physical characteristics and hand dominance in the study group.

Variables	Male (n: 712)	Female (n: 647)	Total (n: 1359)
Age (years±SD)	41.8±15.9	46.9±16.1	44.2±16.2
Weight (kg±SD)	80.8±12.9	73.0±14.6	77.1±14.3
Height (cm±SD)	173.1±6.9	160.5±6.5	167.1±9.2
BMI (kg/m2±SD)	27.0±4.3	28.4±5.9	27.6±5.2
Right dominant (n, %)	674 (94.7%)	618 (95.5%)	1292 (95.1%)
Left dominant (n, %)	38 (5.3%)	29 (4.5%)	67 (4.7%)

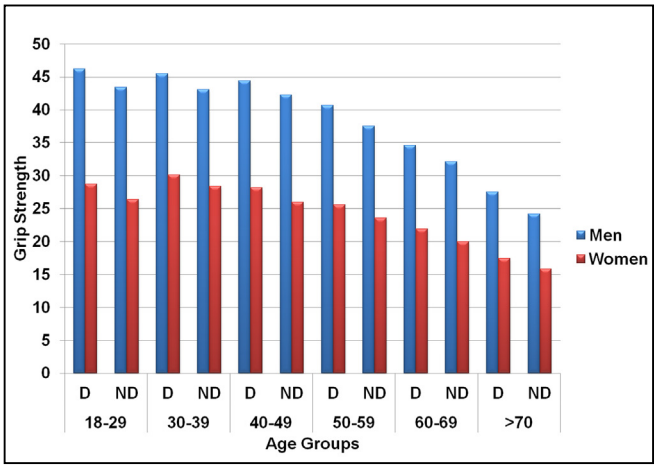

Figure 2. HGS according to age, gender, and dominance.

Discussion

This study was conducted to identify the normal values of HGS in a Turkish population and to create a reference scale and to understand the impact of the dominant hand on HGS. The reference intervals which were formed at the end of the study can be used for other studies of Turkish populations. The normative HGS data published by Mathiowetz et al. in 1985 are currently widely accepted as standard reference values and are used internationally in clinical practice and research studies [3]. However, HGS studies held in different countries and ethnic populations have shown

Table 3. Age and gender stratified normative data of grip strength (abbreviations: D: dominant, ND: non-dominant, SD: standard deviation, and CI: confidence interval).

		Male				Female			
Age group (years)	**Hand**	**n**	**Mean±SD**	**95% CI**	**Range**	**n**	**Mean±SD**	**95% CI**	**Range**
18-29	D	177	46.2±8.2	44.9-47.4	23.0-69.0	111	28.7±6.2	27.5-29.9	14.0-58.3
	ND		43.4±8.1	42.2-44.6	22.0-67.3		26.4±5.8	25.3-27.5	12.0-51.0
30-39	D	186	45.5±8.4	44.3-46.7	23.3-65.6	108	30.1±5.4	29.0-31.1	14.0-42.3
	ND		43.1±7.7	42.0-44.2	22.0-63.3		28.4±5.5	27.4-29.5	12.0-42.3
40-49	D	127	44.4±8.3	42.9-45.8	16.3-65.6	132	28.2±5.7	27.2-29.2	17.0-59.0
	ND		42.3±8.0	40.9-43.7	23.3-62.6		26.0±5.2	25.1-26.9	16.3-47.6
50-59	D	108	40.7±9.0	39.0-42.4	20.3-65.0	135	25.6±5.2	24.7-26.5	15.3-40.6
	ND		37.5±7.6	36.1-39.0	20.0-59.0		23.6±5.4	22.7-24.6	13.6-45.3
60-69	D	66	34.6±6.9	32.9-36.3	20.0-52.3	105	21.9±4.5	21.1-22.8	12.0-35.6
	ND		32.1±6.9	30.4-33.8	16.3-50.6		20.0±4.1	19.2-20.8	10.0-28.6
>70	D	48	27.5±9.1	24.8-30.2	12.3-53.6	56	17.4±5.1	16.0-18.8	8.3-29.0
	ND		24.2±7.6	22.0-26.5	10.3-41.0		15.8±5.4	14.4-17.3	7.0-30.6
Total	D	712	42.5±9.8	41.8-43.2	12.3-69.0	647	26.1±6.6	25.6-26.6	8.3-59.0
	ND		39.9±9.5	39.2-40.6	10.3-67.3		24.1±6.4	23.6-24.6	7.0-51.0

significant variations among populations, and the international application of this normative data may be misleading. Kamarul et al. compared the American HGS data with an Asian population (Malaysia) and concluded that the data of Western populations cannot be applied to a comparable Malaysian population [20].

To date there have been studies to create reference values in various countries and races (Table 1) and those reference intervals have been seen to vary in different countries. Generally higher values have been found in European studies when compared to Asian studies. These variations strengthen the need for this current study. European countries have been shown to have higher HGS values than Asian countries [2,3, 11-37]. It can also be considered that there will be variations in countries of large geographical area, such as Turkey. Therefore, each surgeon should use their own normative HGS data for the assessments of the population on which they practice. From this point of view, this study can be considered to meet an important requirement for surgeons in Turkey by providing normative data for HGS.

The results of this study have shown that HGS shows significant differences between age groups and gender. In both genders, as the age increased, HGS decreased significantly. It is well known that aging has several deleterious effects on the musculoskeletal system such as a decrease in muscle mass and strength, so this was an anticipated finding which is consistent with the relevant literature [40]. In all age groups, HGS was significantly lower in females. Although the exact reason why males are stronger than females of comparable size is not clear, some authors have suggested that it is due to the effect of anthropometric characteristics, greater muscle bulk, and a difference in neurophysiologic functions [41]. These characteristics do not seem to vary between different populations, suggesting a culture-independent age- and gender-related distribution of hand strength.

Contradictory findings have been reported regarding the relationship between HGS and dominance in current literature. According to some authors, the

dominant hand is approximately 10% stronger than the non-dominant side. This is also called the '10% rule.' However, other authors have claimed that there is no significant difference in the HGS measurements between body sides, and they have advocated using the direct measurement of the contralateral HGS as a reference [4-6]. Incel et al. found that the HSG value of the right hand was 8.2 % stronger than the left hand in right-handed individuals and the HSG value of the left hand was 3.2 % stronger than the right hand in those who were left-handed. They claimed that the difference between the dominant and non-dominant hand in left-handed subjects was less than in right-handed subjects [7]. They suggested that left-handed subjects use their non-dominant right hands much more frequently, because many daily activities and equipment are designed for right-handed people [7]. It is difficult to make definitive interpretations of the effect of hand dominance on daily activities. In both left- and right-handed subjects, the dominant hand was found to be stronger, which is consistent with previous reports in literature.

There were several strengths and limitations of this study. Although the study population was one of the largest in current literature of grip strength evaluation, as all the participants lived in the same city, it may not reflect the whole country. A strong aspect of the study is that the data collection can be considered reliable as strict inclusion criteria were followed and all measurements were performed by the same investigator. There may be other factors which may affect grip strength such as body mass index, occupation, nutritional status, and sports participation, but these factors were not evaluated in this study. The small number of left-hand dominant subjects (n=67), which resulted in skewed distribution of data, could also be considered a limitation.

In conclusion, this study is the first and largest study to present normative values of HGS in a Turkish population in current literature. The findings can be used as a reference for future studies in a Turkish population. HGS was seen to be higher in males and to decrease proportionally with age. The dominant hand was determined to be on average 8% stronger than the non-dominant hand in both genders and all age groups.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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