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ORIGINAL ARTICLE

Factors related to muscle strength in postmenopausal women aged younger than 65 years with normal vitamin D status

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ABSTRACT

Objective: The study aimed to determine the impact of age, age at menopause, body mass index (BMI), and lumbar and hip bone mineral density (BMD) on muscle strength in young postmenopausal women with normal vitamin D levels.
Methods: This was a cross-sectional study performed in 392 postmenopausal women aged <65 years with normal serum 25-hydroxyvitamin D levels (≥ 30 ng/ml) and no physical disabilities. The following variables were recorded: age, age at menopause, BMI, BMD (measured by dual-energy X-ray absorptiometry [DXA] scanning and expressed as lumbar and hip *T*-scores), and dominant hand grip strength (measured with a digital dynamometer). Results are reported as mean ± standard deviation or odds ratio (OR) and 95% confidence interval (CI) as appropriate.
Results: The mean age of the whole sample was 57.30 ± 3.69 years with a mean age at menopause of 50.46 ± 2.16 years and a mean BMI of 24.93 ± 3.78. Mean DXA results were lumbar *T*-score of −1.16 ± 1.18 and hip *T*-score of −0.98 ± 0.93. The mean dominant hand grip force was 24.10 kg. A total of 12.2% (48/392) of women were diagnosed with dynapenia using a cut-off value of <20 kg. A weak but significant inverse correlation was found between grip strength in the dominant hand and age ($r = -0.131$, $p = 0.009$). Multivariable logistic regression analysis determined that earlier age at menopause (50 years or younger) was significantly associated with a higher risk of dynapenia (OR 2.741, 95% CI 1.23–6.11, $p = 0.014$). No other significant association was found with the other variables.
Conclusions: A total of 12.2% of the studied young postmenopausal women with normal vitamin D status had dynapenia. There was a weak inverse correlation between grip strength and age, and earlier age at menopause was associated with an increased dynapenia risk.

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Introduction

During the menopausal transition and the early postmenopausal years, the decline of estrogen levels causes loss of bone mass due to an imbalance between bone resorption and formation, in addition to a reduction of muscle mass and strength and a redistribution of body fat from the periphery to the abdominal region[1–3]. In recent years, there has been growing interest in dynapenia and its association with body mass index (BMI) and nutritional status. Dynapenia is defined as the age-related loss of muscle strength that is not caused by neurological or muscular diseases[4]. Muscle strength has been associated with bone mass. Indeed, loss of grip force has been related to low bone mineral density (BMD) in both lumbar and hip sites, and to an increased risk of vertebral fracture[5,6]. Hand grip strength can be measured with a hand dynamometer, which is a simple test that evaluates the isometric strength of the hand and forearm and correlates well with leg strength. It has also been suggested as a predictor of nutritional status[7,8].

In clinical practice, BMI is used to assess nutritional status, considering weight and height, although this index does not ensure an adequate evaluation of body composition[9]. Body weight has been associated with BMD, but when body composition is analyzed by dual-energy X-ray absorptiometry, the most important component related to bone mineral status in women is total body fat[10]. The age-related changes that occur in mid-aged women are largely due to muscle mass loss and abdominal adiposity increase, which account for the muscle weakness and decreased muscle strength. This is a process known to begin during the fourth decade of life and to accelerate after the sixth decade, and is even faster after prolonged periods of physical inactivity[11–13].

Vitamin D plays an essential role in muscle function and is involved in maintaining gait, muscle tone, and balance[14]. This vitamin also exerts a significant influence on BMD by ensuring intestinal calcium absorption, thus preventing secondary hyperparathyroidism; and therefore reducing the risk of fractures in high-risk populations[15,16]. In postmenopausal women, low serum 25-hydroxyvitamin D (25(OH)D) levels have been associated with low muscle strength and an increased risk of falls and osteopenia[17,18]. Despite these facts, the association between age and age at menopause and muscle strength and dynapenia risk in postmenopausal women with sufficient vitamin D is still not clear. The

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objective of this study was to determine the impact of age, age at menopause, BMI, and lumbar and hip BMD on muscle strength in young postmenopausal women with normal vitamin D levels.

