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Different reference values for hand dynamometry: a conflicting issue

Diferentes valores de referencia para dinamómetro de mano: una cuestión conflictiva

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RESUMEN

Objetivo: Identificar valores de normalidad de la dinamometría manual a nivel internacional que pudieran servir como referencia en población adulta joven sana de Colombia.

Métodos: Estudio observacional prospectivo y comparativo realizado con 294 estudiantes universitarios evaluados en una clínica de consulta externa de la Universidad. Se les midió dinamometría manual, peso, estatura y porcentaje de grasa corporal, éste ultimo mediante la medición de 4 pliegues de grasa subuctuánea.

Resultados: Como se esperaba, se encontró que el promedio de la fuerza manual máxima obtenida de tres mediciones dinamométricas fue mayor en los hombres que en la mujeres. Estos valores promedio fueron muy diferentes cuando se compararon con los de tres poblaciones de la misma edad obtenidos en otros países. Al categorizar a los sujetos según su fuerza manual mediante dinamometría, los porcentajes de anormalidad variaron considerablemente. Cuando se usó un cuarto conjunto de valores que tenían promedios más bajos que los tres anteriores, los resultados tampoco fueron comparables con los de la población del presente estudio. Más aún, los resultados no cambiaron luego de realizar ajustes por el índice de masa corporal y el porcentaje total de grasa.

Conclusiones: Los valores que podrían haber servido como referencia no son válidos para determinar la proporción de personas con fuerza muscular alterada medida mediante dinamometría manual en una población de jóvenes colombianos.

Como la utilidad de las mediciones de dinamometría se basa en valores de referencia establecidos que sean confiables, se debe tener precaución cuando se usen como referencia datos de otros países en diagnósticos relacionados con la fuerza muscular de la mano, ya que existen diferencias significativas a nivel global.

Relevancia Clínica: La dinamometría manual es una herramienta muy útil para varios profesionales relacionados con la salud y el deporte. Sin embargo, es necesario contar con valores de referencia confiables con el fin de evitar diagnósticos errados. Es asi como se hace necesario necesario tener valores de referencia obtenidos de una población similar a la que se evaluará con los datos recolectados para favorecer un diagnóstico preciso en la evaluación clínica de los pacientes.

Adicionalmente, al construir tablas de referencia para dinamometría manual se debe tener en cuenta la dominancia de los sujetos evaluados ya que varias tablas construidas a partir de otras poblaciones no la reportan y éste puede ser un factor adicional de error.

Una situación similar a la descrita en este estudio puede ocurrir en poblaciones de otros países y los investigadores deberían asegurarse de que los valores de referencia que usan sean compatibles con su población.

PALABRAS CLAVES

Colombia, estudiantes dinamómetro, fuerza de la mano, valores de referencia.

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ABSTRACT

Objective: To identify international normative data sets of handgrip strength (HGS) to be used as reference values in Colombian young and healthy adults.

Methods: A prospective and comparative observational study with 294 university students evaluated in an outpatient clinic at the University. Manual dynamometry, weight, height and percentage of body fat were measured. The latter was obtained by measuring 4 skin folds.

Results: As expected, it was found that the average maximum manual force obtained from three dynamometric measurements was higher in men than in women. These mean values were very different when compared to those of three populations of the same age obtained in other countries. When classifying subjects with alterations according to their hand strength by dynamometry, the abnormality rates varied considerably. After using a fourth set of values with lower averages than the previous ones, the results were not comparable with those of the population of the present study. The results did not change after adjusting for body mass index and total fat percentage.

Conclusions: The values that could have served as reference are not valid to determine the proportion of people with altered hand strength measured by dynamometry in a population of young adults from Colombia.

As the usefulness of dynamometry measurements relies upon established and reliable reference values, caution should be taken when using normative data sets from other countries for diagnoses related to hand strength, because global differences can occur.

Clinical Relevance: Manual dynamometry is a very useful tool for several professionals related to health and sports. However, it is necessary to have reliable reference values in order to avoid misdiagnosis. For this reason, it is important to have reference values obtained from a population similar to that which will be evaluated, in order to make an accurate diagnosis during the clinical evaluation of patients.

