Clinical Nutrition ESPEN xxx (2017) e1–e5

Contents lists available at ScienceDirect

Clinical Nutrition ESPEN

journal homepage: http://www.clinicalnutritionespen.com

Original article

Handgrip strength: Reference values and its relationship with bioimpedance and anthropometric variables

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ARTICLE INFO

Article history:
Received 8 November 2016
Accepted 20 January 2017

Keywords:
Handgrip strength
Reference values
Mexico

SUMMARY

Background & aims: Handgrip strength by dynamometry is an anthropometric measurement used to estimate muscle function in healthy adults, predict functional limitations, disabilities and survival in older people. Low handgrip strength is considered a better predictor of clinical outcomes than low muscle mass when it is measured in standard conditions and compared with reference populations. It is well known that age, sex and height are the most important factors correlated with handgrip strength. The aim of this study was to establish reference values for handgrip strength in Mexican adults for both genders and identify its relationship with anthropometric factors.
Methods: Cross-sectional study with 902 apparently healthy adults (478 women and 424 men) older than 20 years old from Mexico City. Personal data, dietary information and anthropometry were assessed. Handgrip strength was measured in dominant hand with a Smedley Hand Dynamometer (Stoelting, Wood Dale, UK).
Results: Mexican population presented the maximum strength at 30 years of age decreasing continuously further on ($p < 0.001$). Handgrip is higher in men than in women for all age ranges. The correlation between height and handgrip strength was stronger ($r = 0.757$, $p < 0.001$) compared with the observed correlation between handgrip strength and diet ($r = 0.397$, $p < 0.001$). In contrast, occupation showed no correlation ($r = 0.057$, $p = 0.123$). We present reference values of handgrip strength for each gender and age categories. Also, we proposed tables with the index of handgrip strength adjusted by the squared of height.
Conclusions: Height is the anthropometric factor with higher correlation to handgrip strength. Factors such as nutrition and occupation had a weak correlation with handgrip. Use of these reference values stratified by age and sex will allow us to have an assessing tool to evaluate muscle functionality in Mexican people with characteristics similar to this study.

1. Introduction

Handgrip strength (HGS), used to estimate the total muscular force, measures the ability that hand muscles have to generate tension (force) through a handshake [1].

The relevance of measuring the HGS has increased in recent years, due to its clinical and epidemiological applications as part of the diagnosis of sarcopenia proposed by the European Working Group (EWGSOP) [2], or as nutritional status marker and because of its relationship with morbidity and mortality [3].

Measurements commonly made to determine nutritional status of teenagers, people of medium age and elderly, both healthy and ill, are mainly based on the measurement of weight, height, skin folds and different perimeters, these measurements are characterized because they are simple and low cost. However, it is important to include in the clinical and nutritional evaluation methods that determine the functionality of different organs and

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http://dx.doi.org/10.1016/j.clnesp.2017.01.010
2405-4577/

systems in relation to its nutritional integrity with accessible equipment and easy handling [4].

In clinical area, HGS in the elderly, has been used as a predictor of functional limitations, disabilities and survival [5–10], it is also very useful in orthopedic and surgical management [1,11,12], as an important part of the assessment of the nutritional status in patients with impaired muscular reserve such as those with diabetes mellitus [13], renal failure [14,15], coronary heart disease [16,17], and COPD [6]. In addition, it has been used as a predictor of post-surgical complications [18].

HGS has been associated with different anthropometric factors, it is well-founded that men have 50–70% more strength compared to women at any age, and that the decrease of the same is one of the most important changes occurring in elderly subjects [12,19–22]. Other variables correlated with HGS mainly in Caucasian population were described: height ($r^2 = 0.713$, $p < 0.001$) [23], weight ($r = 0.247$, $p < 0.001$) and arm circumference ($r = 0.375$, $p < 0.001$) [12].

There are several studies [11,12,20], few in Latin-American population [21], that present reference values of HGS, however the techniques to measure HGS and the equipment they use are different.

There are no HGS reference values for Mexican population, that is because the objective of this study is to propose tables with reference values (stratified by gender, age and height) and to determine the association of anthropometric and body composition variables, occupation and diet with HGS.

