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Original article

Reference equations for handgrip strength: Normative values in young adult and middle-aged subjects

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SUMMARY

Background & aims: Handgrip strength (HS) has been widely used as a functionality parameter of the upper limbs (UL) and general health. The measurement of HS by dynamometry is a low cost, non-invasive method of simple applicability, widely used in pulmonary rehabilitation and in critical care units. However, there are no reports in the literature of reference equations for the Brazilian population involving young and middle-aged adults. The aim of this study was to establish reference equations to predict normal HS for young and middle-aged adults through demographic and anthropometric data.
Methods: This is a cross-sectional study with a sample of 80 healthy subjects (40 men and 40 women), aged 20–60 years. Inclusion criteria were: 1) BMI between 18.5 and 30 kg/m^2; 2) presence of dominant hand; 3) no cardiac, pulmonary, metabolic, or neurologic diseases; 4) lack of musculoskeletal disorders; 5) no history of fractures or trauma of the UL. Anthropometric measurements of the UL were obtained by a tape (hand length and width, forearm circumference and length). The dominance of hands was defined by the Dutch Handedness Questionnaire. HS measures were obtained by a manual hydraulic dynamometer, according to the recommendations of the American Association of Hand Therapists. Data were analyzed with SPSS for Windows, version 17.0, and treated with descriptive and inferential analysis. Normality was evaluated by Kolmogorov–Smirnov. Pearson or Spearman coefficients and multiple regression analysis were also used.
Results: HS was significantly higher for men compared to women, and also higher for the dominant hand (HSD) compared to the non-dominant hand (HSND) ($p < 0.05$). No significant differences were found for HS between the age groups 20–30, 30–40, 40–50 and 50–60 years ($p > 0.05$). No correlation was found between HS and age. A weak correlation was found between HS and BMI. A moderate correlation of HS was observed with weight and height. Finally, moderate and high correlations were found between HS and anthropometric variables of UL. The best reference equations with R^2, adjusted to 0.71 and 0.70, were respectively: $HSD_{kg} = -15.490 + (10.787 \times \text{Gender}_{\text{male}=1;\ \text{female}=0}) + (0.558 \times \text{Forearm circumference}) + (1.763 \times \text{Hand Length})$; $HSND_{kg} = -9.887 + (12.832 \times \text{Gender}_{\text{male}=1;\ \text{female}=0}) + (2.028 \times \text{Hand Length})$.
Conclusion: The variability of HS is largely explained by gender, forearm circumference, and hand length.

Introduction

According to the current definition, sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life, and death [1–3]. Even though sarcopenia is originally known as a condition related to aging, its development may be secondary to catabolic and chronic diseases such as chronic obstructive pulmonary disease [4], heart failure [5], and chronic kidney disease [6], also associated to cancer [7] and present in critically ill patients [8].

For the diagnosis of sarcopenia it is necessary to observe the presence of both low muscle mass and low muscle function (performance or strength) [1,2]. To assess the muscle mass, several techniques can be used, for instance, body images techniques

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(computed tomography, magnetic resonance imaging, dual energy X-ray absorptiometry and ultrasound), bioimpedance analysis and anthropometric measures (mid-upper arm circumference, skin fold thickness and calf circumference) [1,9]. To evaluate the physical performance, a wide range of tests are available, including the Short Physical Performance Battery (SPPB), usual gait speed, 6-min walk test, timed get-up-and-go test (TGUG), and the stair climb power test. Finally, to measure muscle strength there are fewer well-validated techniques that involve the assessment of strength using isokinetic dynamometers and handgrip strength [1].

Among the methods to assess the muscular strength, handgrip strength (HS) measurement has been widely used because it is a simple, fast, inexpensive and efficacious test which uses a portable device [10]. This method correlates closely with measures of muscle strength from other muscle groups, including the lower limbs [11], and is a useful tool to identify mobility limitation [12,13] and physical [14]. Furthermore, handgrip is a marker of nutrition status [15] and better predictor of clinical outcomes than muscle mass [12,16], has a powerful predictor of cause-specific and total mortality, and may help identify patients at increased risk of health deterioration [10,17–19].

HS is generally influenced by a person's level of physical activity, type of occupation, hand dominance and anthropometric characteristics such as forearm circumference, body height and weight [15,20,21]. Since demographic factors and ethnicity also affect HS, several studies have reported normative data of HS from different populations, especially from high-income countries and European ethnicity [22–26]. To the Brazilian population, some studies have been published defining normal values for age ranges in adults and the elderly [27,28]. Only one study proposes reference equation for individuals older than 50 years [29]. Therefore, the aim of this study was to establish reference equations to predict normal HS for young and middle-aged adults of the Brazilian population through demographic and anthropometric data.