In addition, when constructing a set of reference values for manual dynamometry, the dominance of the evaluated subjects must be taken into account, since several sets of reference values from other populations do not report it, and this may be an additional factor for errors.

A situation similar to that described in this study may occur in populations in other countries and researchers should ensure that the reference values they use are compatible with their population.

KEYWORDS

Colombia, students, dynamometry, hand strength, reference values.

ABBREVIATIONS

HGS: Hand grip strength.

BMI: Body Mass Index.

ASHT: American Society of Hand Therapists.

WHO: World Health Organization.

INTRODUCTION

Hand grip strength (HGS) is used to evaluate post-acute and long-term care patients by many professionals such as geriatricians, hand therapists, physicians, hand surgeons, occupational therapists, physical trainers, sport doctors, physiatrist and nutritionists. The technique has a low cost, is easy, fast and produces reliable results. It has been shown that this technique is sensitive and specific to predict effects in a significant variety of diseases associated with malnutrition clinical conditions[1,2]. The HGS is correlated with the proportion of protein loss, and shows changes much earlier before the deprivation or in response to nutritional support when compared with other indicators of body composition[3]. In the hospital setting this evidence has given value to the determination of nutritional status by HGS.

When interpreting test results from a patient, it is necessary to have reference values to compare and produce a reliable diagnosis. These reference values should be produced with a good sample size for each group of age, sex and dominance, representing the heterogeneity of the population, using the same dynamometer, and taking into account the time of the day when the data were collected.

Studies show differences between data reported by different countries. Because of this, countries like Brazil[4], Nigeria[5], Spain[6], Germany[7], Greece[8], Switzerland[9], Australia[10], United States[11], Malaysia[12], England[13], Canada[14], Finland, New Zealand, Sweden and Zimbabwe, among others, have their own reference values and have no difficulty in interpreting results. In Colombia these data do not exist. This leads to conflict when establishing a diagnosis. Therefore, the aim of this study was to exam different international normative data sets of HGS in order to identify if one of them could be used as reference values in Colombian adults.

MATERIALS AND METHODS

Design

This was an observational comparative and prospective study conducted with university students. The methods were approved by the Bioethics Committee of this University and all volunteers signed a consent form. University of Caldas supported the study but it did not have involvement in study design, data collection and analysis, writing the report or decision to submit the article for publication.

Subjects

The study included 294 college students. The purpose and procedures of the study were explained to the volunteers. To be included in the study, the individual must be a student of the University of Caldas, be between 20 and 40 years of age and have no apparent disease.

Anthropometric Measures

Measurements were performed in one session early in the morning to minimize environmental and biological variations. Participants were asked to evacuate their bladder 30 minutes before the test and wear a hospital gown during test. All equipments were previously calibrated, as recommended by each manufacturer.

Anthropometric measurements were made by the same trained person using standard procedures[15]. Weight was measured to the nearest 0.1 kg on an electronic scale PP2000 (Icob-Detecto, A&D Co, Japan). Height was measured to the nearest 1 mm using a wall mounted stadiometer Heightronic-235 (Seca, Hamburg, Germany). Weight and height were measured twice, and a third measurement was taken if the difference between the two measures were greater than 0.1 kg or 5 mm, respectively.

Students were evaluated for nutritional status determination by calculating the Body Mass Index (BMI = weight in kg / height in m2) and % BF by skinfolds[16].

Measurement of Hand grip strength (HGS)

HGS was measured following the guidelines of the American Society of Hand Therapists (ASHT)[17] using a Baseline® digital dynamometer. The subjects were seated with their elbow by their side and flexed to right angle and a neutral wrist position with de dynamometer in handle position II. Each participant made three trials of grip with their dominant hand. The dominance was registered and the maximum of three values was used for calculations. For left hand dominance subjects, who were few, the reference values of the left hand were used.

International Reference data set of HGS values used

The reference values used for comparison were those of Mathiowitz[18] (Americans), Kamarul[12] (Malaysians), Bohannon et al[19] (Americans, Europeans, and Canadians) and Klidjian[20] (British) under the criteria that they had categorized subjects for five-year periods When reference values were expressed in pounds, they were converted into kgf.