Materials and methods

Study design and participants

This was a cross-sectional study comprising 392 otherwise healthy white Spanish postmenopausal women, aged 49–64 years, who were assessed in 2017 at the Department of Obstetrics, Gynecology and Reproduction, Dexeus Hospital, Barcelona, Spain including their muscle strength, BMI, and BMD. The study was approved by the Institutional Review Board of the Clinical Center. Informed consent was obtained from all participants who met inclusion criteria: being naturally postmenopausal (amenorrhea of 1 year or more before the initiation of the study), vitamin D levels $\geq$ 30 ng/ml, and no physical disability. Exclusion criteria included use of menopausal hormonal treatment, poorly controlled chronic diseases, smoking more than five cigarettes daily, consumption of more than two units of alcohol daily, sedentary lifestyle, surgical menopause, and a history of cancer.

Hand grip strength was measured with a digital dynamometer CAMRY EH101™ calibrated in kilograms. The measurement was carried out with the arm against the side and the elbow bent to a 90° angle. The assessment was performed two times with each hand and the maximum value for each hand was recorded. Dynapenia was diagnosed in women whose dominant hand force was less than 20 kg[8]. This cut-off value was established in accordance with the proposal of the European Working Group on Sarcopenia in Older People[8].

BMI was calculated as the weight in kilograms divided by the square of the height in meters after weighing and measuring participants without shoes and wearing a disposable gown. BMI categories were established according to WHO criteria[19] as low (<18.50 kg/m^2), normal (18.50–24.99 kg/m^2), and high that included overweight ($\geq$25.0–29.99 kg/m^2) and obesity ($\geq$30.0 kg/m^2). BMD was measured by dual-energy X-ray absorptiometry scanning (Lunar-General Electric™), rendering hip and lumbar *T*-scores which were used to classify women's BMD status according to WHO criteria[20].

Serum 25(OH)D concentrations were assessed by a chemiluminescent immunoassay (DiaSorin 25-OH-Vitamin D Assay Kit) in an automated LIASON® analyzer (DiaSorin, Italy). The detection limit was 4.0 ng/ml. Women with sufficient levels of vitamin D were included, considering serum concentrations of 25(OH)D $\geq$ 30 ng/ml[21]. The range of our participants was 30–61 ng/ml.

Sample size calculation was based on the fact that 10% of women present dynapenia in the postmenopausal years. Hence, a minimal sample of 270 women was calculated considering a 10% precision and a 90% confidence level.

Statistical analysis

The data were analyzed using SPSS version 22.0 (IBM, Armonk, NY, USA). For the descriptive analysis the data are presented as means, standard deviations, and minimum and maximum values (numerical variables), and for the categorical variables as frequencies and percentages. The Kolmogorov–Smirnov test was used to determine the normality of data distribution and the Bartlett test to evaluate the homogeneity of the measured variance.

Bivariate correlations between muscle strength in the dominant hand and each numerical variable were analyzed with Pearson's correlation coefficients (for parametric data). Subsequently, a multiple linear regression analysis was performed taking dominant hand muscle strength as the dependent variable and age, BMI, lumbar *T*-scores, and hip *T*-scores as covariates. Finally, multivariable logistic regression analysis was performed in order to determine factors related to the risk of presenting dynapenia (as the dependent variable). Independent variables to be included in the model were age, age at menopause, BMI, and bone mineral status, which were dichotomized using defined criteria (in the case of bone status) or median values as cut-off points (remaining variables). For all calculations, $p < 0.05$ was considered statistically significant.

