

# Normative data for hand grip strength in healthy children measured with a bulb dynamometer: a cross-sectional study

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## Abstract

**Objective** To present the normative hand grip strength values measured with a bulb dynamometer for children, by gender and age, and to correlate the findings with weight, height, body composition and handedness.

**Design** Cross-sectional study.

**Participants** Data from 295 healthy children of both genders aged 6 to 13 years were analysed.

**Methods** Weight, height, body composition (Biodynamics model 450 bioimpedance analyser), handedness (Edinburgh scale) and grip strength measured with a bulb dynamometer (North Coast) were obtained.

**Results** Grip strength of both hands increased with age in the two genders. Grip strength was similar in boys and girls between 6 and 13 years of age. The dominant hand was stronger than the non-dominant hand [mean (standard deviation) 7.0 (2.3) psi vs 6.5 (2.1) psi], with a mean difference of 0.52 psi (95% confidence interval of the difference 0.46 to 0.58). Grip strength was positively correlated with fat-free mass and height ( $r \geq 0.75$ ).

**Conclusion** This study provides normative values for hand grip strength measured with a bulb dynamometer in children aged 6 to 13 years. This dynamometer provides a simple method to measure grip strength, and the results of this study provide further evidence of its performance in the measurement of grip strength.

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**Keywords:** Adolescents; Children; Dynamometer; Grip strength

## Introduction

In clinical practice, health professionals are faced with a variety of conditions that compromise upper limb strength [1–3]. In this respect, the measurement of hand grip strength contributes to the detection of deficits, therapeutic management and evaluation of treatment outcomes. The Jamar and hand-held dynamometers are the most widely used instruments to measure muscle strength in children [4]. Other devices used for the quantitative analysis of grip strength

include isokinetic [5], electrical [6–8], digital (Takei Ltd.) [9–11] and electronic (Grippit) dynamometers (AB Detektor, Göteborg, Sweden) [12,13].

The Jamar (Lafayette Instrument, Lafayette, United States) dynamometer has been recommended by the American Society of Hand Therapists, and has been adopted in many studies as an excellent instrument for the measurement of hand grip strength [14–17]. This dynamometer permits adjustment of the handle in five different positions, including acquisition of maximum isometric grip strength. However, the Jamar dynamometer showed low validity in the detection of weakness in early stages of myopathic disorders [4]. According to Massy-Westropp *et al.* [18], low grip strength values can be detected with the Grippit dynamometer but not with the Jamar dynamometer. However, differences in the

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instruments used, the type of handle and hand size impair the comparison of data generated in clinical studies [15].

Electrical dynamometers provide recordings of strength as a function of time that are easy to interpret and can be stored [6]. However, the cost of these instruments is high and transportation is difficult. The Grippit dynamometer has been shown to be a reliable instrument for the measurement of hand grip strength in children [13]. Molenaar *et al.* [7] compared the reliability of a Jamar-like dynamometer (Lode BV, Groningen, The Netherlands) and the Martin Vigorimeter (Elmed, Addison, United States) (bulb design) for the measurement of grip strength in children. As expected, smaller children needed a wider grip to use the Jamar-like dynamometer. However, both instruments showed good to excellent reliability, but the intraclass correlation coefficients indicated better results for the Jamar-like dynamometer.

Factors that influence force generation are handle [19], age, gender, height, weight, body composition, hand anthropometric measures and handedness [2,9,12,20]. The bulb dynamometer is smaller and lighter than instruments frequently cited in the literature; a fact facilitating the recording of isometric strength and its use by children. Link *et al.* [21] established normative data for hand grip strength in children aged 3 to 6 years using a Martin Vigorimeter, which is similar to a bulb dynamometer. Therefore, more complete reference data of hand grip strength in healthy children measured with the bulb dynamometer are necessary to permit the use of this instrument in clinical practice.

As marked differences in strength are observed between genders at the onset of puberty, the aim of the present study was to present normative hand grip strength values measured with a bulb dynamometer for children, by gender and age, and to correlate the findings with weight, height, body composition and handedness.

## Methods

### Participants

In total, 313 healthy children and adolescents from public schools, ranging in age from 6 to 13 years, participated in the study. The participants were divided by age as shown in Table 1. Exclusion criteria were: confirmed history of

neurological, orthopaedic and metabolic diseases; hand injuries or previous hand surgery; complaints of weakness or pain; and continuous use of medications during the 6 months preceding the study. Eighteen children were excluded and the final sample consisted of 295 participants. The schools were selected after authorisation by the Regional Board of Education of Ribeirao Preto, Brazil. The parents or legal guardians of the children/adolescents agreed to their participation by signing an informed consent form. The study was approved by the Ethics Committee of HCFMRP-USP (Ref. No. 6990/2007).

### Instrument and test procedure

Personal data of the participants were collected from the parents/legal guardians using a questionnaire, including issues that could interfere with grip strength (e.g. use of drugs, trauma). Handedness was evaluated using the Edinburgh scale and was confirmed by the parent/legal guardian. Weight, height, body composition, handedness and grip strength were measured at school. Body composition was determined with a tetrapolar electrical bioimpedance device Biodynamics 450 (Biodynamics, Shoreline, United States) according to the manufacturer's instructions.

A North Coast bulb dynamometer (NC 70154)-North Coast, California, United States was used for grip strength tests. This bulb dynamometer is composed of soft rubber, has a circumference of 13 cm, and was calibrated every 6 months. Different bulb sizes are not available. The dynamometer was calibrated by positioning the red pointer at the zero mark before each trial.

The test was performed in the standardised position recommended by the American Society of Hand Therapists [22] (i.e. sitting in a straight-backed chair with feet supported on the floor, shoulder in adduction and neutral rotation, elbow flexed at 90°, forearm in neutral position, and wrist between 0° and 30° of extension and between 0° and 15° of ulnar deviation). The participants were verbally encouraged to use maximal grip strength using the word 'strength' four times: 'strength, strength, strength, strength'. The dynamometer was supported slightly by the examiner to prevent any accidental falls. Three measurements were obtained, alternating between dominant and non-dominant hands. All tests were performed by the same examiner.

### Statistical analysis

The sample size was calculated in accordance with Royston [23]. Exploratory analysis of the data was performed using the PROC MEANS procedure from SAS Version 9.2. A linear regression model with mixed (random and fixed) effects was used to compare grip strength between dominant and non-dominant hands, and to determine differences in dominant and non-dominant grip strength between genders and ages. The association of grip strength with weight, height, body mass index, fat-free mass and fat mass was

Table 1  
Number of participants by gender and age.

Age (years)	Boys	Girls	Total
6	15	11	26
7	21	16	37
8	15	21	36
9	21	28	49
10	17	23	40
11	17	23	40
12	18	19	37
13	12	18	30
Total	136	159	295

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