Data Analysis

Quantitative variables were expressed as mean value and standard deviation, differentiated by sex, age and hand dominance. For comparison of the percentage of students with normal grip strength, the average minus one standard deviation was determined as the lower limit for Mathiowitz,[18] Bohannon et al[19] and Kamarul[12] reference values. In the case of Klidjian[20] the lower limit for normality was 85% of the reference value for each age group and sex.

Test for normality of the study variables was performed using the Kolmogorov-Smirnov statistic with *p*-value of 0.05. For comparison with Klidjian[20] pattern, it was assumed a normal distribution with the idea of using the median as representative of the mean of the distribution.

The reference values for BMI were those by World Health Organization (WHO). Normal %BF was considered up to 30% for females and up to 20% for males[21].

RESULTS

Two hundred and ninety four participants were analyzed: 151 (51, 4%) females and 143 (48, 6%) males. Ninety five percent of females and ninety four percent of males were right handed. Subjects´ characteristics are shown in Table 1. The maximum value of HGS resulted normally distributed in men but not in women. The percentage difference between HGS mean values and the reference values by sex, age and hand dominance were significantly different for all reference data set with a value of $p = 0.000$ with the Wilcoxon test.

Due to the existence of different reference values it was decided to compare the results of abnormality obtained with each of them, which are presented in Table 2.

Table 1. Mean, standard deviation and frequencies of subjects´ characteristics.

Variables	Females (n=151)		Males (n=143)	
	Mean	SD	Mean	SD
Age (years)	22,7	2,6	23,9	3,5
Weight (kg)	55,7	7,8	65,3	8,9
Stature (cm)	156,7	6,3	169,6	7,3
BMI (kg/m2)	22,7	2,9	22,7	2,6
Maximum HGS (kg)	24,6	5,1	38,3	6,6
% Body fat	32,6	4,0	19,2	4,3
	Frequency		Frequency	
BMI 18,5 to 24,9	75,5%		79,7%	
BMI > 24,9	21,9%		18,2%	
Excess body fat	74,8%		41,3%	

Table 2. Percentage of HGS abnormalities by sex and age based on reference values minus one standard deviation for Mathiowitz (1985), Bohannon (2008) Kamarul (2006) and 85% of the median of Klidjian (1980).

Age (years)	n		Mathiowitz (1985)		Bohannon (2008)		Kamarul (2006)		Klidjian (1980)	
	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males
20-24	120	98	60,8%	83,7%	70,0%	83,7%	3,3%	1,0%	40,0%	90,8%
25-29	29	35	75,9%	85,7%	89,7%	85,7%	0,0%	0,0%	34,5%	88,6%
30-34	2	7	50,0%	100,0%	100,0%	100,0%	0,0%	0,0%	50,0%	100,0%
35-39	0	3	—-	66,7%	—-	66,7%	—-	0,0%	—-	66,7%

Table 3 shows the percentage difference between the mean of the maximum HGS values and the chosen reference values. Because there were 21.9 % of females and 18.2% with BMI higher than normal it was decided to perform the same analysis only to those with a normal BMI and then only with those with normal BF % and calculate the percentage difference between them.

Figure 1 illustrates the difference HGS mean values for subjects aged 20 to 39 and the different reference values.

