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LETTER TO THE EDITOR

Muscular maximal strength indices and bone variables in a group of elderly men

Les indices de la force musculaire maximale et les paramètres osseux chez un groupe d'hommes âgés

Introduction

We have recently shown that bone mineral density (BMD) at different sites, hip geometry indices and L1—L4 TBS are positively correlated with lower limb muscle strength in elderly women [1]. In the present study, we sought to extend these findings and explore the relations between maximal muscular strength indices and DXA-variables in elderly men. This study included 17 healthy elderly men whose ages range between 65 and 75 years. They were randomly selected from an autonomous and independent population, living in their ordinary environment in north Lebanon. Participants were healthy and not engaged in any muscle strengthening program neither before nor during the study. Exclusion criteria included: smoking, alcoholism, history of major orthopedic problems or other disorders known to affect bone metabolism. This study was approved by the ethical committee of the University of Balamand, and written informed consent was obtained from all participants.

Height (cm) was measured in the upright position to the nearest 1 mm with a standard stadiometer. Body weight (kg) was measured on a mechanic scale with a precision of 100 g. Lean mass (LM) and fat mass (FM) were evaluated by DXA (GE Lunar Healthcare, Madison, WI, USA). BMD (g/cm^2) at the whole body (WB), L1—L4, total hip (TH), and femoral neck (FN) were determined using DXA. TBS (L1—L4) that reflects bone texture was evaluated by DXA using the TBS iNsight software (version 2.1.0.0). HSA program was used to evaluate FN cross-sectional area (CSA, mm^2), section modulus (Z, mm^3), cross-sectional moment of inertia (CSMI, mm^4), strength index (SI) and buckling ratio (BR) [2].

All muscle strength variables were measured as previously described [1]. For upper limb strength, maximal muscle strength of bench press (1-RM bench press) was measured using a bench installed in a permanent position on a Smith machine [1,3] and handgrip (HG) was measured using hand-held calibrated dynamometer [1,4]. For lower limb strength, maximal muscle strength of leg press (1-RM leg press) was measured using a horizontal leg press machine.

Associations of bone variables with anthropometric and muscle strength measures were tested using Pearson's or Spearman's rank correlation. We used stepwise multiple regressions to assess the independent contributions of the independent variables that were significantly correlated with each bone parameter. Differences were considered significant at P-value $\leq$ 0.05. Data were analyzed using SPSS 20 for windows release (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY, USA).

Thirty-five percent were osteopenic and 47.1% were osteoporotic at the L1—L4. Fifty-nine percent were osteopenic and 17.6% were osteoporotic at the FN.

Relationships between age, anthropometric measures, muscle strength parameters and bone measurements are shown in Table 1. Age was negatively correlated with FN CSA, CSMI, and Z (moderate correlation, $P < 0.05$). Body weight and LM were positively correlated with BMD at all sites and with CSA, CSMI, and Z at the FN (moderate and strong correlation, $P < 0.05$). Fat percentage was not correlated to any of the bone variables. 1-RM bench press was positively correlated with BMD at all sites and with CSA, CSMI, and Z at the FN (strong correlation, $P < 0.05$). 1-RM leg press was positively correlated with WB BMD, FN BMD, TH BMD, FN CSA ad FN Z (strong correlation, $P < 0.05$). Handgrip was strongly correlated only with FN BMD and FN CSA ($P < 0.05$). Multiple linear regressions demonstrated that 1-RM bench press was the single most predictive factor of WB BMD, LS BMD, FN CSMI, and FN Z accounting for 48.7%, 40.5%, 68.2%, and 63.9% of their variations respectively. LM was the most predictive factor of FN BMD, TH BMD and FN CSA accounting for 55.3%, 64.8% and 68.6% of their variations respectively.

Discussion

The major finding in our study is that interactions between muscle and bone persist in older men. Lean mass, 1-RM bench press and 1-RM leg press were strongly correlated

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Table 1 Associations between age, anthropometric measures, muscle strength parameters and bone measurements.