Results

The mean age of participants was 57.30 ± 3.69 years, with a mean age at menopause of 50.46 ± 2.16 years. Mean grip strength in the dominant hand was 24.10 ± 3.88 kg, whereas non-dominant hand grip strength was 22.70 ± 3.99 kg. A total of 12.2% ($n = 48/392$) of the women were diagnosed with dynapenia. Mean BMI of the whole sample was 24.93 ± 3.78 kg/m^2 (0.80% low, 52.79% normal, 33.20% overweight, and 13.30% obesity). The mean lumbar *T*-score value was −1.16 ± 1.18 and the mean hip *T*-score was −0.98 ± 0.93 (Table 1).

Concerning the correlation analysis, a weak but significant inverse correlation was observed between the dominant hand muscle strength and women's age ($r = -0.131$, $p = 0.009$). A weak but significant positive correlation was observed between BMI and the non-dominant hand muscle strength. No other significant correlations were found with the other variables (Table 2 and Figure 1). A multiple linear regression analysis was performed where the dependent variable was the dominant hand muscle strength and the covariates were age, BMI, lumbar *T*-scores, and hip *T*-scores. As shown in Table 3, the only variable found to significantly correlate with dominant hand strength was women's age, thus indicating that the older the participants, the lower the dominant hand muscle strength (Table 3).

Finally, a multivariable logistic model was fitted in order to analyze the effect of various covariates over the risk of presenting

Table 1. Descriptive statistics of the 392 postmenopausal women participating in the study.

Characteristic	*Mean ± standard deviation*
Age (years)	57.30 ± 3.69
Body mass index (kg/m^2)	24.93 ± 3.78
Age at menopause (years)	50.46 ± 2.16
Lumbar *T*-score	−1.16 ± 1.18
Hip *T*-score	−0.98 ± 0.93
Dominant hand muscle grip strength (kg)	24.10 ± 3.88
Non-dominant hand muscle grip strength (kg)	22.70 ± 3.99

dynapenia. A significant increased association was found between an earlier age at menopause (50 years or younger) and the risk of presenting dynapenia (odds ratio = 2.741, 95% confidence interval 1.23–6.11, $p = 0.014$). No other significant association was found with the other variables (Table 4).

Table 2. Bivariate Pearson correlation analyses between hand muscle strength and age, body mass index, and lumbar and hip *T*-scores.

Covariate	*Dominant hand muscle strength*	*Non-dominant hand muscle strength*
Age	−0.131 ($p = 0.009$)	−0.086 ($p = 0.090$)
Age at menopause	−0.033 ($p = 0.514$)	−0.023 ($p = 0.653$)
Body mass index (kg/m^2)	0.038 ($p = 0.457$)	0.109 ($p = 0.031$)
Lumbar *T*-score	0.021 ($p = 0.675$)	−0.019 ($p = 0.713$)
Hip *T*-score	0.007 ($p = 0.892$)	0.005 ($p = 0.915$)

Discussion

Postmenopause and advancing age lead to a series of changes over the years that affect muscle strength, body

Table 3. Multiple linear model analyzing the correlation between muscle strength of the dominant hand (numerical variable) and age, body mass index, and lumbar and hip *T*-scores (also numeric variables).

Variable	*Beta*	*Lower 95% confidence interval*	*Upper 95% confidence interval*
Age	−0.148	−0.255	−0.042
Body mass index (kg/m^2)	0.063	−0.042	0.169
Lumbar *T*-score	0.028	−0.405	0.461
Hip *T*-score	−0.078	−0.629	0.472

