Normative Data for Grip Strength of Elderly Men and Women

Johanne Desrosiers, Gina Bravo, Réjean Hébert, Élisabeth Dutil

Key Words: aging • assessment process, occupational therapy

Objectives. Grip strength is an important prerequisite for good performance of the upper limb, hence it is important to evaluate it correctly. However, one of the main difficulties in evaluating the grip strength of elderly patients is the absence of valid norms. Therefore, the objective of this study was to develop normative data for maximum grip strength of persons aged 60 years and older.

Method. The grip strength of 360 subjects aged 60 years and older, randomly recruited by age and gender strata, was evaluated with the Jamar dynamometer and the Martin vigorimeter according to the protocol of the American Society of Hand Therapists.

Results. Grip strength diminishes curvilinearly with age, and men are consistently stronger than women. The data are presented by the means, standard deviations, and range, and as predictive equations obtained by regression analysis. In addition to age and gender, hand circumference and body height proved to be the best indicators of grip strength for this population of elderly subjects.

Conclusion. The random recruitment of subjects, the high participation rate in the study, and the comparability of the subjects who agreed to participate and those who refused give this study the high external validity that is essential to any norm study. The predictive equations will help occupational therapists to better estimate the expected grip strength of elderly patients than they could if using only age and gender.

Upper limbs play an important role in everyone's daily life. A number of sensorimotor parameters, including grip strength, are necessary for their optimal performance. Grip strength is frequently evaluated in clinical settings as an indicator of disease activity (Rhind, Bird, & Wright, 1980). It has also proved to be a prognostic indicator of mortality risk in a population of elderly hospitalized women (Phillips, 1986). In addition to being an economical measure that is easy to administer, grip strength is one of the best indicators of the overall strength of the limb (Rice, Cunningham, Pater­son, & Rechnitzer, 1989). Grip strength is evaluated as a component of hand function (American Society of Hand Therapists, [ASHT] 1992; Dent, Smith & Caspers, 1985; Jones, 1989).

The Jamar' dynamometer1 and the Martin vigorimeter2 are well known for measuring grip strength. The Jamar' dynamometer consists of a sealed hydraulic system with a sensitive gauge calibrated in pounds and kilograms. It is considered to be the most precise instrument for measuring grip strength (ASHT, 1992; Fess, 1987; 1Manufactured by Therapeutic Equipment Corporation, 60 Page Road, Clifton, NJ 07012.
Kirkpatrick, 1956; Mathiowetz, Weber, Volland, & Kashieman, 1984; Schmidt & Toews, 1970). Mathiowetz et al. (1984) reported that the mean of three trials has the highest test–retest reliability (Pearson product–moment correlation coefficients: 0.89 for the right hand and 0.93 for the left) compared with only one trial (0.79 and 0.86). The test–retest reliability of the highest score on three trials is also high (0.82 for the right hand and 0.92 for the left). No learning effect or fatigue is present when three consecutive measures are taken (Mathiowetz, 1990).

The Martin vigorimeter consists of a rubber bulb connected by a tube to a manometer; measures are expressed in kiloPascals (Agnew & Maas, 1991; Fike & Rousseau, 1982; Giles, 1984). It is particularly recommended for and used with persons with arthritis to avoid increasing stress on joints that are already weak or painful (Helewa, Goldsmith, & Smythe, 1981; Melvin, 1977). Unlike the Jamar™ dynamometer, the Martin vigorimeter involves isotonic muscular action because of the movement needed to compress the bulb. Jones et al. (1991) demonstrated the stability of Martin vigorimeter measures with high test–retest reliability (intraclass correlation coefficients of 0.96 for the mean of three measures on the dominant hand and 0.98 on the other).

Over the last 20 years and more, researchers have developed normative reference values for grip strength based on convenience samples. Kellor, Frost, Silberberg, Iversen, and Cummings (1971) were among the first to develop grip strength norms by using the Jamar™ dynamometer with a sample aged 20 to 84 years. These norms are still used in some clinical settings in spite of the lack of standardization in the data collection procedure. Because of this limitation, Mathiowetz et al. (1985) developed new norms based on data obtained with a convenience sample of 628 volunteers of both genders aged from 18 years to 84 years. These norms are more valid than those of Kellor et al. (1971) because of the standardization in the data collection procedure. However, Flood-Joy and Mathiowetz (1987) reported the incorrect calibration of one of the instruments used in developing the norms. This incorrectly calibrated instrument would have been used with 25% of their subjects, especially those aged 50 and older. The main tendency would have been to underestimate the performance of the subjects. Because of these technical problems, there are currently no valid norms for grip strength measured with the Jamar™ dynamometer for people aged 60 and older.

