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# Ageing influence in the evolution of strength and muscle mass in women with fibromyalgia: the al-Ándalus project

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**Abstract** Fibromyalgia is associated with physical disabilities in daily activities. Moreover, patients with fibromyalgia present similar levels of functional capacity and physical condition than elderly people. The aim of this study was to analyse the evolution of strength and muscle mass in women with fibromyalgia along ageing. A total sample of 492 fibromyalgia patients and 279 healthy control women were included in the study. Participants in each group were further divided into four age subgroups: subgroup 1: 30–39 years old, subgroup 2: 40–49 years old, subgroup 3: 50–59 years old and subgroup 4: 60–69 years old. Standardized field-based fitness tests were used to assess muscle strength (30-s chair stand, handgrip strength and arm curl tests). Fibromyalgia patients did not show impairment on muscle mass along ageing, without values of skeletal muscle mass index below 6.76 kg/m$^2$ in any group. However, in all variables of muscle strength, the fibromyalgia group showed less strength than the healthy group ($p < 0.05$) for all age groups. As expected, handgrip strength test showed differences along ageing only in the fibromyalgia group ($p < 0.001$). Age was inversely associated with skeletal muscle mass ($r = -0.155$, $p < 0.01$) and handgrip strength ($r = -0.230$, $p < 0.001$) in the FM group. Women with fibromyalgia showed a reduction in muscle strength along ageing process, with significantly lower scores than healthy women for each age group, representing a risk of dynapenia.

**Keywords** Muscle strength · Ageing · Body composition · Fibromyalgia · Dynapenia

## Introduction

Ageing has been associated with frailty and functional limitation due to three factors: an irreversible biological process, deconditioning due to sedentary lifestyle and the comorbidity effects [1]. Moreover, maximal voluntary strength production declines with age and contributes to physical dependence and mortality [2]. The age-associated reduction in skeletal muscle mass and strength has been defined as sarcopenia [3]. The term dynapenia is also used to further describe the age-related loss of muscle strength and power [4]. Dynapenia predisposes older adults to an increased risk of functional limitations and mortality [4]. Subclinical deficits in the structure and function of the nervous system and/or impairments in the intrinsic force-generating properties of skeletal muscle are potential antecedents to dynapenia [4].

Fibromyalgia (FM) is associated with physical disabilities in daily activities as walking, lifting and transportation of objects [5]. Patients with FM have lower levels of physical activity compared to healthy people [6] and lower levels of cardiopulmonary condition [8]. Moreover, patients with FM present similar levels of functional capacity and physical condition than elderly people [9, 10] and are prone to falls [11]. Accordingly, it may be that ageing in patients with FM has more serious consequences on physical function.

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Obtaining information regarding the decrease in muscle mass and strength in women with FM is important for a better understanding of the clinical impact of ageing in FM patients. Therefore, the aim of the present study was to analyse muscle mass and strength along the ageing process in women with FM.

## Materials and methods

### Participants

This cross-sectional study involved a total of 492 FM versus 279 healthy (control) women living in Andalusia (Spain). FM participants were recruited from different FM associations via e-mail, letter or telephone. We also recruited a group of healthy individuals with similar age, socio-demographic characteristics and demographic area in order to carry out appropriate comparisons between groups. All participants gave their written informed consent after receiving detailed information about the aims and study procedures. The inclusion criteria for FM participants were as follows: (1) to be previously diagnosed by a rheumatologist; (2) to meet the 1990 American College of Rheumatology (ACR) [12] FM criteria: widespread pain for more than 3 months and pain with at least 4 $kg/cm^2$ of pressure for 11 or more of 18 tender points; and (3) not to have acute illness and dementia [Mini-Mental State Examination (MMSE) <10] [13]. Fibromyalgia and healthy participants were divided into four age subgroups, respectively: (1) 30–39 years, (2) 40–49 years, (3) 50–59 years and (4) 60–69 years. The study was reviewed and approved by the ethics committee of the hospital *Virgen de las Nieves* (Granada, Spain).

