Key points

• Return to home following hip fracture can be predicted at admission
• Prediction of timing of return to home may be useful for discharge planning
• Future research studies may benefit from stratifying patients according to likelihood of return to home following hip fracture

Conflicts of interest

None declared.

References


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Abstract

Background: muscle strength is essential for physical functions and an indicator of morbidity and mortality in older adults. Among the factors associated with muscle strength loss with age, ethnicity has been shown to play an important role.

Objective: to examine the patterns and correlates of muscle strength change with age in a population-based cohort of middle-aged and older Afro-Caribbean men.

Methods: handgrip strength and body composition were measured in 1,710 Afro-Caribbean men. Data were also collected for demographic variables, medical history and lifestyle behaviours.

Results: the age range of the study population was 29–89 years. Grip strength increased below age 50 years, and decreased after age 50 years over 4.5-year follow-up. The average loss in grip strength was 2.2% (0.49% per year) for ages 50 years or older and 3.8% (0.64% per year) for ages 65 years or older. The significant independent predictors of grip strength loss included older age, a greater body mass index, lower initial arm lean mass and greater loss of arm lean mass.

Conclusion: Afro-Caribbean men experience a significant decline in muscle strength with advanced age. The major independent factors associated with strength loss were similar to other ethnic groups, including age, body weight and lean mass.

Keywords: male, population-based study, muscle strength, strength loss, ageing, elderly

Introduction

Muscle strength is essential for physical performance, especially for activities of daily living among older adults [1, 2]. Muscle strength has also been associated with increased mortality [3–9], incidence of cardiovascular disease [4–6], and type 2 diabetes [10] and overall health [11] in older adults. Although muscle strength is closely related to muscle mass, which is also reduced with ageing [10], the reduction in muscle mass with age only explains a limited fraction of the inter-individual variance in the loss of muscle strength [11–13]. Moreover, muscle strength, but not muscle mass, has been associated with mortality in older adults [8].

Cross-sectional studies suggest that muscle strength peaks between ages 20 and 35, then declines from ages 35 to 50, with rapid decreases occurring after age 65 [14, 15]. Although both men and women experience age-related losses in muscle strength, men may be less likely to preserve their muscle strength and quality with advancing age [16–20]. In addition to gender, race may also influence muscle strength. For example, black men had 20% lower strength than white men despite having higher total body lean mass in one population study [21]. Other studies have found that depression [22], low vitamin D levels [23], markers of inflammation and carotenoid levels [24] may be associated with skeletal muscle strength. However, the age-related patterns and epidemiological correlates of muscle strength and its loss with ageing have been less well defined among persons of African ancestry, especially among men. To address this gap in knowledge, we conducted a population-based analysis to identify the patterns and potential lifestyle and medical-related correlates of grip strength change with age in a large cohort study of middle-aged and older Afro-Caribbean men.

Materials and methods

Study population

Between 1997 and 2003, 3,170 men were recruited for a population-based prostate cancer screening study on the Caribbean Island of Tobago, Trinidad and Tobago [25]. To be eligible, men had to be ambulatory, non-institutionalised and not terminally ill. Recruitment for the study was accomplished by flyers, public service announcements, posters, informing health care workers at local hospital and health centres and word of mouth. Approximately 60% of all age-eligible men on the island participated. The recruited cohort was 97% African, 2% East Indian, less than 1% white and less than 1% ‘other’ as defined by participant report of paternal and maternal grandparents’ ethnicity. Between 2004 and 2007, men in the cohort were invited to return for a repeat examination. A total of 2,031 men from the original cohort (70% of survivors) participated in the follow-up visit. For the current analysis, we excluded men with incomplete grip strength measurements either at baseline or during follow-up, and men who were not of African ancestry (final, n = 1,710). The Institutional Review Boards of the University of Pittsburgh and the Tobago Division of Health and Social Services approved the study.

Measurements

Handgrip strength was measured in kilograms for both the left and right hands using a dynamometer (Preston Grip Dynamometer, JA Preston Corp.). Hand grip strength is a valid measurement of upper body muscle strength and correlates well with total body muscle strength [7, 8, 10]. Six trials were performed: one practice for each limb, and two trials for each limb. Results were recorded to the nearest
0.5 kg. An overall measure of grip strength was determined by averaging the values for all four trials. The same protocol for measuring grip strength was used at the follow-up visit. Change in grip strength was calculated as absolute values as well as percent change during follow-up.

Body weight was measured in kilograms with participants wearing light clothing and without shoes using a calibrated balance beam scale. Height was measured in centimetres without participants wearing shoes using a wall-mounted height board. Two height measurements were taken and the average was used. The body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.