Normative reference values have also been developed for the three sizes of bulbs in the Martin vigorimeter with right-handed subjects aged 20 to 79 years who had different occupations and showed no evidence of impairment in the upper limbs (Fraser & Benten, 1983). However, the groups that were stratified according to age and gender are very small (n = 10 per group). Another norms study for the Martin vigorimeter was done with 450 randomly selected subjects aged 21 to 65 years; it used the large bulb for men and the medium one for women (Thorogreen & Werner, 1979).

Except for the latter study, these normative studies were done with convenience samples that might not be representative of the targeted population because of the recruiting methods. Another important limitation of the current norms for elderly persons using the Jamar™ dynamometer and the Martin vigorimeter is the small number of very old subjects (older than 80 years of age) included in the studies. The norms obtained by Mathiowetz et al. (1985) categorized the subjects aged 75 years and older into a single group; no subjects older than 80 years were included in the norm study done by Fraser and Benten (1983). It is difficult to assume that the performance of an 85-year-old is the same as that of a 75-year-old.

In addition to age, many factors may influence grip strength: upper extremity position (Balogun, Akomolafe, & Amusa, 1991; Kuzala & Vargo, 1992), physical activity practice (Grimby, 1986), handedness or sidedness (Peterson, Petrik, Copover, & Conklin, 1989), intramuscular temperature (Johnson & Leider, 1977), motivation (Lennmarken, Bergman, Larsson, & Larsson, 1985), and time of day (Pearson, Mackinnon, Meek, Myers, & Palmer, 1982). Body and hand anthropometrics are also important factors to consider. Many studies demonstrated significant relationships between anthropometry and grip strength. In most of these studies, weight was the variable most related to strength (Chatterjee & Chowdhury, 1991; Everett & Sills, 1952; Lunde, Brewer, & Garcia, 1972), followed by hand width, body height, hand length, and finger length (Everett & Sills). However, Bassey & Harries’ works (1993) indicated that body height is the variable most related to grip strength.

The goal of the present study was to develop normative reference values for maximum grip strength measured with the Jamar™ dynamometer and the Martin vigorimeter for persons aged 60 years and older on the basis of a randomly recruited sample.

Method

Subjects

A random sample of 360 subjects aged 60 years and older, stratified for age (60–69 years, 70–79 years, and 80 years and older) and gender, was drawn from the electoral list of the city of Sherbrooke in Quebec, Canada, located 100 miles east of Montreal. Sherbrooke has a population of 76,000, nearly 17% of whom are older than 60 years of age. Each subject was first contacted by mail and then by telephone to verify eligibility criteria and willingness to participate in the study. The eligibility criteria were lucidity, independence in activities of daily living, sufficient vision, and absence of any impairment affecting upper limb function. When a subject refused or was not eligible, another subject was selected until 60 subjects per stratum were reached. Persons who refused to participate in the
study even though eligible were asked to reply to a general information telephone questionnaire in order to estimate refusal bias. Questions covered age, hand dominance, height, weight, current activity level, and self-perceived health. Each subject was evaluated at the Upper Limb Function Measurement Laboratory at the Centre de recherche en gériatrie et gériologie of the Hôpital D’Youville de Sherbrooke in Quebec. This study was part of a more comprehensive research on upper extremity performance of elderly men and women aged 60 years and older.

Procedure

Subjects were seated on a standard height chair without armrests. Anthropometric data (body weight, body height, hand length, hand circumference) were collected first. Hand circumference was measured at the thumb commissure following the axis of the head of the metacarpals; hand length was measured from distal crease of the wrist to the tip of the middle finger. A structured interview quantified other variables potentially related to strength, such as hand dominance (right-handed, left-handed, ambidextrous), previous or current work characteristics (active vs. sedentary, high use vs. low use of upper extremities, high vs. low upper extremity strength required, high vs. low fine dexterity required), self-perceived health (excellent, good, fair, poor), current activity level (very active, active, slightly active, sedentary), and frequency of current manual activities (very often, often, sometimes, seldom or never). Dominance was estimated with the Edinburgh Handedness Inventory (Oldfield, 1971).

