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ORIGINAL ARTICLE

Handgrip Strength but not Appendicular Lean Mass is an Independent Predictor of Functional Outcome in Hip-Fracture Women: A Short-Term Prospective Study

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Abstract

Objective: To investigate the contribution of muscle mass and handgrip strength in predicting the functional outcome after hip fracture in women.

Design: Observational study.

Setting: Rehabilitation hospital.

Participants: White women (N=123 of 149) who were consecutively admitted to a rehabilitation hospital because of their first fracture of the hip.

Interventions: Not applicable.

Main Outcome Measures: We measured appendicular lean mass (aLM) by dual-energy x-ray absorptiometry (DXA) 21.1±8.7 (mean ± SD) days after hip fracture occurrence in the 123 women. On the same day, we assessed grip strength at the nondominant arm with a dynamometer. At the end of acute inpatient rehabilitation we measured the ability to function in activities of daily living by using the Barthel Index, and lower limb performance by using the Timed Up and Go (TUG) test.

Results: We found significant correlations between handgrip strength measured before rehabilitation and Barthel Index scores after rehabilitation ($\rho=.50$; $P<.001$), Barthel Index effectiveness ($\rho=.45$; $P<.001$), and the TUG test ($\rho=-.41$; $P<.001$). Conversely, we found no significant correlations between aLM/height^2 and Barthel Index scores after rehabilitation ($\rho=.075$; $P=.41$), Barthel Index effectiveness ($\rho=.06$; $P=.53$), or the TUG test ($\rho=.005$; $P=.96$). Significant associations between grip strength and all the outcome measures persisted after adjustment for 8 potential confounders, including Barthel Index scores before rehabilitation, age, number of medications, number of comorbidities, pressure ulcers, concomitant infections, time between fracture occurrence and assessment, and aLM/height^2.

Conclusions: Grip strength, but not DXA-assessed aLM, significantly predicted short-term functional outcome in women after a hip fracture.

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A decrease in muscle mass accompanies aging, as shown by several longitudinal studies.[1,2] Muscle loss is associated with mobility disorders, an increased risk of falls, a reduced ability to function in activities of daily living, a loss of independence, frailty, and a reduced life expectancy.[3-7] However, the reduction in muscle mass found in older persons does not fully account for the loss in muscle function. In particular, muscle strength does not depend solely on muscle mass, and the relationship between mass and strength is not linear.[8,9] That is why it is recommended to take into account both muscle mass and function for the diagnosis of the geriatric syndrome termed *sarcopenia*, which is strongly associated with unfavorable clinical outcomes in older people.[10,11]

Hip fracture often occurs in frail persons,[12,13] and it is associated with a high risk of both death and disability. After hip fracture, there is an 8% to 36% excess mortality within 1 year,[14] and approximately 20% of hip fracture survivors require long-term nursing home care, whereas only 40% fully regain their preinjury level of independence.[15]

Sarcopenia is thought to play a role in the genesis of hip fracture because it enhances the risk of falling,[16] and nearly all hip fractures occur as a result of a fall in individuals with reduced

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bone strength.[15] Furthermore, the loss of muscle tissue is strictly linked with the loss of bone mass and strength,[17-19] and a high prevalence of low muscle mass together with its association with low bone mass has actually been shown in women with hip fracture.[20,21]

Besides enhancing fracture risk, sarcopenia may increase the risk of poor functional outcome after fracture occurrence, but the relationship between muscle mass, muscle strength, and functional recovery has not been fully elucidated in this group of frail subjects.

Our aim was to investigate the relative contribution of muscle mass and handgrip strength in predicting the functional outcome after hip fracture in women. We hypothesized that muscle strength but not mass could influence both the ability to function in activities of daily living and lower limb performance after a hip fracture.

Methods

Participants

The study was performed in a city with about 1 million inhabitants. We evaluated 149 white women without cognitive impairment (Mini-Mental State Examination score >23) and without prevalent motor impairment caused by neurologic diseases, who were consecutively admitted to our physical medicine and rehabilitation division because of their first hip fracture during an 18-month period (between January 2012 and June 2013). We focused on white patients because few nonwhite elderly subjects live in our country. The women came from several orthopedic wards from various hospitals and were referred for acute inpatient rehabilitation by the consultant physiatrists of the orthopedic wards. The criteria agreed on for selecting women with hip fractures to undergo acute inpatient rehabilitation were as follows: (1) health conditions allowing a total of 3 hours of physical therapy and/or occupational therapy daily; (2) weight-bearing to tolerance on the fractured hip; and (3) a potential high increase in ability to function in activities of daily living as a result of an intensive rehabilitation regimen.