Body composition (bone mineral-free lean tissue mass and fat mass) was measured using dual-energy X-ray absorptiometry on a Hologic QDR-4500W scanner (Hologic, Inc., Bedford, MA, USA). For all participants, the same scanner was used and DXA scans were completed using the array beam mode. Standardised positioning and utilisation of QDR software was based on the manufacturer’s recommended protocol. Scans were analysed with QDR software version 8.26a. To ensure consistency, the DXA technician scanned a spine phantom daily and completed a weekly quality control whole body air scan, prior to completing any participant scans.

Other measurements

Trained interviewers and nurses administered questionnaires to participants. Information was collected pertaining to demographic characteristics, medical history and lifestyle variables. Ethnicity was self-reported and participants provided detailed information on the ethnic origin of their parents and grandparents. Participants were asked whether they had been diagnosed by a health care provider with selected conditions including diabetes, hypertension, and prostate cancer. Smoking status was categorised as ever and never. Men who smoked fewer than 100 cigarettes were considered to have never smoked. Physical activity was assessed by the frequency and duration of walking in the past 7 days for exercise, to work, the store or church. We also used hours of television watching per week as a surrogate of physical inactivity.

Data analysis

Descriptive statistics were used to examine the study population’s characteristics by mean (SD) or % where is appropriate. Grip strength change patterns by age were evaluated by the average of age-specific grip strength at baseline as well as age-specific rate of grip strength change per year (%/year) after adjusting for baseline grip strength. Grip strength change was determined by follow-up values—baseline values with an average 4.5-year follow-up time. ANCOVA was used to examine the age-specific grip strength adjusting for covariates. To evaluate the univariate relationship between measured factors at baseline and grip strength at baseline and follow-up, Pearson correlation coefficients were used for continuous variables with a normal distribution, and Spearman correlation coefficients were used for other variables. Variables that had a P-value of 0.1 or less from the univariate analysis were included in a multivariate model with a stepwise selection method to identify the independent correlates of grip strength at baseline or its change in grip strength during follow-up. The changes of some variables (follow-up—baseline), such as body weight and arm lean mass, were also included in the multivariate model. A forward step-wise selection method was used in the multivariate models. All data analyses were conducted using SAS (Version 9.1; Cary, NC, USA).

Results

A total of 1,710 Afro-Caribbean men were included in the current study. Compared with these 1,710 participants, those who were not included in the current study were 3.7 years older, and were significantly more likely to have lower baseline grip strength, higher BMI and lower lean mass (data are not shown).

The mean (±SD) age of the participants at baseline was 54.3 ± 10.2 years (range 29–89 years), with a distribution of 1.8% for 29–39 years, 20.1% for 40–44 years, 19.6% for 45–49 years, 15.5% for 50–54 years, 13.7% for 55–59 years, 12.3% for 60–64 years, 9.0% for 65–69 years, 4.7% for 70–74 years and 3.3% for 75–89 years. Other characteristics of the men are shown in Table 1.

Baseline grip strength was highest among the youngest age group, and declined as age increased (Figure 1). The mean (±SD) of age-specific baseline grip strength (kg) was 51.0 ± 11.2, 48.8 ± 8.6, 47.8 ± 8.3, 45.1 ± 8.6, 43.2 ± 8.2, 38.8 ± 8.1, 36.2 ± 8.4, 32.8 ± 7.7 and 29.1 ± 7.4 for age group 29–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74 and 75–89, respectively. In longitudinal analysis, as age increased, grip strength increased for ages younger than 50 years, and decreased for ages 50 years or older. The

Table 1. Baseline characteristics of the study population of Afro-Caribbean men

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean (SD) or % (n) (n = 1,710)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54.3 (10.2)</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>84.2 (15.4)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.4 (7.0)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>27.6 (4.3)</td>
</tr>
<tr>
<td>Whole body fat mass (kg)</td>
<td>16.9 (7.0)</td>
</tr>
<tr>
<td>Whole body lean mass (kg)</td>
<td>64.7 (8.7)</td>
</tr>
<tr>
<td>Leg lean mass (kg)</td>
<td>22.4 (3.3)</td>
</tr>
<tr>
<td>Arm lean mass (kg)</td>
<td>8.8 (1.4)</td>
</tr>
<tr>
<td>Ever smoke (%)</td>
<td>38.5 (654)</td>
</tr>
<tr>
<td>Watch TV (h/week)</td>
<td>15.7 (12.3)</td>
</tr>
<tr>
<td>Walking (h/week)</td>
<td>31.1 (21.5)</td>
</tr>
<tr>
<td>Ever worked on a farm (%)</td>
<td>51.5 (878)</td>
</tr>
<tr>
<td>Ever worked in fishing industry</td>
<td>17.5 (299)</td>
</tr>
<tr>
<td>Arthritis (%)</td>
<td>11.3 (192)</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>10.5 (178)</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>28.5 (484)</td>
</tr>
<tr>
<td>Prostate cancer (%)</td>
<td>10.4 (178)</td>
</tr>
</tbody>
</table>
mean (±SD) age-specific change (kg) in grip strength during 4.5-year follow-up was 1.8 ± 6.9, 0.6 ± 7.0, −0.4 ± 7.2, −1.2 ± 6.7, −0.8 ± 6.8, −1.8 ± 6.9, −1.9 ± 6.7, −2.2 ± 7.3 and −2.0 ± 5.8 for age group 29–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74 and 75–89, respectively. The average loss in grip strength during 4.5-year follow-up among those aged 50 years or older (n = 1,002) was 2.2% (SD 19.0%), equivalent to a 0.49% rate of decline per year. The average loss in grip strength for those aged 65 years or older (n = 291) was 3.8% (SD 22.4%), equivalent to a 0.64% rate of decline per year. Figure 1 also shows the age-specific rate (%) of grip strength change per year after adjusting for grip strength measured at baseline.