Three grip strength measures of each hand were taken with the Jamar™ dynamometer and the Martin vigorimeter with a rest of about 30 sec between each. Contrary to the ASHT’s recommendation, the highest score on these three trials was retained. Both hands were tested; the dominant hand was tested first. Measures were first collected with the Jamar™ dynamometer (Model 1) and then with the Martin vigorimeter. Occupational therapists collected data following Mathiowetz’s instructions (Mathiowetz et al., 1984) and the ASHT (1992) recommendations concerning upper extremity position: shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in neutral position, and wrist in slight extension (0° to 30°). Calibration of the Jamar™ dynamometer was verified according to Fess’ recommendations (Fess, 1987) before and during the study. Calibration of the vigorimeter was not verified. The Jamar™ dynamometer was set at the second handle position; the large bulb of the Martin vigorimeter was selected for all subjects.

Data Analysis

The characteristics of the study sample are described by the mean, the standard deviation, and the range for continuous variables and by frequency and percentage for categorical variables. T tests and chi square statistics were used to compare persons who participated in the study with those who refused.

The grip strength results are first presented by age group and gender in the form of means, standard deviations, and minimum and maximum values. These values are also presented through regression equations that relate strength to age. A 95% confidence interval around the predicted value is reported, to take sample variation into account. Multiple regression analyses were done to determine which variables might best explain grip strength and thus increase precision of estimates. With the object of simplifying clinical use, the predictive equations are reported according to gender and side, avoiding interaction terms. In order to avoid overestimating the real adjustment in the population, the adjustment measure in the prediction models considers the number of variables (adjusted R²). The assumptions underlying the regression analysis were verified by residual analysis.

Results

Stratifying the 360 subjects by age and gender resulted in 60 men and 60 women in each age group, with the exception of women aged 60 to 69 years (n = 59) and men of the same age (n = 61) (see Table 1). The age of the women and men is equivalent across all groups with a mean age of 73.9. As expected, the anthropometric variables are higher among the men than the women and the large majority of subjects are right-handed (92%). Most of the subjects did physically active work (83%) that required great use of the upper limbs (84%) but little strength (63%) and fine dexterity (74%). They described themselves as being in excellent or good physical health (84%) compared with others their age. Seventy-five percent of the subjects considered themselves to be active or very active. Because of the small number of subjects who are not right-handed, the results were analyzed without considering dominance.

The participation rate in the study was 78% (74% for women and 82% for men). Statistical analyses (t tests or chi square) revealed no difference between those who refused and those who accepted in terms of age (p = 0.47), gender (p = 0.06), height (p = 0.06), weight (p = 0.11), dominance (p = 0.83), self-perceived health (p = 0.19), and current activity level (p = 0.23). As expected, the men were consistently stronger than the women (p < 0.0001) (see Table 2). Grip strength diminished with increasing age (women: r = -0.37 to -0.47 and men: r = -0.55 to -0.60, depending on the hand and the instrument; p < 0.0001). This loss in strength was accentuated among the subjects aged 80 years and older (negative curvilinear relationship existed between grip strength and age). The right hands of the
Table 1
Descriptive Data of Study Subjects

<table>
<thead>
<tr>
<th>Variables</th>
<th>Women (n = 179)</th>
<th>Men (n = 181)</th>
<th>Total (n = 360)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hand size (cm)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hand circumference (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous or current work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>characteristics</td>
<td></td>
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<tr>
<td>Self-perceived health</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Current activity level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of current manual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>activities</td>
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</tbody>
</table>

Table 2
Grip Strength on the Jamar™ Dynamometer and the Martin Vigorimeter (Highest Score on Three Trials) According to Age and Gender