DISCUSSION

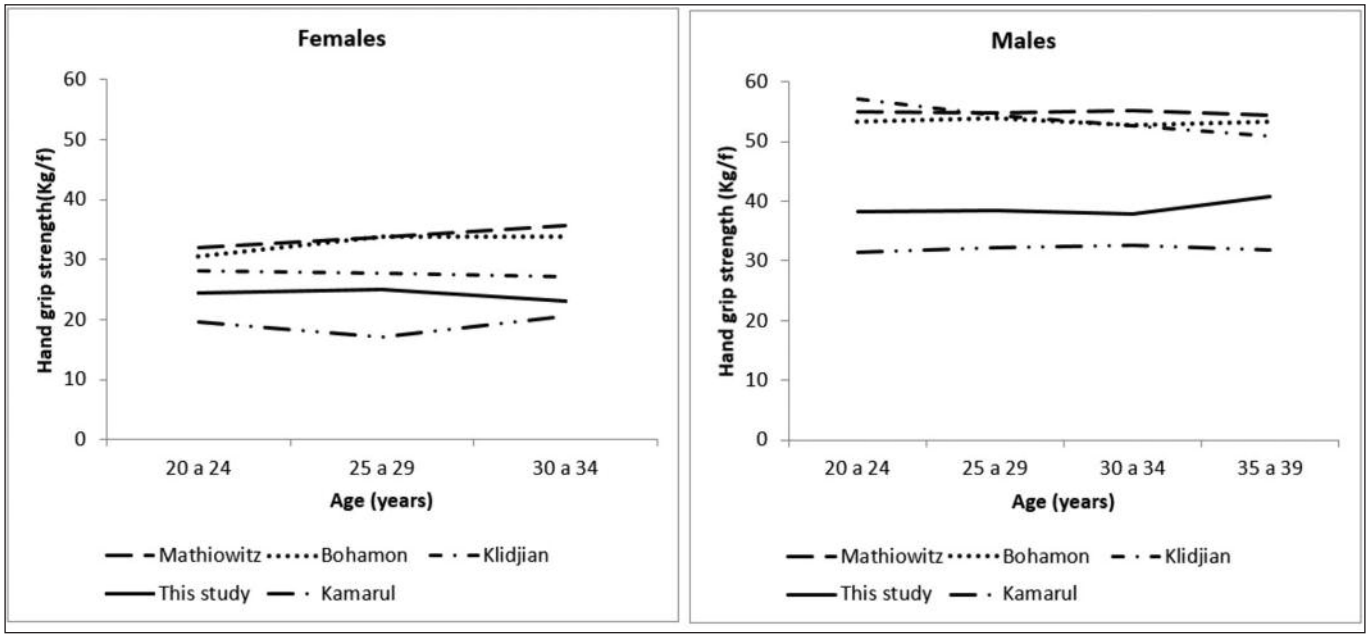
HGS is an important parameter to assess outcome and risk of morbidity and mortality[22]. However, normative data are needed to interpret HGS results. This study compares the results of a Colombian sample with international grip strength norms. HGS mean values of university students in Colombia are significantly different from international published data sets. In general terms, the HGS values of this specific population were higher than those from Malaysians[12], and lower

Table 3. A. Percent difference between the mean of the maximum value of HGS obtained in this study and several reference values by sex and dominance. **B**. Percent difference between the mean of the maximum value of HGS only for who had normal BMI in this study and several reference values by sex and dominance. **C**. Percent difference between the mean of the maximum value of HGS only for who had had normal percent body fat and different reference values by sex and dominance.

Sex and hand dominance	n	Age years	HGS Kg/f		A (References)					B (References)					C (References)			
			Mean	SD	(18)	(28)	(12)	(20)		(18)	(28)	(12)	(20)		(18)	(28)	(12)	(20)
					%	%	%	%	n	%	%	%	%	n	%	%	%	%
Right handed females	113	20-24	24,6	5	29,7 *	24,4 *	-20,3 *	14,3 *	86	33,5 *	28,0*	-18,0*	17,7*	29	26,1*	20,9*	-22,5*	11,1*
	29	25-29	25,1	5	34,7 *	34,7 *	-31,9 *	10,2 *	20	33,1 *	33,1 *	-32,7*	8,9	7	26,6*	26,6*	-36,0*	3,6
	2	30-34	23,0	7	55,2 *	47,0	-10,9	18,3	2	55,2	47,0	-10,9	18,3	1	98,3	87,8	13,9	51,2
Left handed females	7	20-24	23,4	4	18,4 *	19,2 *	-24,4 *	10,5	6	23,1 *	24,0 *	-21,3*	14,9	1	31,9	32,9	-15,7	23,1
Right handed males	93	20-24	37,9	7	44,9 *	40,6 *	-17,2 *	50,8 *	81	46,8 *	42,5*	-16,0*	52,8*	64	45,6*	41,4*	-16,7*	51,6*
	32	25-29	38,3	7	43,1*	40,7 *	-15,9 *	42,1	21	44,6 *	42,2*	-15,0*	43,6*	14	36,0*	33,7*	-20,1*	35,1*
	7	30-34	37,9	5	45,6 *	39,3 *	-13,7 *	38,8 *	2	31,4 *	25,7*	-22,1	25,3*	2	31,4	25,7	-22,1	25,3
	3	35-39	40,7	7	33,4	31,0	-21,9	24,8	2	23,4	21,1	-27,7	15,5	0	—	—	—	—
Left handed males	5	20-24	44,0	8	7,7	7,7	-35,0 *	19,6	5	7,7	7,7	-35,0*	19,6	2	4,2	4,2	-37,1	15,6
	3	25-29	38,7	1	29,5 *	29,2 *	-22,2 *	31,3 *	3	29,5 *	29,2*	-22,2*	31,3*	2	31,8	31,6	-20,8	33,7

