REVIEW

Muscle strength: clinical and prognostic value of hand-grip dynamometry

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Purpose of review

Grip strength measured by dynamometry is well established as an indicator of muscle status, particularly among older adults. This review was undertaken to provide a synopsis of recent literature addressing the clinical and prognostic value of hand-grip dynamometry.

Recent findings

Numerous large-scale normative grip strength projects have been published lately. Other recent studies have reinforced the concurrent relationship of grip strength with measures of nutritional status or muscle mass and measures of function and health status. Studies published in the past few years have confirmed the value of grip strength as a predictor of mortality, hospital length of stay, and physical functioning.

Summary

As a whole, the recent literature supports the use of hand-grip dynamometry as a fundamental element of the physical examination of patients, particularly if they are older adults.

Keywords

body composition, dynamometry, muscle, physical function

INTRODUCTION

Muscle strength refers herein to the maximal voluntary force or torque of short duration that skeletal muscles can bring to bear on the environment. Although the respiratory [1] and pelvic floor [2] muscles and the muscles of the trunk [3] can bring force to bear on the environment, it is the limb muscles whose strength is most often of interest. Of the many limb muscles, those generating grip force are measured most commonly. The frequent measurement of grip strength is likely based on several factors. First, grip strength is the simplest and least complicated of a plethora of instrumented muscle strength measures; this is true even though procedures used to measure it are not fully standardized [4]. Second, there is some, albeit inconsistent, evidence that grip strength tends to reflect overall muscle strength [5]. Beyond these factors, grip strength has clinical and prognostic value. These values are the focus of this review.

CLINICAL VALUE OF GRIP STRENGTH

Herein, grip strength is considered to have clinical value because of its ability to characterize the current strength of an individual. The clinical value of grip strength is also supported by its association with other concurrent clinical measures of importance.

Characterizing current strength

The current strength of an individual can be interpreted in relation to values obtained from ostensibly normal individuals. These values may be norms for comparable individuals or T-scores derived from healthy young adults.

Numerous studies have purported to provide normative values for grip strength, either for specific strata or on the basis of regression equations including relevant independent variables. In 2006 Bohannon *et al.* [6] used meta-analysis to generate stratified grip strength norms from data obtained from 3317 adults in 12 studies. After the analysis of

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KEY POINTS

- The grip strength of older adults can be interpreted using age and sex stratified norms or T-scores from younger adults.
- Decreased muscle mass and physical function accompany low-grip strength.
- Low-grip strength is predictive of mortality, longer hospital stays, and limited physical function.

subsets of the data, Bohannon *et al.* [7,8] concluded that the consolidation of grip strength data may be justified for adults 20–49 years of age but not for adults greater than 75 years. More recently, numerous studies providing normative grip strength data have been published. Table 1 [9,10▪,11–16] summarizes eight studies involving sample sizes in excess of 2000 participants. The studies originated in the UK or Ireland, Japan, South Africa, the Netherlands, the USA, and China. Most of these studies provide norms for older adults, but two include data for children. The Jamar dynamometer, considered by some to be the gold standard among hand-grip dynamometers [4], was used to measure grip strength in most (but not all) of the studies. Norms provided in the studies are sometimes presented separately for each hand (i.e., left and right or nondominant and dominant) [9,14,15], but at other times norms are based on the maximum force measured without reference to the hand from which they were obtained [10▪,11,13,17]. Reported norms always take sex and age into account. However, other variables associated with grip strength are also used to provide more refined norms. These include height and weight [9,11–14], self-rated health and functional disability [13], and number of chronic diseases [15]. Recent studies other than those summarized above and in Table 1 have provided additional normative values. They, however, involve smaller samples, and thus provide potentially less dependable estimates of normal grip strength [17–24].

Whereas norms can provide an age-relevant standard for determining an individual's status, T-scores provide a young age standard to which the status of older adults can be compared. Although T-scores are used most often to compare the bone density of older adults with that of younger adults, grip strength T-scores can be used in a similar fashion [10▪,20,25,26▪]. This is an important alternative as it provides an opportunity to see how the strength of an older adult may have declined with age. Having grip strength comparable to younger adults is certainly more desirable for an older adult than having grip strength comparable to other older adults whose strength has also declined with age. Bohannon and Magasi [26▪] used data from the National Institutes of Health project to derive T-scores and identify dynapenia in adults 60–85 years of age. Defined as having grip strength that was more than 1.0 standard deviation below the mean for healthy 20–40 year olds, dynapenia was present in the majority of men and women 70–85 years of age.