Methods

Subjects

This study had a cross-sectional design and included healthy subjects in a convenience sample, aged 20–60 years. They were recruited among students and employees of a private and tertiary hospital in São Paulo (Brazil), as well as their relatives. Data were collected from February 2013 to December 2013. Inclusion criteria were as follows: 1) BMI between 18.5 and 30 kg/m [2]; 2) presence of hand dominance; 3) absence of cardiac, pulmonary, metabolic or neurological disease; 4) absence of chronic renal failure, musculoskeletal disorders or early postoperative period (<30 days for medium-sized surgeries and <60 days for large ones); and 5) absence of fracture history or trauma of the upper limbs. The exclusion criteria were: 1) presence of pain at the time of evaluation; and 2) inability to understand or perform any procedure during the protocol. This study was approved by the Ethics Committee on Research of the *Hospital Sírio-Libanês* (HSL2013/05), and written informed consent was given by all participants.

Demographic and anthropometric evaluation

After the inform consent was obtained, we applied a questionnaire in order to investigate and obtain additional information, including age, type of work and occupation, sports activities, health status, medication, previous surgeries, smoking habits, symptoms of pain or tingling in the upper limbs, reporting of range of motion limitation in the upper limbs, history of fractures or injuries, and whether subjects were engaged in any medical treatment that would involve prescription medication, over-the-counter drugs or allied health support.

Anthropometric data of all individuals were collected. Body weight (expressed in kg) was measured using a digital balance (Toledo®, Model 2096PP/2, Inc., Brazil) with the subjects wearing light clothes and no shoes. Height (expressed in meters) was measured twice for each subject using the stadiometer of the same balance. In addition, we calculated the body mass index (BMI) by means of the ratio between the weight and the square of height (kg/m^2). Subjects were classified as underweight (BMI < 18.5 kg/m^2), normal (18.5 kg/m^2 < BMI < 25 kg/m^2) or overweight (BMI $\geq$ 25 kg/m^2). The study also included anthropometric measurements of the hand width (measured at the level of the distal palmar crease); hand length (measured from the distal wrist crease to the tip of the longest finger); forearm length (distance between lateral humeral epicondyle and radial styloid process); and the forearm circumference (measured at the midpoint of forearm length) [22]. All measurements were performed using the same tape.

Habitual physical activity

The habitual physical activity (HFA) score was quantified by applying a cross-culturally adapted and validated version for use in Brazil [30] of the Baecke's questionnaire [31]. This instrument consists of 16 questions that cover three HPA scores for the last 12 months: 1) score of occupational physical activity (OPA) with eight questions; 2) score of physical exercise in leisure (PEL) with four questions; and 3) score of leisure and locomotion activities (LLA) with four questions. The answers are scored on a scale of 0–5 points and the final result is expressed in a summary index.

Handedness evaluation

The handedness of the participants was defined by the Dutch Handedness Questionnaire. This is a self-assessment questionnaire consisting of 16 items of manual activities. The subjects should report which hand is usually used for each activity or whether both hands are used. If the subject does not have a clear preference, the use of both hands should be indicated. Each item may be coded from 0 to 2, with “left” receiving a score of 0, “right” receiving a score of 2, and “both” receiving a score of 1. The total score could range from 0 (i.e. extremely left-handed) to 32 (i.e. extremely right-handed). Therefore, the subjects were classified as: 1) strongly left-handed subjects (score $\leq$ 4); 2) ambidextrous (5 $\leq$ score $\leq$ 27); and 3) strongly right-handed subjects (score $\geq$ 28) [32].

Handgrip dynamometry

HS was measured in both sides (dominant and non-dominant) by means of a manual hydraulic dynamometer (SH 5001; SAEHAN corporation; Masan; Yangdeok-Dong; South Korea), according to the recommendations of the American Association of Hand Therapists [33]. Thus, the subjects were asked to remain seated in a chair with their shoulders in a neutral position, one hand resting on the thigh and the elbow of the member to be evaluated flexed at 90° with the forearm in neutral rotation [34], and wrists between 0° and 30° of flexion and between 0° and 15° of ulnar deviation [35]. For all subjects, the movable handle of the dynamometer was individually adjusted according to the size of the hands so that the handle was positioned under the second phalanges of the index, middle and ring fingers [36,37]. The subjects were instructed to grip the dynamometer with maximum strength in response to a standardized voice command [38], and to hold the grip for three seconds. The measurements for the dominant and the non-dominant handgrip strength were done in a random order,