### Material and procedures

A group of researchers from the al-Ándalusproject, previously trained in conducting the different test, controlled all testing sessions.

#### *Anthropometry and body composition assessment*

We used a portable eight-polar tactile-electrode impedanciometer (InBody R20, Biospace, Gateshead, UK) to measure weight (kg) and skeletal muscle mass (kg). The reliability of the measuring instruments in women with FM was measured by the research team group of al-Ándalus project, showing appropriate values of reliability [14]. Body mass index (BMI) was calculated as weight (in kilograms) divided by height squared (in metres). Sarcopenia was defined as a skeletal muscle mass index (SMMI) (skeletal muscle mass divided by height in metres squared) below 6.76 $kg/m^2$ [15]

#### *Socio-demographic and clinical characteristics data*

Socio-demographic and clinical information was recorded using a self-report instrument which included date of birth, marital status, educational status, current occupational status, *FM Impact Questionnaire (FIQ)* total score, tender points count and algometer score.

#### *Fibromyalgia symptomatology*

We used the Spanish version [16] of the FIQ [17] to assess the FM-related symptoms. It is composed of ten subscales: physical impairment, overall well-being, work missed and a seven items (subscales) of a visual analogue scale (VAS) marked in 1-cm increments on which the patient rates the work difficulty, pain, fatigue, morning tiredness, stiffness, anxiety and depression. The FIQ score ranges from 0 to 100. A higher value indicates a higher impact of the disorder [18].

#### *Physical fitness assessment*

The reliability of the measuring instruments in women with FM was conducted by the research team group of al-Ándalus project, showing appropriate values of reliability [19]

*Lower body muscular strength* The "30-s chair stand test" involves counting the number of times within 30 s that an individual can rise to a full stand from a seated position with back straight and feet flat on the floor, without pushing off with the arms. The arms were crossed at the chest level. The participant executed one trial after familiarization [20].

*Upper body muscular strength* Handgrip strength was assessed using a hand dynamometer with adjustable grip (TKK 5101 Grip D; Takey, Tokio, Japan). Optimal grip span was calculated using the formula suggested by Ruiz et al. [21]: $y = x/5 + 1.5$; being "$x$" the hand size, and "$y$" the grip length. Each participant performed two attempts with each hand, with the arm fully extended, forming an angle of 30° with respect to the trunk. The maximum score in kilograms for each hand was recorded, and the mean score of both hands was used in the analyses. Participants also performed the "Arm Curl test", which measures the maximum number of flex extensions that participants are able to run during 30 s, sitting on a bench and holding a dumbbell 2.3 kg [20]. The test was performed once with each arm. The mean of both arms was used in the analysis.