2. Material and methods

A total of 972 adults from Mexico City were enrolled in the study. All subjects were volunteers, apparently healthy by self-report and born in Mexico. Excluded participants were high performance athletes and pregnant women; also those with any traumatic event in upper extremities or presence of pain while squeezing; hospitalizations in the last six months; positive history of inflammatory or neurologic diseases. This work was supported by General Directorate of Faculty Affairs, Universidad Nacional Autonoma de Mexico (DGAPA, UNAM) and performed in the subway of Mexico City (from February to April 2012), each participant was informed about the purpose of the study and confirmed consent by participating actively.

The survey and the measurements were performed in a consulting room of a station of Metro public transport system, which is a commuting transportation system used by a large percentage of the population living in this City (One billion 410 million 121 thousand 151 users in 2010) therefore, it was considered an adequate place for the sample. The sample size was calculated based on the hypothesis of normality of the HGS variable stratified by age (decades) and gender. It was required to cover the number of people for 5 age ranges, stratified by gender, and pooled into HGS terciles, obtaining a sample size of 750 people.

The questionnaire gathered demographic and dietary information, also anthropometric measurements (weight, height, and forearm circumference), body composition and HGS by dynamometry.

2.1. Anthropometry

Anthropometric measurements were performed according to the reference manual for anthropometric standardization [24]. For weight, all subjects were barefoot, avoiding extra weight from money, wallets, and phones. Forearm circumference was measured at the midpoint of the right arm. Body mass index (BMI) was calculated by dividing the total body weight (kg) by the squared height (m).

2.2. Body composition

Body composition was measured with whole-body bioelectrical impedance using four-pole mono-frequency equipment (50-kHz, Quantum X, RJL System) using the standard technique: the person in supine position with arms separated from trunk by about 30° and legs separated by about 45° free of drafts and portable electric heaters. The area was cleaned with alcohol and the electrodes were placed on the hand and unilateral foot, finally we register the resistance and reactance [25].

To determine the proportions of fat free mass (FFM) and fat mass (FM), validated predictive equations for Mexican population were employed (MLG (kg) $= 0.7374 * (\text{height cm}^2/R) + 0.1763 * (\text{weight}) - 0.1773 * (\text{age}) + 0.1198 * (X_c) - 2.4658$) and the percentages of FFM and FM were recorded [26].

2.3. Handgrip strength

Handgrip strength was measured with a mechanical Smedley Hand Dynamometer (Stoelting, Wood Dale, UK) adjustable to the width of the hand. Subjects were placed standing with arms outstretched parallel to the trunk then took the dynamometer and applied maximum strength with each hand without support. The measurement was repeated three times alternately in dominant hand with separation of 1 min to avoid fatigue. The maximum value was recorded in kg.

2.4. Dietary intake

Diet was assessed using 24 hour recall, total nutrient intake (macronutrient and micronutrient) was analyzed using Food Processor software®, 4747 Skyline Rd Suite 100, Salem, OR 97306 D [27].

2.5. Statistical analysis

The normal distribution for the variables studied was tested by Kolmogorov–Smirnov. For the descriptive analysis, the variables with normal distribution are reported in mean ± Standard Deviation (SD) and those non-normally distributed, as median and interquartile intervals. The categorical variables were presented as absolute and relative frequencies. The χ^2-test was used for comparisons between categorical variables, and for continuous variables the unpaired *t*-test or *U* Mann–Whitney was used as appropriate, according with normal or non-normal distribution. Variations of HGS for each age range and gender were tested by one-way ANOVA with Scheffé post-hoc contrast. Levene test was used to analyze equality of variances.

The distribution of HGS terciles stratified by gender and age ranges was reported. The HGS/height index was calculated. The Pearson's or Spearman's correlation coefficient was calculated to verify the correlations between HGS with demographic and nutrition variables (anthropometric, body composition, diet, occupation and physical activity) according with normal or non-normal distributed values. Finally, a multiple linear regression analysis was performed with the variables that in the bivariate analysis had a value of $p < 0.2$. Data were analyzed using the SPSS program version 21.0.

Please cite this article in press as: Rodríguez-García WD, et al., Handgrip strength: Reference values and its relationship with bioimpedance and anthropometric variables, Clinical Nutrition ESPEN (2017), http://dx.doi.org/10.1016/j.clnesp.2017.01.010