After adjusting for age, baseline grip strength was found to be positively correlated with body weight, height, BMI and lean body mass (see the Supplementary data available in Age and Ageing online, Table S1). Change in grip strength during follow-up was negatively correlated with baseline grip strength, BMI and hypertension, but positively correlated with height, change in weight during follow-up and change in arm lean mass during follow-up. Multivariate analysis (Table 2) shows that younger age, lower BMI, greater arm lean mass and not having diabetes were all independently associated with greater grip strength measured at baseline. These four factors explained 44% of the variation in baseline grip strength. The significant independent predictors of grip strength decline in longitudinal analyses included older age, greater BMI, lower arm lean mass at baseline, greater baseline grip strength and greater loss of arm lean mass. These five factors explained 27% of the variation in grip strength changes during follow-up.

**Discussion**

Hand grip strength is a simple and inexpensive indication of skeletal muscle function among older adults. In the current study, we examined the patterns and correlates of grip strength changes with age in a large observational cohort of community-dwelling middle-aged and older Afro-Caribbean men. This population shares similar genetic ancestry as African Americans but lives in a different environment [26]. We observed that muscle strength increased until age 50 years and decreased thereafter in this study population. In contrast, in the US population muscle strength appears to begin to decline at an earlier age (40 years) [12]. Furthermore, muscle strength appeared to decline at a slower rate at older ages in our cohort of Afro-Caribbean men compared with previous studies. For example, the rate of decline in grip strength was 0.64% per year during 4 years of follow-up among those aged 65 years or older in our cohort. In contrast, Schaap et al. reported an average 1.5% per year decline in grip strength over 3 years in a mixed white and black population sample aged 73 years or older [27]. Among Caucasian American men, we previously observed an average annual rate of decline of 2%/year among men aged 50–60 years and 3.4% among those aged 75 and older [28]. Although it is important to compare longitudinal changes in grip strength among different populations, these comparisons should be interpreted with caution due to the differences in study samples, measurements and study designs. Differences in subject characteristics between cohorts might also explain the different rates of decline in grip strength with age.

Tobago is a rural population whose physical activities are mainly from occupations and daily activities. A large proportion of male residents have a history of farming, fishing or other manual labour. It is also very common for Tobagonians to walk to work, to the market, or to social activities. Such an active lifestyle may explain the slower rate of decline in grip strength with age that we observed in our cohort compared with past studies. Although number of hours walking per week was positively associated with grip strength in the univariate analysis, there are no lifestyle factors that were significant in the multivariate analysis. This phenomenon may be due to the fact that physical activity is related to grip strength, but was confounded by BMI.

While Afro-Caribbean men in our study showed a slower loss of grip strength with age compared with other ethnic groups, the factors associated with stronger grip strength in cross-sectional analysis and the determinants of loss of grip strength longitudinally were similar to the findings from
Afro-Caribbean men

Table 2. Independent correlates of baseline grip strength and change in grip strength during 4 years of follow-up in Afro-Caribbean men

<table>
<thead>
<tr>
<th>Correlates</th>
<th>Units</th>
<th>Baseline grip strength</th>
<th>Change in grip strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>β (SE)</td>
<td>P-value</td>
</tr>
<tr>
<td>Age</td>
<td>5 years</td>
<td>−1.81 (0.12)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Body mass index</td>
<td>1 SD (4.33 kg/m²)</td>
<td>−1.69 (0.26)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Arm lean mass</td>
<td>1 SD (1.44 kg)</td>
<td>4.86 (0.28)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Yes/No</td>
<td>−1.64 (0.07)</td>
<td>0.0148</td>
</tr>
<tr>
<td>Baseline grip strength</td>
<td>1 SD (10.01 kg)</td>
<td>−4.54 (0.23)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Change in arm lean mass during follow-up (kg)</td>
<td>1 SD (6.95 kg)</td>
<td>11.26 (2.01)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td>0.4372</td>
<td>0.2725</td>
</tr>
</tbody>
</table>

Note: To eliminate collinearity, BMI was used as an indicator variable for weight and height. Arm lean mass was used as an indicator variable for total lean mass, total fat mass and leg lean mass.