**Table 1** Demographic and clinical characteristics of the study sample by groups

| | FM group ($n = 492$) | | Healthy group ($n = 279$) | | *P* value |
|---|---|---|---|---|---|
| | *n* | Mean (SD) | *n* | Mean (SD) | |
| Age (years) | | | | | |
| 30–39 | 34 | 36.88 (2.17) | 34 | 35.76 (2.53) | 0.055 |
| 40–49 | 152 | 45.57 (2.49) | 97 | 46.11 (2.67) | 0.107 |
| 50–59 | 218 | 54.57 (2.59) | 104 | 54.51 (2.77) | 0.841 |
| 60–69 | 88 | 63.37 (2.31) | 44 | 63.43 (2.25) | 0.894 |
| Total | 492 | 52.14 (7.80) | 279 | 50.71 (8.51) | 0.018 |
| | | *n* (%) | | *n* (%) | |
| Marital status | | | | | |
| Married | | 372 (75.6) | | 204 (73.4) | 0.294 |
| Single | | 43 (8.7) | | 34 (12.2) | |
| Separated | | 15 (3.0) | | 13 (4.7) | |
| Divorced | | 37 (7.5) | | 17 (6.1) | |
| Widow | | 25 (5.1) | | 10 (3.6) | |
| Educational status | | | | | |
| No studies | | 53 (10.8) | | 19 (6.8) | 0.006 |
| Primary school | | 232 (47.2) | | 105 (37.6) | |
| Professional training | | 77 (15.7) | | 49 (17.6) | |
| Secondary school | | 61 (12.4) | | 45 (16.1) | |
| University medium degree | | 43 (8.7) | | 33 (11.8) | |
| University higher degree | | 26 (5.3) | | 28 (10.0) | |
| Current occupational status | | | | | |
| Working | | 120 (24.4) | | 118 (42.3) | <0.001 |
| Unemployed | | 88 (17.9) | | 45 (16.1) | |
| Sick leave | | 39 (7.9) | | 2 (0.7) | |
| Retired/pensioner | | 91 (18.5) | | 28 (10.1) | |
| Housewife | | 149 (30.3) | | 83 (29.7) | |
| Student | | 5 (1.0) | | 3 (1.1) | |
| | | Mean (SD) | | Mean (SD) | |
| FIQ total score | | 65.96(14.96) | | NA | |
| Tender points count | | 16.76 (1.92) | | 2.86 (2.94) | <0.001 |
| Algometer score | | 42.87(13.42) | | 109.45 (22.39) | <0.001 |

*SD* standard deviation, *FIQ* fibromyalgia impact questionnaire, *NA* not applicable

*Algometer score and tender points count* We assessed the 18 tender points (TP) count according to the American College of Rheumatology [12] criteria for classification of FM. A standard pressure algometer (EFFEGI, FPK 20, Italy) was used. The pain threshold at each TP was determined by applying increasing pressure with the algometer perpendicular to the tissue, at a rate of ~1 kg/s. Patients were asked to say "stop" when pressure became painful. The mean of two measurements at each TP was used for the analysis. TP scored as positive when the patient noted pain at pressure of 4 $kg/cm^2$ or less. The total of such positive TP was recorded as the individual's TP count. An *algometer score* was calculated as the sum of the pain–pressure values obtained for each TP.

## Statistical analysis

The normality of data was studied (i.e. skewness and kurtosis tests and histograms for normality), and parametric or non-parametric statistics were used accordingly. Socio-demographic variables were analysed using Chi-squared test and Student's *t* test. An analysis of the variance (ANOVA) was executed for intragroup and intergroup analyses, using as co-variables: BMI in physical fitness analysis and height in muscle mass analysis. Post hoc analyses comparisons were done using Bonferroni or Games-Howell according to the homogeneity of variance. Pearson correlation was performed between muscle mass and strength