	Age (years)	Weight (kg)	BMI (kg/m^2)	FM (%)	LM (kg)	1-RM bench press (kg)	1-RM leg press (kg)	Handgrip (kg)
WB BMD	−0.252	**0.592**[a]	0.422	0.270	**0.603**[a]	**0.652**[b]	**0.613**[b]	0.437
LS BMD	−0.387	**0.560**[a]	**0.488**[a]	0.382	**0.578**[a]	**0.551**[a]	0.422	0.290
FN BMD	−0.250	**0.534**[a]	0.375	0.159	**0.686**[b]	**0.625**[b]	**0.679**[b]	**0.501**[a]
TH BMD	−0.393	**0.674**[b]	**0.500**[a]	0.304	**0.684**[b]	**0.721**[b]	**0.804**[b]	0.392
FN CSA	**−0.506**[a]	**0.613**[b]	0.420	0.226	**0.810**[b]	**0.831**[b]	**0.666**[b]	**0.598**[a]
FN CSMI	**−0.520**[a]	**0.490**[a]	0.350	0.211	**0.662**[b]	**0.691**[b]	0.397	0.461
FN Z	**−0.525**[a]	**0.510**[a]	0.316	0.172	**0.672**[b]	**0.713**[b]	**0.568**[a]	0.481
FN SI	−0.251	−0.284	−0.321	−0.396	−0.082	−0.194	0.027	−0.146
FN BR	0.026	0.118	0.256	0.227	0.034	0.015	−0.016	0.216
L1—L4 TBS	0.112	−0.151	0.061	−0.194	−0.355	−0.233	−0.017	−0.128

The results shown represent *r* values. Note: significant *P*-values are in bold. BMI: body mass index; FM: fat mass; LM: lean mass; WB: whole body; FN: femoral neck; TH: total hip; BMD: bone mineral density; CSA: cross-sectional area; CSMI: cross-sectional moment of inertia; Z: section modulus; SI: strength index; BR: buckling ratio; TBS: trabecular bone score.
[a] $P < 0.05$.
[b] $P < 0.01$.

with bone mass of different osteoporotic sites and with several HSA-derived factors. These positive associations could be explained by the mechanostat theory of Frost and the genetic and hormonal factors that influence both muscle and bone [5].

Correlations between muscle strength and bone phenotype in elderly individuals are not necessarily site-specific [1]. 1-RM bench press was the single most predictive factor of bone variables even in regions where muscles have no insertions. It was significantly correlated with BMD at the lumbar spine and FN and with bone geometry at the FN. One plausible explanation is that relationship between muscle and bone can be local as well as systemic depending on other factors such as hormones.

Our data are consistent with the results of a previous study evaluating the impact of lean mass and muscle strength on bone [5]. To our knowledge, our study is the first in the literature to determine correlations between muscle strength and TBS in elderly men. In contrast to our previous study established on elderly women, TBS was not correlated with 1-RM leg press. The reason for this discrepancy is not clear. We cannot be certain whether additional factors including genetic factors and nutritional status, impact the relationship between muscle strength and TBS. Further studies with larger samples to confirm such finding in elderly men are warranted.

Our study is unique as several muscle strength measurements have been correlated with several DXA-variables in elderly men. Available data are limited to young individuals and post-menopausal women and to a specific technology i.e. QCT. Our study has some limitations. First, the cross-sectional nature of the study limits our ability to establish a direct causal relationship between muscle strength and bone variables. Second, the low number of participants may have prevented us from reaching some statistical significance. Further studies with larger samples are needed to confirm our results and to clarify the effect of muscle strength on bone variables.

In conclusion, this study suggests that 1-RM bench press and 1-RM leg press positively correlated with several DXA-variables such as BMD and FN geometry. Such findings may be clinically important. Promoting regular and systemic resistance training in order to minimize the decline in muscle strength in this population could be effective to reduce bone loss and prevent further deterioration of FN geometry.

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Disclosure of interest

The authors declare that they have no competing interest.

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