†β (SE): regression coefficient estimate (standard error).

other study populations. We found that a higher BMI was associated with lower grip strength measured at baseline as well as greater loss of grip strength during follow-up in Afro-Caribbean men. Body weight was also inversely associated with muscle strength in other study populations [29–31]. In the current study population, lower arm lean mass measured at baseline and greater losses of arm lean mass during follow-up contributed to a greater decline in muscle strength. Similar findings were also observed in other studies [29, 32]. However, some studies suggest that muscle mass might not play a substantial role in the variations of muscle strength loss with age [13, 29, 33]. Nonetheless, much of the variation in grip strength loss with age could not be explained by age, body mass, body composition or lifestyle factors and remains to be defined.

Afro-Caribbean men who had greater baseline grip strength experienced a more rapid strength decline during follow-up compared with those with lower grip strength at study entry. This finding is consistent with previous reports in older Caucasian American men [28]. Rantanen et al. [34] also reported a significant negative correlation between baseline knee and trunk muscle strength and the change in muscle strength among men and women. Goodpaster et al. found an independent association between higher baseline muscle strength and greater loss of muscle strength during 3 years among older men and women [33]. This phenomenon might be due to regression to the mean, or suggest that older adults with greater initial muscle strength may experience a larger strength decline with ageing.

We were unable to document a relationship between several variables and muscle strength or its change with age. In particular, prostate cancer and its treatment with androgen deprivation have been correlated with a decline in muscle strength in past studies [35, 36]. Although prostate cancer is more common among African than Caucasian ancestry populations, we did not observe an association between prostate cancer and muscle strength measured at baseline or with its change during follow-up in our analysis. Since no participants used androgen deprivation therapy at baseline in our study, we were unable to evaluate the relationship between androgen deprivation therapy and muscle strength.

Although our study is the first population-based study to describe the patterns and correlates of muscle strength loss with age in a large cohort of African ancestry individuals, there are some limitations that should be acknowledged. Data on lifestyle and health-related factors were derived from self-report and are thus subject to potential recall bias. Several factors that were related to muscle strength in previous studies, including depression [22], low vitamin D levels [23] and certain biomarkers, such as interleukin-6, tumour necrosis factor-α and carotenoids [24], were not available in the current study. The decline in mean grip strength with age was linear in cross-sectional analysis, but grip strength increased before 50 years in the longitudinal analyses. This disparity might be due to the fact that the participants who were included in the current analysis were younger and healthier compared with those who did not provide follow-up data and thus were excluded from analysis. Longer follow-up time and multiple time points of measurements may be necessary to generate more precise assessments of the magnitude of grip strength loss with age.

In summary, we found that hand grip strength increased until age 50 years in this cohort of community-dwelling Afro-Caribbean men and decreased significantly thereafter. There was considerable inter-individual variability in the rate of decline of grip strength after age 50 years and much of this variability remains to be explained. Further studies are clearly needed to better understand the factors responsible for the loss of muscle strength with ageing, such as physiological and clinical factors, in racially diverse populations.

Key points

- Afro-Caribbean men showed a slower loss of grip strength with age compared with other ethnic groups.
- The major independent factors associated with strength loss were similar to other ethnic groups.
- Besides older age, body mass index and arm lean mass were associated with strength loss.
Conflicts of interest

None declared.

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Supplementary data

Supplementary data mentioned in the text is available to subscribers in Age and Ageing online.

References

The cost of stroke and transient ischaemic attack in Ireland: a prevalence-based estimate

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Abstract

Background: stroke is a leading cause of death and disability globally. The economic costs of stroke are high but not often fully quantified. This paper estimates the economic burden of stroke and transient ischaemic attack (TIA) in Ireland in 2007.

Methods: a prevalence-based approach using a societal perspective is adopted. Both direct and indirect costs are estimated.

Results: total stroke costs are estimated to have been €489–€805 million in 2007, comprising €345–€557 million in direct costs and €143–€248 million in indirect costs. Nursing home care and indirect costs together account for the largest proportion of total stroke costs (74–82%). The total cost of TIA was approximately €11.1 million in 2007, with acute hospital care accounting for 90% of the total.