**Table 2** Anthropometric and body composition variables in FM patients and healthy group by age subcategories

| Age group | $n$ | FM group mean (SD) | $n$ | Healthy group mean (SD) | $p$ value intergroup | 95 % confidence interval |
|---|---|---|---|---|---|---|
| Body mass index (kg/m$^2$) | | | | | | |
| 30–39 years | 34 | 26.27 (5.48) | 34 | 25.64 (4.48) | 0.601 | −1.788/3.064 |
| 40–49 years | 152 | 27.77 (5.76) | 97 | 26.58 (4.52) | 0.088 | −0.177/2.544 |
| 50–59 years | 217 | 29.14 (5.48) | 103 | 27.62 (4.05) | 0.013 | 0.327/2.712 |
| 60–69 years | 88 | 29.74 (4.30) | 44 | 27.24 (4.10) | 0.002 | 0.943/4.043 |
| Total | 491 | 28.62 (5.45) | 278 | 26.96 (4.31) | <0.001 | 0.920/2.414 |
| $p$ valour intragroup | | 0.001 | | 0.086 | | |
| Post hoc | 1 < 3*/1 < 4**/2 < 4* | | | | | |
| Muscle mass (kg) | | | | | | |
| 30–39 years | 34 | 23.95 (4.57) | 33 | 25.76 (5.41) | 0.173 | −3.174/0.582 |
| 40–49 years | 152 | 23.69 (3.98) | 95 | 25.28 (5.84) | 0.745 | −0.731/1.020 |
| 50–59 years | 215 | 22.75 (3.60) | 100 | 24.20 (4.56) | 0.133 | −1.151/0.153 |
| 60–69 years | 81 | 21.79 (3.00) | 44 | 24.70 (5.50) | 0.632 | −1.379/0.841 |
| Total | 482 | 22.97 (3.76) | 272 | 24.85 (5.29) | 0.198 | −0.722/0.160 |
| $p$ valour intragroup | | 0.102 | | 0.277 | | |
| SMMI (kg/m$^2$) | | | | | | |
| 30–39 years | 34 | 8.91 (1.35) | 34 | 9.44 (1.44) | 0.131 | −1.208/0.161 |
| 40–49 years | 152 | 9.27 (1.21) | 95 | 9.41 (1.45) | 0.402 | −0.482/0.194 |
| 50–59 years | 215 | 9.11 (1.05) | 100 | 9.40 (1.18) | 0.027 | −0.556/−0.034 |
| 60–69 years | 81 | 9.05 (0.85) | 44 | 9.45 (1.42) | 0.049 | −0.810/−0.002 |
| Total | 482 | 9.13 (1.10) | 272 | 9.42 (1.34) | 0.002 | −0.462/−0.106 |
| $p$ valour intragroup | | 0.246 | | 0.997 | | |

1. 30–39 years, 2. 40–49 years, 3. 50–59 years, 4. 60–69 years

* $p < 0.05$, ** $p < 0.01$, *SD* standard deviation, *SMMI* skeletal muscle mass index

variables. All analyses were performed using the Statistical Package for Social Sciences v.19 (SPSS Inc, Chicago, USA), and the level of significance was set at $p < 0.05$.

## Results

Socio-demographic and clinical characteristics of the study sample by groups are presented in Table 1. From all the socio-demographic variables, educational status and current occupational status were different between the FM and control group ($p < 0.01$). Regarding clinical variables, tender points count and algometer score were statistically different between groups ($p < 0.001$), found higher values in tender points and lower values in algometer score in FM group.

Table 2 shows the anthropometric variables and body composition by age subgroups in FM and healthy participants. In the FM group, the BMI was different between the age subgroups ($p = 0.001$). Post hoc analysis showed differences between subgroups 1 versus 3, 1 versus 4 and 2 versus 4. No differences between the age subgroups were shown in healthy women ($p = 0.086$). Skeletal muscle mass and SMMI did not differ between the age subgroups either in patients with FM or in healthy people. The BMI differed between FM and healthy group in the third and fourth age subgroups ($p = 0.013$ and $p = 0.002$, respectively), found higher values in FM group. Muscle mass was not different between FM and healthy group. SMMI differed between the third and fourth age subgroups ($p = 0.027$ and $p = 0.049$, respectively), found higher values in healthy group.

Table 3 shows muscle strength in FM and healthy group. In FM group and healthy group, differences were found throughout the ageing in the 30-s chair stand test (FM group, $p = 0.007$; healthy group, $p < 0.001$) and in the arm curl test (FM group, $p = 0.015$; healthy group, $p < 0.001$). In the handgrip strength test, are found significant differences along ageing, only in FM group ($p < 0.001$). We observed significant differences ($p < 0.01$) in handgrip strength, arm curl test and 30-s chair stand test, between FM group and healthy group in all age ranges, finding lower values in FM group.