Association with concurrent clinical measures

Figure 1 shows the association of grip strength with various concurrent clinical measures. Muscle weakness, as measured by hand-grip dynamometry, is often used alone or in conjunction with other measures to describe nutritional status or body composition (e.g., muscle mass). Most notably, hand-grip force stratified by sex and BMI has been used along with unintentional weight loss and three other variables to define frailty [27]. Grip force so stratified has also been used along with muscle mass and physical performance to define sarcopenia [28]. Significant and strong correlations have been reported between the grip strength and muscle mass (determined by bioelectrical impedance) of older community-dwelling women [29] and older sarcopenic adults residing in assisted living [30▪▪]. A significant correlation between grip strength and muscle mass has also been reported for nonsarcopenic adults residing in assisted living, but the correlation was only of fair magnitude [30▪▪]. Fülster *et al.* [31] demonstrated that the grip strength of patients with heart failure was significantly lower if they had muscle wasting identified by dual radiograph absorptiometry. Itoh *et al.* [32] found strong correlations between the grip strength and muscle mass of patients hospitalized with liver related problems. The correlations were somewhat higher when muscle mass was quantified with computerized tomography rather than bioelectrical impedance. Among hospitalized patients grip strength has been shown to correlate with adductor pollicis muscle thickness, midarm circumference [32], and the Patient-Generated Subjective Global Assessment of nutritional status [32,33]. Flood *et al.* [34] found changes in grip strength to explain more than 40% of the variance in changes in the Patient-Generated Subjective Global Assessment over a 2-week period. Silva *et al.* [35] showed that the grip strength of hospitalized pediatric patients 'was independently associated with undernutrition as defined by BMI z scores'. Martín-Ponce *et al.* [36] found low but

Table 1. Summary of large sample studies providing norms for hand-grip strength

Study	Sample	Procedure	Stratification/ explanatory variables
Spruit *et al.* [9]	Origin: UK Size: 224 852 (left), 224 830 (right) Age range: 39–73	Dynamometer: Jamar Measurement: 3 with each hand. Criterion: not stated	Sex Side (left and right) Age Height
Dodds *et al.* [10■]	Origin: Great Britain Size: 49 964 Age:4–90	Dynamometer: Jamar, Smedley, Harpenden, or Takei Measurement: 2–5 with each hand Criterion: maximum of 2 sides	Sex Age
Kenny *et al.* [11]	Origin: Ireland Size: 5819 Age: 50–85	Dynamometer: Baseline Measurement: 2 with each hand Criterion: maximum of 2 sides	Sex Age Height
Seino *et al.* [12]	Origin: Japan Size: 4551 Age: 65 and older	Dynamometer: Smedley Measurement: 1 or 2 from the dominant hand. Criterion: best	Sex Age Weight
Ramlagan *et al.* [13]	Origin: South Africa Size: 3840 Age: 50 and older	Dynamometer: not stated Measurement: 2 with each hand. Criterion; mean of maximum from each hand	Sex Age Height Self-rated health Functional disability
Ploogmakers *et al.* [14]	Origin: Netherlands Size: 2241 Age: 6–19	Dynamometer: Jamar Measurement: 2 with each hand Criterion: not stated	Sex Side (dominant and nondominant) Age Height Weight
Yorke *et al.* [15]	Origin: USA Size: 5877 Age 50 and older	Dynamometer: Jamar Measurement: 2 with each hand Criterion: Mean for each hand	Sex Side (left and right) Age Number of chronic diseases (0, 1, 2, ≥3)
Auyeung *et al.* [16]	Origin: China (Hong Kong) Size: 2941 Age: 65 and older	Dynamometer: Jamar Measurement: 2 with each hand Criterion: maximum of 2 sides.	Sex Sex Age

significant correlations between grip strength and the serum albumin and Subjective Nutritional Scores of hospitalized older adults.

Numerous researchers have investigated the concurrent relationship between grip strength and other variables not focused on nutritional status or body composition. Of particular relevance is research addressing physical function. Ramlagan *et al.* [13] reported functional disability to be significantly lower in older South African adults who had greater grip strength. Beseler *et al.* [37■■] documented a highly significant relationship between grip strength and walking performance as characterized using Functional Ambulation Categories and the Functional Classification of Sagunto Hospital Ambulation in older adults. Alley *et al.* [38■■] found walking speed to be related to grip strength. Using a gait speed criterion of 0.8 m/s, they identified grip strength cutpoints for differentiating older adults who walked above or below this criterion speed. They classified men and women as weak if their grip strengths were less than 26 kg and 16 kg, respectively. Martín-Ponce *et al.* [36] documented a low but significant correlation between the grip strength