(* $p < 0.05$).

Figure 1. HGS mean values for females and males aged 20 to 39 according to this study and four different reference values.



than those from Americans[18], Americans, Europeans, and Canadians[19] and British[20] reference values. For females, the HGS values were closer to those of British data2[20] Values for males were closer to those of Malaysians[12].

By classifying individuals as normal or abnormal according to different reference values, significant differences in relation to gender, age, and dominance were found. These discrepancies may be due to the distinctive demographic populations from which the samples were obtained[23]. Other factors may also contribute to the results. For example, since the reference data of publications used for this study were obtained at different years Klidjian 1980[20], Mathiowitz 1985[18], Bohannon et al 2006[19] and Kamarul 2006[12] it could be thought that, due to new technologies, occupations today require less effort and reduced muscle training[24].

A strength of this study is that it took into account normal body composition of the subjects. A literature review showed no studies reporting both; the reference values of HGS and the BF % of individuals. Body composition can affect HGS and produce biased results[25]. The population of the present study demonstrated to have higher BMI and lower grip strength than much of the international published data. The number of students with overweight and obesity by BMI was five times higher (21.9% females and 18.2 % males) than the percentage of students with thinness (3.7%) In addition, as it has been established in previous assessments, the percentage of overweight and obesity varies significantly depending on the indicator used. Authors have shown that BF % is a better predictor of risk of weight-related diseases than BMI[26]. Thus, whereas with BMI, 20.0% of students were classified in this category, the evaluation using high BF % parameter got values up to 45.6%. Hence the BF % probably reflects much better the nutritional status of the studied population. However, a complete exploration of the relationship between BMI and hand grip strength was not fully explored as there were very few participants with BMI in the underweight range.

Using different dynamometers in different studies may lead to differences when comparing results and there were 3 types o dynamometers used in the reported studies here[27,28].

Another issue is that the reference values of the studies used for this comparison did not take into account the hand dominance. It is reported that in right handed subjects, HGS is stronger in the 89.1% of subjects in the right hand, but not so for left handed who only had stronger HGS in left hand in 66.7 % of the cases[29]. In various studies, no more than 12% of people with left dominance are reported[30].

The high percentage of people with decreased muscle strength could be explained by the fact that muscle strength is not only altered by disorders of macronutrients (proteins, lipids and carbohydrates) but also deficits in some micro nutrients such as calcium, iron, zinc, magnesium, vitamin C and D, among others[31,32], which would indicate a poor dietary habits. Given this uncertainty, studies supported by a statistical analysis of the variables and objective measures of nutritional status, serum micronutrient levels and BF % are required to determine which are the most frequent deficiencies and their relation to poor HGS.

Finally, the measurement of grip strength is a quick and easy assessment tool. If a standard protocol is followed, it could be measured with a reasonable reliability and validity.

In addition, the method has several features that make it a good candidate for a screening test and could be an input to the routine evaluation of patients in medical practice as well as measuring blood pressure, weight or height: it could be used in population studies because of its low cost and because does not affect the beliefs and cultural aspects of people. Instruments used to measure grip strength, although many and varied, are readily available and easy to use. Further, dynamometry can be used by different health professionals and requires little training. It also has the ability to detect anomalies in nutritional status and be predictor of complications before clinical evidence.

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