Pearson correlation analysis in the group of women with FM ($r = 0.387$, $p < 0.001$) and healthy group ($r = 0.786$, $p < 0.001$) showed significant correlation between skeletal

**Table 3** Muscle strength in FM patients and healthy group by age subcategories

| Age group | *n* | FM group mean (SD) | *n* | Healthy group mean (SD) | *p* value intergroup | 95 % confidence interval |
|---|---|---|---|---|---|---|
| 30-s chair stand test (number of repetition) | | | | | | |
| 30–39 years | 34 | 11.41 (3.72) | 32 | 17.66 (3.06) | <0.001 | −7.999/−4.620 |
| 40–49 years | 147 | 10.86 (3.19) | 92 | 15.46(2.92) | <0.001 | −5.278/−3.669 |
| 50–59 years | 203 | 9.98 (3.25) | 95 | 14.38 (2.61) | <0.001 | −5.078/−3.565 |
| 60–69 years | 85 | 9.53 (3.39) | 40 | 13.75 (2.63) | <0.001 | −5.055/−2.609 |
| Total | 469 | 10.28 (3.34) | 259 | 15.07 (3.00) | <0.001 | −5.126/−4.144 |
| *p* valour intragroup | | 0.007 | | <0.001 | | |
| Post hoc | | 2 > 4* | | 1 > 2**/1 > 3***/ 1 > 4***/2 > 4* | | |
| Handgrip strength test (kg) | | | | | | |
| 30–39 years | 34 | 24.88 (8.28) | 32 | 30.82 (7.07) | 0.002 | −9.928/−2.366 |
| 40–49 years | 147 | 20.68 (8.01) | 92 | 29.83 (7.87) | <0.001 | −11.299/−7.095 |
| 50–59 years | 208 | 18.72 (6.87) | 95 | 28.79 (7.23) | <0.001 | −11.899/−8.461 |
| 60–69 years | 86 | 17.83 (6.23) | 40 | 28.92 (9.85) | <0.001 | −14.202/−8.254 |
| Total | 475 | 19.60 (7.44) | 259 | 29.43 (7.88) | <0.001 | −11.035/−8.700 |
| *p* valour intragroup | | <0.001 | | 0.299 | | |
| Post hoc | | 1 > 2*/1 > 3***/ 1 > 4***/2 > 4* | | | | |
| Arm curl test (number of repetition) | | | | | | |
| 30–39 years | 34 | 16.19 (5.73) | 32 | 25.71 (4.29) | <0.001 | −12.140/−7.591 |
| 40–49 years | 145 | 14.71 (5.05) | 92 | 22.96 (4.13) | <0.001 | −9.376/−6.892 |
| 50–59 years | 201 | 14.05 (4.78) | 95 | 21.34 (4.61) | <0.001 | −8.563/−6.226 |
| 60–69 years | 85 | 13.29 (4.79) | 40 | 21.02 (4.11) | <0.001 | −9.138/−5.559 |
| Total | 465 | 14.27 (4.98) | 259 | 22.41 (4.55) | <0.001 | −8.852/−7.362 |
| *p* valour intragroup | | 0.015 | | <0.001 | | |
| Post hoc | | 1 > 4* | | 1 > 2*/1 > 3***/1 > 4*** | | |

1. 30–39 years, 2. 40–49 years, 3. 50–59 years, 4. 60–69 years

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, *SD* standard deviation

muscle mass and handgrip strength. Figure 1 shows the scatter plot between skeletal muscle mass and handgrip strength in women with FM and healthy women. Moreover, age was inversely associated with skeletal muscle mass ($r = -0.155$, $p < 0.01$) and handgrip strength ($r = -0.230$, $p < 0.001$) only in the FM group.

## Discussion

The main finding of this study is that women with FM showed a reduction in muscle strength along ageing process, with significantly lower scores than healthy women for each age group. Muscle strength is the single best measure of age-related muscle change, and it is associated with physical disability in activities of daily living and functional limitation [22]. Muscle mass and SMMI as sarcopenia indicators did not change along ageing in FM patients. Indeed, muscle mass and SMMI values found in each age subgroup of FM patients were similar to those obtained in the healthy group. Considering the normal muscle reference value, based on SMMI $\geq 6.76$ kg/m$^2$ [15], it appears that there is not early risk of sarcopenia in women with FM.