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Jamar™ Dynamometer</th>
<th>Martin Vigorimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Hand (kg)</td>
<td>Left Hand (kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right Hand (kPa)</td>
</tr>
<tr>
<td>Women 60-69 years</td>
<td>25.3 (4.8)</td>
<td>23.6 (4.7)</td>
</tr>
<tr>
<td></td>
<td>18-22</td>
<td>16-25</td>
</tr>
<tr>
<td>Women 70-79 years</td>
<td>23.7 (5.1)</td>
<td>22.0 (4.7)</td>
</tr>
<tr>
<td></td>
<td>11-16</td>
<td>10-20</td>
</tr>
<tr>
<td>Men 60-69 years</td>
<td>45.6 (8.6)</td>
<td>43.6 (8.7)</td>
</tr>
<tr>
<td></td>
<td>31-70</td>
<td>29-72</td>
</tr>
<tr>
<td>Men 70-79 years</td>
<td>42.4 (9.1)</td>
<td>40.5 (8.5)</td>
</tr>
<tr>
<td></td>
<td>24-69</td>
<td>22-70</td>
</tr>
<tr>
<td>80 years and older</td>
<td>20.0 (4.3)</td>
<td>18.5 (4.4)</td>
</tr>
<tr>
<td></td>
<td>12-32</td>
<td>10-30</td>
</tr>
</tbody>
</table>

The same results may be described by regression equations expressing strength as a function of age and their 95% confidence interval (see Table 3). The curvilinear relationship of strength with age required the transformation of the independent variable, namely age.2

The predictive equations for strength deduced from multiple regressions, where grip strength is the dependent variable and the personal variables of the subjects are the independent variables, are shown in Table 4. For the Jamar™ dynamometer, the variables that best predict grip strength are age,2 hand circumference, and body height (or the size of the hand for women on the right side). For the Martin vigorimeter, age2 is also the best predictor, but the other predictive variables differ according to gender and side. Residual analysis suggested that the assumptions underlying the regression analysis were satisfied. The standardized residuals appear normally distributed. Moreover, two-dimensional displays of residuals against predicted values and dependent variables did not suggest heterogeneity of variance or lack of linearity.

Discussion

The goal of this study was to develop grip strength norms applicable to persons aged 60 years and older. The sample used for this study was randomly recruited and the high participation rate suggests good representation of the population from which it was drawn. Moreover, statistical analyses revealed no difference between those who refused and those who agreed to participate in terms of specific variables, thus minimizing the possibility of a refusal bias.

The highest score on three trials was retained as the grip strength. Even though the reliability is slightly lower than that of the mean of the three measures (Mathiowetz et al., 1984), the highest score appears more valid because it corresponds to the real potential maximum

Subjects, the majority of whom are right-handed, were stronger than the left hands (p < 0.0001 for the dynamometer and p = 0.0004 for the vigorimeter). On the Jamar™ dynamometer, these differences are 7.1% for the women and 3.3% for the men, with 5.1% and 2.1%, respectively, on the Martin vigorimeter.

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Table 3
Age Predicted Maximum Grip Strength and 95% Confidence Interval for Men and Women Aged 60 Years and Older with the Jamar™ Dynamometer and the Martin Vigorimeter

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Predictive Equations</th>
<th>Variability of the Estimated Score</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jamar™ Dynamometer (kg)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>33.9 - 0.0020 (age²)</td>
<td>9.2</td>
<td>0.21</td>
</tr>
<tr>
<td>Left hand</td>
<td>33.2 - 0.0020 (age²)</td>
<td>8.5</td>
<td>0.22</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>65.7 - 0.00453 (age²)</td>
<td>15.7</td>
<td>0.30</td>
</tr>
<tr>
<td>Left hand</td>
<td>64.9 - 0.00475 (age²)</td>
<td>15.2</td>
<td>0.34</td>
</tr>
<tr>
<td><strong>Martin Vigorimeter (kPa)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>70.3 - 0.0057 (age²)</td>
<td>20.6</td>
<td>0.15</td>
</tr>
<tr>
<td>Left hand</td>
<td>67.8 - 0.0055 (age²)</td>
<td>20.8</td>
<td>0.14</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>134.6 - 0.0010 (age²)</td>
<td>30.8</td>
<td>0.36</td>
</tr>
<tr>
<td>Left hand</td>
<td>129.7 - 0.00095 (age²)</td>
<td>30.1</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Note: Example: The expected score for maximum right grip strength on the Jamar dynamometer for a 75-year-old man is: 35.7 - 0.00453 (75²) = 3.8 kg.