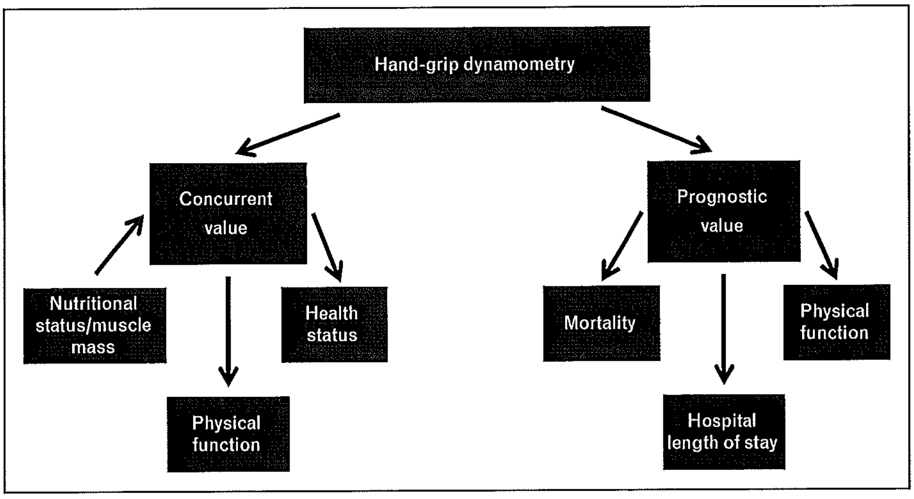

FIGURE 1. Value of grip strength as an indicator of concurrent and future status.

and six-minute walk distance of older hospitalized adults. Patients with grip strength below the sample median walked less than half as far as patients with grip strength above the sample median. Research identifying a relationship between grip strength and walking notwithstanding, lower limb (knee extension) strength has been shown to explain walking performance as well or better than grip strength in some populations [39].

Grip strength is related to diverse health status variables as well. Specifically, grip strength has been shown to be diminished in individuals with a greater number of chronic diseases [25], lower in patients with depression [40] or reduced self-rated health [41], and less in nursing home residents than in rehabilitation inpatients and less in rehabilitation inpatients than in community-dwelling individuals [42]. Grip strength is associated with the severity of Parkinson's disease [43].

PROGNOSTIC VALUE OF GRIP STRENGTH

Herein, the prognostic value of grip strength refers to its ability to forecast future outcomes. Grip strength is well established historically in this regard. In a 2008 review, Bohannon identified grip strength as an important predictor of future mortality, disability, complications, resource utilization, and discharge disposition [44]. He concluded that 'grip strength should be considered as a vital sign useful for screening middle-aged and older adults'. Numerous studies published over the past several years have reinforced grip strength as a robust predictor of mortality, hospital length of stay, and physical functioning (Fig. 1).

Recent studies have confirmed consistently that low-grip strength is a risk factor for mortality. Using data from over 139 000 adults residing in 17 countries, Leong *et al.* [45] determined that grip strength was related to all-cause, cardiovascular, and noncardiovascular mortality over a median 4 years follow-up. They noted that 'grip strength was a stronger predictor of all-cause and cardiovascular mortality than SBP'. McLean *et al.* [46■■] who pooled data from six cohort studies involving older adults, showed that weak grip was associated with 10-year mortality rates that were 63–74% higher in men and 48% higher in women. Koopman *et al.* [47] found 20-month mortality to be lower in a sample of rural Africans with high hand-grip strength. Martín-Ponce *et al.* [36] showed that both in-hospital and postdischarge mortality were higher in patients with low hand-grip strength. According to Matos *et al.* [48] all-cause mortality over 4 years among Brazilians receiving hemodialysis was higher if they had weaker grip strength. Hand-grip strength was shown to be highly predictive of survival in a study of Canadians with advanced cancer [49]. The mean survival time was 51.9 weeks for patients with grip strength at or above the 50th percentile but only 23.3 weeks for patients at or below the 10th percentile. Mendes *et al.* [50] noted 'an, approximate, three-fold decrease in probability of discharge alive' for patients with low-grip strength. Finally, Kim *et al.* [51] examined the value of muscle mass, knee extension strength normalized against body weight and grip strength for predicting 5-year mortality; they found grip strength to be a more powerful predictor than either knee extension strength or muscle mass.

Low-grip strength is predictive of longer hospital lengths of stay. This has been demonstrated for patients hospitalized with cancer [50], older adults hospitalized in Malaysia [52], Portuguese adults admitted to medical or surgical units [53■], and older adults admitted to the rehabilitation ward of a community hospital [54].

Grip strength measured soon after hip fracture is predictive of later physical functioning. Di Monaco *et al.* [55] reported fair but significant correlations between grip strength measured before rehabilitation and Barthel Index scores and Timed Up and Go test performance after rehabilitation. The correlations remained significant after adjustment for confounders. They also found grip strength measured before rehabilitation to correlate significantly with Barthel Index scores at 6-month follow-up [56■]. Grip strength measured at the time of admission has been shown by Savino *et al.* [57] to be associated with 'both incident and persistent walking recovery'.

CONCLUSION

Grip strength can provide an indication of an individual's overall strength. Grip strength also informs regarding nutritional status and muscle mass, physical function, and health status. It is predictive of morality, hospital length of stay, and physical function. Grip strength should be considered for routine use as a vital sign.

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Conflicts of interest

Dr Bohannon is a paid consultant with Hoggan Scientific.

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