Upper and lower body muscle strength (30-s chair stand test, handgrip strength and arm curl tests) is lower in FM patients compared to age-matched healthy peers along ageing. This phenomenon concurs with the previous literature which affirms that muscle strength in FM patients is similar to healthy older adults [9, 10]. Comparing results of strength tests (arm curl and 30-s chair stand tests), with normative values [20], it is important to note that in our study, FM women obtained similar values (14.3 ± 5) to older healthy women between 75 and 79 years old (14.0 ± 4.2) in the arm curl test [20]. In addition, 30–39-year-old FM patients' subgroup obtained similar values (16.2 ± 5.7) to the 60–64-year-old reference healthy group (16.1 ± 4.6) [20] and displayed significantly lower values to the group of healthy women aged 60–69 years. Regarding the 30-s chair stand test, the entire group of FM women obtained a similar result (10.3 ± 3.3) to women aged 85–89 years

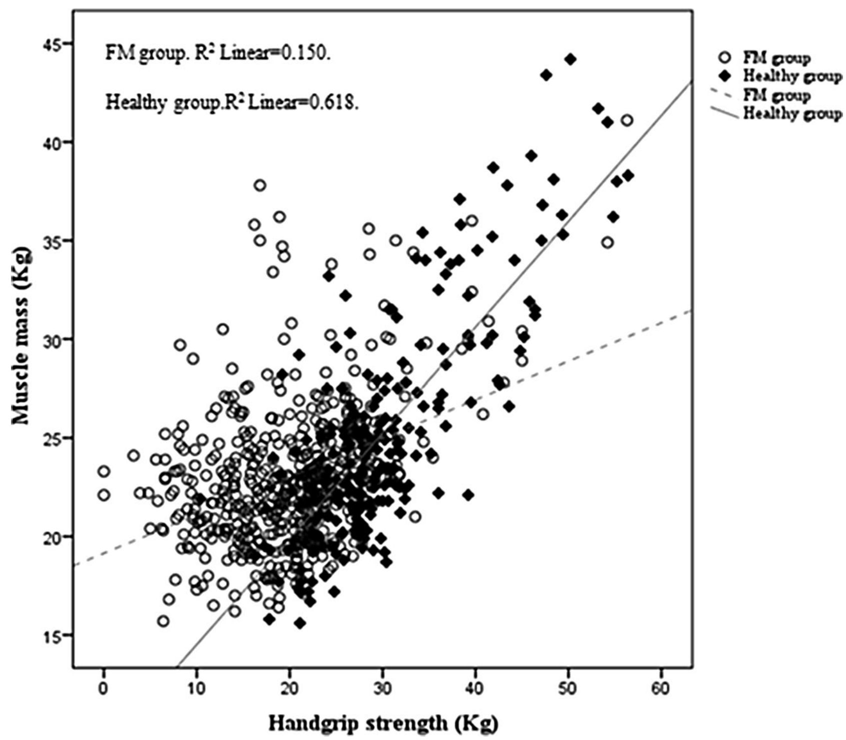


**Fig. 1** Scatter plot between skeletal muscle mass and handgrip strength

(10.3 ± 4.0) [20]. Moreover, 30–39 years subgroup of FM obtained values (11.4 ± 3.72) similar to healthy women with 80–84 years old (11.3 ± 4.2) [20]. In our study, the 30–39-year-old FM subgroup obtained values significantly lower to the healthy group between 60 and 69 years old. In any case, in agreement with previously studies [7, 23], this finding might be explained by the lower levels of physical activity in patients with FM in comparison with healthy control people [6]. However, recently, Ruiz et al. [24] observed that the proportion of FM women meeting the physical activity recommendations of 30 min/day of moderate to vigorous physical activity on 5 or more days/week was 61 %.