Variability associated with this score is 15.7. Therefore, the 95% confidence interval around the score expected for a man that age is given by (224.5, 331.1).

The finding that the older subjects have lower grip strength scores than the younger ones was not unexpected and agrees with numerous studies (Bassey & Harries, 1993; Chatterjee & Chowdhuri, 1991; Fernando & Robertson, 1982; Keilor et al., 1971; Mathiowetz et al., 1985). The reduction in strength with age may be caused by different factors, including a reduction in the number of muscle fibers and changes in their size (Aniansson, Grimby, & Rungren, 1980), especially the slow twitch fibers (type I) (Grimby, Aniansson, Zetterberg, & Saltin, 1984; Larsson, Grimby, & Karlsson, 1979). Muscle changes and atrophy seem to accelerate after 70 years of age (Aniansson, Hedberg, Henning, & Grimby, 1986), which may explain the greater loss in strength of the older subjects in the present study. The movements of elderly persons are less likely to attain maximum tension levels, thus involving less use of type II fibers (McDonagh, White, & Davies, 1984). This interpretation is plausible because of the fact that the reduction in the size of type II fibers is reversed in the muscle of elderly subjects who participated in intensive physical training (Aniansson & Gustafsson, 1981; Larsson, 1978). However, when the influence of the size of type II fibers is controlled for by factorial analysis, age still remains strongly correlated with the decline in strength (Larsson et al., 1979), suggesting that factors other than atrophy of the fast twitch fibers are responsible for this loss of strength with age. Therefore, it should be considered that the decline in muscle strength with age may not be solely due to primary aging of the skeletal muscle but also to secondary changes brought out in the muscle by the aging of other body systems, such as the nervous, vascular, and endocrinal systems (Aniansson et al., 1980) and to a reduction in physical activity (see Grimby, 1986).

Also expected was the finding that men are consistently stronger than women (p < 0.0001). The women in this study have, depending on the hand and the instrument, between 54% and 68% of the grip strength of men, which is close to the 60% to 67% found by Aniansson et al. (1980) and the 53% and 57% obtained by Bassey and Harries (1993). Regarding the men, those aged 80 years and older showed significantly less strength than those aged 70 to 79 years (loss in the order of 20% compared with a 15% loss for women in the same age groups).

Table 4
Predictive Equations of Maximum Grip Strength Measured With the Jamar™ Dynamometer and the Martin Vigorimeter

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Predictive Equations</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jamar™ Dynamometer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>1.25 (hand circumference; cm) + 0.94 (hand size; cm) - 0.0018 (age²) = 8.21</td>
<td>0.54</td>
</tr>
<tr>
<td>Left hand</td>
<td>1.46 (hand circumference; cm) + 0.12 (body height; cm) - 0.0018 (age²) = 15.64</td>
<td>0.38</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>1.52 (hand circumference; cm) + 0.40 (body height; cm) - 0.0005 (age²) = 41.69</td>
<td>0.45</td>
</tr>
<tr>
<td>Left hand</td>
<td>1.55 (hand circumference; cm) + 0.32 (body height; cm) - 0.0057 (age²) = 50.42</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>Martin Vigorimeter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>1.85 (hand circumference; cm) + 0.34 (body height; cm) - 0.0054 (age²) = 19.96</td>
<td>0.25</td>
</tr>
<tr>
<td>Left hand</td>
<td>2.24 (hand circumference; cm) + 2.39 (hand size; cm) - 0.0032 (age²) = 15.30</td>
<td>0.24</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hand</td>
<td>0.90 (body height; cm) - 0.0088 (age²) = 24.66</td>
<td>0.41</td>
</tr>
<tr>
<td>Left hand</td>
<td>0.58 (body height; cm) + 0.21 (body weight; kg) - 0.0079 (age²) + 6.97</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Note: The expected score for maximum right grip strength on the Jamar dynamometer for a 78-year-old man with a height of 174 cm and a hand circumference of 24 cm is: 3.12 (24) + 0.40 (174 cm) - 0.0035 (78)² - 41.69 = 45.1 kg.
accentuation in the loss of strength with age among the men agrees with the results of Lundgren-Lindquist and Sperling’s study (1983). They attributed this difference between gender to the lower strength among women right from the age of adulthood. These results could also be attributed to the life-style of the very elderly subjects or to a differential aging process depending on gender. In view of the existence of a positive, significant relationship between strength and weight and height and the superiority of men on these variables, Balogun et al. (1991) attributed the difference in strength between the genders to their physical characteristics rather than to biological differences. However, even when the body weight and height of the subjects in the present study are controlled for, the grip strength of the women remains less than that of the men. In a study of the strength of different muscle groups in the upper and lower limbs of a population aged between 62 and 102 years, Rice et al. (1989) also concluded that when body weight is controlled for, grip strength on the dynamometer is significantly different between the genders, but the strength of other muscle groups is not.