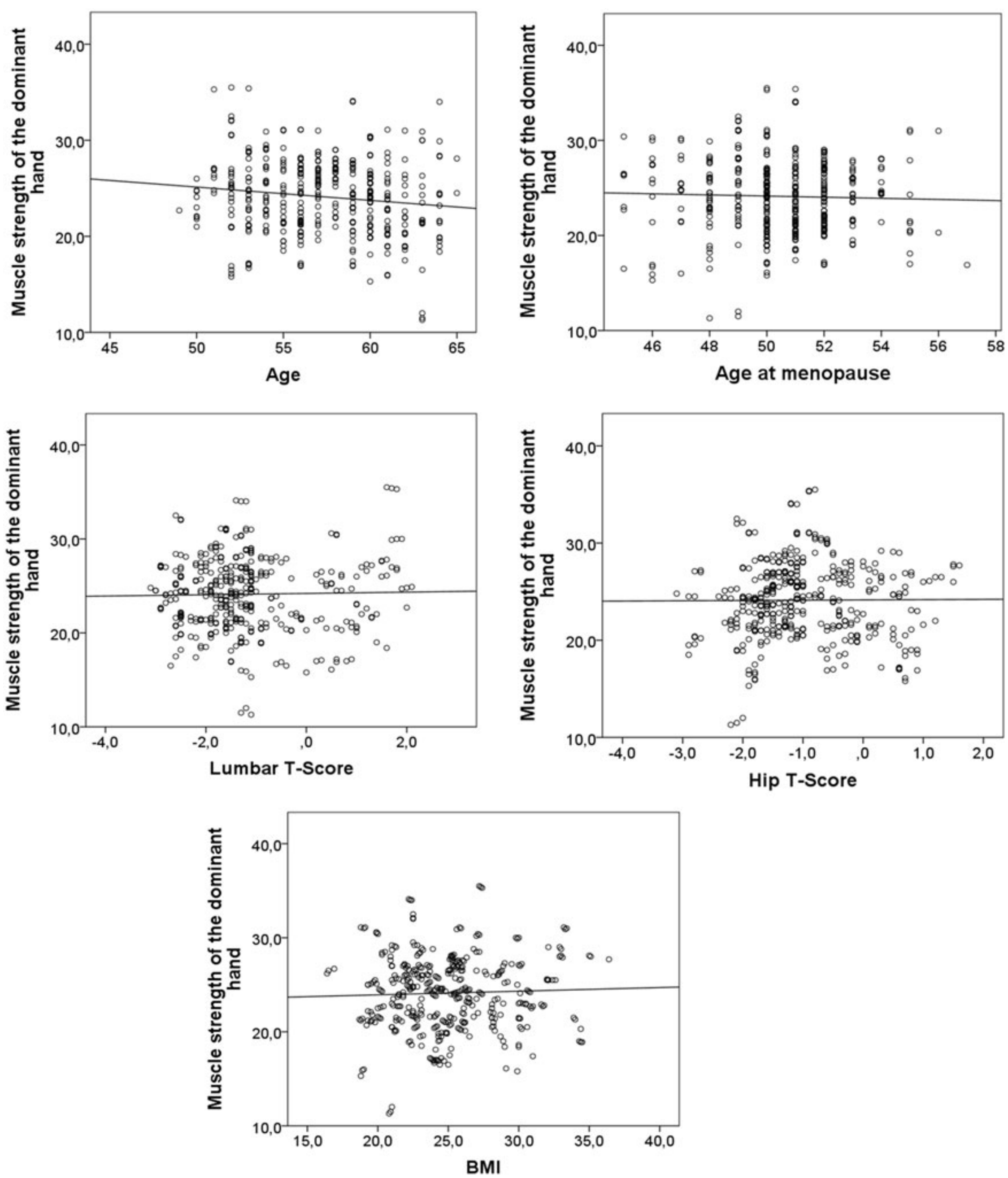

Figure 1. Correlations between dominant hand muscle grip strength and age, age at menopause, lumbar *T*-score, hip *T*-score, and body mass index (BMI).

Table 4. Logistic regression model analyzing the effect of age, age at menopause, body mass index, and bone status over the risk of presenting dynapenia.