Women with FM showed lower scores of handgrip strength than healthy women for all age groups. These findings concur with those observed by other authors [25, 26]. Maquet et al. [26] found a reduction of 39 % in handgrip strength in women with FM compared to healthy women. Several studies have indicated that handgrip strength in men and women is reduced as age increases [27] and that this reduction is linear [28]. Considering normative values established in previous studies [29], FM women obtained lower values in handgrip strength, locating the whole group around the 30th percentile. Aparicio et al. [25] observed that handgrip strength is reduced in women with FM as well as in those with severe FM compared to their peers with moderate FM. However, in the healthy group, handgrip strength remains constant throughout ageing.

Considering that the values of muscle strength analysed in this study are lower in the FM group for all age ranges when compared to the healthy group, we may indicate the presence of dynapenia in patients with FM. In this sense, Panton and Kingsley [9] and Latorre et al. [10] observed that lower limbs strength and functional capacity were similar in FM women and older healthy women, which suggest that FM increases the risk of early incapacity associated with age. Other authors [30] also indicated that women with FM show static and dynamic muscle strength similar to their elderly counterparts, 25 years older. This premature deficit in muscle strength and functional capacity may compromise an independent lifestyle and can lead to negative implications on functionality, which can then lead to disability and a reduction in the quality of life of younger women (<65 years old) [30]. Moreover, loss of strength is a more steady risk of incapacity and death than is loss of muscle mass [31]. Exercise programs may be important in the development of strength in women with FM. Latorre et al. [32] showed significant improvements in handgrip strength and 30-s chair stand test after 24 weeks of physical training.

We have observed a higher association between muscle mass and handgrip strength in healthy women than in patients with FM, which may indicate that other factors (pain, fatigue, depression and mood state), also muscle mass, may be associated with the strength in women with FM.

Some limitations must be mentioned. First, the cross-sectional design does not allow establishing causal relationships. Second, the lower prevalence of fibromyalgia in men and their low rate of participation made us to exclude them from the analysis. Therefore, this study was carried out only with women, and future studies are needed to confirm or contrast the present findings in men with fibromyalgia. Furthermore, the fibromyalgia women sample size doubled the control women. On the other hand, these sample sizes were fairly large and representative of the Andalusian fibromyalgia population [33]. Moreover, the present study employed standardized and validated tests to assess muscle mass and strength.

## Conclusions

Women with FM showed a higher risk of dynapenia. Nevertheless, muscle mass and SMMI as sarcopenia indicators did not change along ageing, which could indicate that there is not early risk of sarcopenia in women with FM. Incorporate exercise programs at an early stage is important in order to preserve physical performance and strength and to prevent negative consequences of dynapenia along ageing in FM patients.

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**Conflict of interest** None.