Six of the 149 patients we evaluated were excluded from our study because their hip fractures resulted from either major trauma or cancer affecting bone. The remaining 143 women sustained fractures that either were spontaneous or resulted from minimal trauma (trauma equal to or less than a fall from a standing position). Two of these women were excluded from our study because they had hip or knee arthroplasties that could alter dual-energy x-ray absorptiometry (DXA) assessment. The remaining 141 subjects were asked to undergo a DXA scan. One of these 141 subjects refused to undergo DXA assessment and was excluded from the study. The 140 remaining women gave their informed consent to participate in the study. Two women could not complete inpatient rehabilitation because of acute concomitant diseases, and 15 women were not able to walk independently at discharge and could not perform the Timed Up and Go (TUG) test.

List of abbreviations:

aLM	**appendicular lean mass**
DXA	**dual-energy x-ray absorptiometry**
ht	**height**
LM	**lean mass**
TUG	**Timed Up and Go**

The final study sample included 123 women whose data were included in the main analyses. Data from the 15 patients who were not able to ambulate independently at the end of the rehabilitation course were recorded, and we included them in additional analyses on the available outcome measures.

Our rehabilitation protocol included 3 hours a day for 5 days a week of physical exercise to improve strength and balance, advice and training on the use of assistive devices, and training in mobility tasks and activities of daily living conducted by physical therapists and occupational therapists. At least 3 hours during the stay in the rehabilitation hospital were dedicated by a skilled occupational therapist to suggest targeted modifications of the home environment and behavioral changes to prevent falls. The criterion for discharge from rehabilitation was the achievement of the highest possible Barthel Index score (as judged by the responsible physiatrist) in the 3 following items: dressing, transfers, and walking. Institutional Review Board approval was obtained for the study protocol.

Outcome measures

DXA (Discovery Wi[a]) was used to measure whole and regional body composition. Appendicular lean mass (aLM) was calculated as the sum of lean mass (LM) in the arms and legs. Because metal implants (prostheses, plates, screws, nails) were reported to affect the regional assessment of body composition with overestimation of LM,[22] and to avoid the confounding role of postoperative edema, we corrected aLM by substituting LM in the unfractured leg for LM in the fractured leg, as previously described[23,24]: corrected aLM $=$ (LM in unfractured leg $\times$ 2) $+$ LM in arms.

LM cannot be interpreted without some indexing to body size: it is necessary to account for height when comparisons are performed among different subjects. Height was assessed by a standard method (with the patients standing) in most of the patients, whereas 4 subjects, who could not keep the standing position, were measured supine. We accounted for body size by dividing corrected aLM by height (ht) squared (aLM/ht^2).[3,4,10,11]

Handgrip strength was measured with a Jamar hand dynamometer[b] on the same day of DXA scan in each subject. Testing was performed with participants in the sitting position and with their shoulder adducted and neutrally rotated, elbow flexed at 90° with the forearm in the neutral position, and wrists between 0° and 30° of flexion and between 0° and 15° of ulnar deviation. The best recorded of 3 attempts of maximal voluntary contraction using the nondominant arm, performed at 1-minute intervals, was considered for analyses.

In each patient we recorded age, number of medications in use, presence of pressure ulcers (stage 2 or higher according to the classification from the National Pressure Ulcer Advisory Panel), number of concomitant diseases (all the prevalent diseases judged clinically relevant during the length of stay), infections ($\geq$1 infection needing antibiotic therapy during the stay in hospital), and time interval between fracture occurrence and DXA scan as potential confounders.

Functional evaluation, both at rehabilitation admission and at discharge from the rehabilitation hospital, was assessed by skilled physiatrists by using the Barthel Index (original version unchanged). The functional index assesses basic activities of daily living; its score ranges from 0 (total dependence) to 100 (total independence). The physiatrists were not aware of the results of the DXA assessment and handgrip strength measure at the time of Barthel Index score evaluation. Barthel Index effectiveness was