Variable	Odds ratio	95% confidence interval	p-Value
Age			
≥55 years	2.154	0.91–5.11	0.082
<55 years (reference)	1	–	–
Age at menopause			
≤50 years	**2.741**	**1.23–6.11**	**0.014**
>50 years	**1**	–	–
Body mass index			
>28 kg/m^2	0.532	0.22–1.28	0.160
≤28 kg/m^2	1	–	–
Lumbar osteopenia			
Yes	0.581	0.25–1.33	0.200
No	1	–	–

composition (changes in BMI), and bone mass quantity and quality (changes in BMD). There is a simple, quick, and reproducible test for the assessment of muscle strength that consists of measuring handgrip muscle strength with a dynamometer. The hand grip test has been reported to show a good correlation with other tests used to assess dynapenia (chair-stand test or one-leg stance test)[22]. This measurement can also serve as a predictive value of the individual's brain function, physical vulnerability, and even mortality[23–26]. Furthermore, it seems that the association between muscular strength and adverse event tends to be stronger in women than in men[24].

According to the proposal of the European Working Group on Sarcopenia in Older People[8], our study found that 12.2% of women had dynapenia, which is relatively high despite the fact that our studied group was younger than 65 years old and had sufficient levels of vitamin D. Dynapenia may also correlate with nutritional status and physical activity. It seems that protein intake may have a significant role in maintaining muscle strength and performance, especially among older women (> 65 years)[27,28]. Since vitamin D levels were adequate in our studied population, dynapenia may have been related to nutrition and diet or a lack of sufficient physical activity.

When the muscle strength of people of a certain age and gender is measured, it may vary according to geographic region and ethnicity, hence these factors should be taken into account when the results of the measurements are assessed[29]. Handgrip strength measurements were found to be within the range of normal values established by age in healthy adults of other studies conducted in our country[30]. We also observed that handgrip strength inversely, yet weakly, correlated with age. Indeed, for each year that age increases, hand grip strength decreases. Interestingly, our study found that earlier age at menopause was significantly associated with a higher risk of dynapenia, hence the decreased muscle strength. Our results must be interpreted in the context of young postmenopausal women (age <65 years), in whom the time elapsed since menopause is smaller as compared to that observed in older populations. This implies that women of a similar age independently increase the risk of losing strength in a proportionate way for each year after menopause onset, demonstrating perhaps the protective effect related to ovarian estrogenic production. One study reported an increase in muscle strength during menopause hormone therapy[31]; whereas in another study such treatment did not improve the baseline physical function (grip strength, chair stands, and timed walk) in women aged 65 years or older[32].

The analysis of BMD revealed that mean *T*-scores were in the range of osteopenia for the lumbar site and normality for the hip. No correlations were found between *T*-scores at both sites and handgrip strength, unlike other studies that have found an association between low grip strength and low hip and lumbar BMD[33].

Assessment of BMI in our study showed that although the calculated mean BMI for all women was in the normal range, up to 46.5% of them were overweight/obese. We also did not find any correlation between BMI and handgrip strength, although some studies have found a weak correlation[34]. Vitamin D deficiency is known to affect a large part of the world's population. Some studies and systematic reviews report that more than 50% of the population is vitamin D deficient[35–37]. The same situation occurs in Spain, where despite being a sunny country paradoxically the population presents lower levels than Nordic countries, which are already accustomed to supplementing their diet with vitamin D due to fewer hours of sun exposure[38–40]. In our department, we have been prescribing vitamin D supplements for more than 5 years to individuals with insufficiency. Although the minimum desirable levels of 25(OH)D in the entire population should be higher than 20 ng/ml, it would be advisable for postmenopausal women to have vitamin D levels of around 30 ng/ml to reduce the risk of fractures and falls[41,42].

Our study has the limitation that all recruited women had normal vitamin D levels, due to either sufficient sun exposure or vitamin D supplementation. Therefore, no comparison was made with a group of participants with similar characteristics and hypovitaminosis D. Secondly, we did not obtain information regarding the individual degree of physical activity and exercise which could have influenced muscle strength.

In conclusion, a 12.2% rate of dynapenia was observed in this series of young postmenopausal women and normal vitamin D status. There was a weak inverse correlation between grip strength and age, and earlier age at menopause was associated with an increased dynapenia risk.

Conflict of interest The authors declare no conflicts of interest.

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