Comparison of the Jamar™ dynamometer norms in the present study with those of Mathiowetz et al. (1985) confirms the problem raised by the incorrect calibration of their measuring instrument. In fact, Mathiowetz’ scores are lower than those in this study, even when they are compared with the mean values of the three measures of our subjects (not given here). These results reinforce the importance of regularly checking the calibration of the dynamometer and correcting it if needed.

The mean of the right-hand strength of this mainly right-handed sample was stronger than that of the left. This difference approaches that obtained by other researchers (Swanson, Matev, & de Groot, 1974; Toews, 1964) but is far from the 13% found by Lundle et al. (1972) and the 10.75% estimated by Peterson et al. (1989).

Because strength is related to age in a curvilinear rather than a linear fashion, it is important to consider it in the estimation of grip strength; hence, age is squared in the predictive equations. The strength equations in relation to age are more precise than the use of the mean and standard deviation because of the 10-year categories. Because grip strength is not related exclusively to age and that other variables, particularly the anthropometric data, are very important, multivariate analyses were done. The predictive equations deduced from these analyses are made up of the best indicators, among the variables measured, of the grip strength of a person. Thus, age, hand circumference, and body height are the variables that best explain the grip strength scores, especially on the Jamar™ dynamometer. Because of the stronger relationship between strength and age, the male models predict strength better than the female ones. The models explain between 23% and 46% of the variation in the data, depending on gender and the instrument. Therefore, other variables, ones not measured in the present study, may explain a part of the grip strength of an elderly person. However, while being simple to calculate, these equations produce better estimates of strength than the exclusive use of the scores obtained as a function of age and gender. They should therefore be used clinically.

Study Limitations

This study presents four limitations. First, because the majority of the sample was right-handed, these norms should be used with caution for left-handed persons. Second, the cross-sectional design of the study can introduce a cohort bias because persons born at the beginning of the century have not experienced the same events as younger ones or have experienced the same events under different conditions, which may influence their strength. However, this design does not affect the quality of the normative data. Third, calibration of the Martin vigorimeter was not checked before and during the study. A study by Solgaard, Kristiansen, and Jensen (1984) indicated that the Martin vigorimeter is a precise instrument when tested with a machine to evaluate the linearity of the readings. However, as with the Jamar™ dynamometer, repeated use of the Martin vigorimeter may reduce the precision of its calibration. Finally, although the subjects are representative of elderly persons in the city where they were recruited, they may not be representative of elderly persons as a whole. Even though all the subjects lived in an urban environment, many of them used to live in a rural environment and only moved to the city upon retirement for practical reasons.

Conclusion

Grip strength is a clinical measure that is frequently used to estimate sensorimotor deficits and monitor how they evolve over time. It is an important prerequisite for good hand function. As specialists of hand function evaluation and treatment, occupational therapists must evaluate grip strength correctly and use valid grip strength norms for comparing patients to the normal population. In this study, it was shown that the grip strength of persons aged 60 years and older varies negatively and curvilinearly with age and that the loss seems more marked among the older subjects. The random recruiting of the subjects, the high participation rate, the comparability of those who refused and the subjects who agreed to participate in the study, and the large number of very old subjects give the study the high external validity that is essential to any norm study. This study demonstrated the importance of taking into account hand circumference and body height, in addition to age and gender, when comparing grip strength to that of a population without disability. The predictive equations deduced from the subjects’ scores give a more precise estimation of the expected grip strength of elderly patients than would be obtained with only age and gender.
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