## References

1. Rittweger J, Kwiet A, Felsenberg D (2004) Physical performance in ageing elite athletes challenging the limits of physiology. J Musculoskelet Neuronal 4(2):159–160
2. Clark BC, Manini TM (2008) Maximal voluntary force (strength) production declines with age and contributes to physical dependence and mortality. J Gerontol A Biol Sci Med Sci 63(8):829–834
3. Morley JE, Baumgartner RN, Roubenoff R et al (2001) Sarcopenia. J Lab Clin Med 137:231–243
4. Clark BC, Manini TM (2012) What is dynapenia? Nutrition 28(5):495–503
5. Verbunt JA, Pernot DH, Smeets RJ (2008) Disability and quality of life in patients with FM. Health Qual Life Outcomes 6:8. doi:10.1186/1477-7525-6-8
6. McLoughlin MJ et al (2011) Are women with fibromyalgia less physically active than healthy women. Med Sci Sports Exerc 43(5):905–912
7. Mengshoel AM, Forre O, Komnaes HB (1990) Muscle strength and aerobic capacity in primary fibromyalgia. Clin Exp Rheumatol 8(5):475–479
8. Clark SR (1994) Prescribing exercise for fibromyalgia patients. Arthritis Rheum 7(4):221–225
9. Panton LB, Kingsley J, Toole T et al (2006) A comparison of physical functional performance and strength in women with fibromyalgia, age- and weight-matched controls, and older women who are healthy. Phys Ther 86(11):1479–1488
10. Latorre PA, Santos MA, Mejía A, Delgado M, Heredia JM (2012) Analysis of the physical capacity of women with fibromyalgia according to the severity level of the disease. Rev Bras Med Esporte 18(5):329–333
11. Goes SM, Leite N, Shay BL, Homann D, Stefanello JM, Rodacki AL (2012) Functional capacity, muscle strength and falls in women with fibromyalgia. Clin Biomech 27(6):578–583
12. Wolfe F, Smythe HA, Yunus MB et al (1990) The American College of Rheumatology 1990 criteria for the classification of fibromyalgia. Report of the multicenter criteria committee. Arthritis Rheum 33:160–172
13. Folstein MF, Folstein SE, McHugh PR (1975) "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 12:189–198
14. Segura-Jiménez V, Aparicio VA, Álvarez-Gallardo IC, Carbonell-Baeza A, Tornero-Quiñones I, Delgado-Fernández M (2014) Does body composition differ between fibromyalgia patients and controls? The al-Ándalus project. Clin Exp Rheumatol [Epub ahead of print]
15. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F et al (2010) Sarcopenia: european Consensus on definition and diagnosis. Age Ageing 39:412–423
16. Rivera J, Gonzalez T (2004) The Fibromyalgia Impact Questionnaire: a validated Spanish version to assess the health status in women with fibromyalgia. Clin Exp Rheumatol 22:554–560
17. Burckhardt CS, Clark SR, Bennett RM (1991) The fibromyalgia impact questionnaire: development and validation. J Rheumatol 18:728–733
18. Bennett R (2005) The fibromyalgia Impact Questionnaire (FIQ): a review of its development, current version, operating characteristics and uses. Clin Exp Rheumatol 23:S154–S162
19. Carbonell-Baeza A, Alvarez-Gallardo IC, Segura-Jiménez V, Castro-Piñero J, Ruiz JR, Delgado-Fernández M, Aparicio VA (2014) Reliability and feasibility of physical fitness tests in female fibromyalgia patients. Int J Sports Med [Epub ahead of print]
20. Rikli RE, Jones J (1999) Development and validation of a functional fitness test for community residing older adults. J Ageing Phys A 7:129–161
21. Ruiz-Ruiz J, Mesa JL, Gutierrez A, Castillo MJ (2006) Hand size influences optimal grip span in women but not in men. J Hand Surg Am 27(5):897–901
22. Hairi NN, Cumming RG, Naganathan V, Handelsman DJ, Le Couteur DG, Creasey H, Waite LM, Seibel MJ, Sambrook PN (2010) Loss of muscle strength, mass (sarcopenia), and quality (specific force) and its relationship with functional limitation and physical disability: the Concord Health and Ageing in Men Project. J Am Geriatr Soc 58(11):2055–2062
23. Hauser W, Zimer C, Felde E, Kollner V (2008) What are the key symptoms of fibromyalgia? Results of a survey of the German FM Association. Schmerz 22(2):176–183
24. Ruiz J et al (2013) Objectively measured sedentary time and physical activity in women with fibromyalgia: a cross-sectional study. BMJ open 3(6):1–9
25. Aparicio VA, Ortega FB, Heredia JM, Carbonell-Baeza A, Sjöström M, Delgado-Fernandez M (2011) Handgrip strength test as a complementary tool in the assessment of fibromyalgia severity in women. Arch Phys Med Rehabil 92(1):83–88
26. Maquet D, Croisier JL, Renard C, Crielaard JM (2002) Muscle performance in patients with fibromyalgia. Joint Bone Spine 69(3):293–299
27. Jansen CS, Niebuhr BR, Coussirat DJ, Hawthorne D, Moreno L, Phillip M (2008) Hand force of men and women over 65 years

of age as measured by maximum pinch and grip force. J Ageing phys Act 16(1):24

28. Rittweger J, Kwiet A, Felsenberg D (2004) Physical performance in ageing elite athletes challenging the limits of physiology. J Musculoskelet Neuronal 4(2):159–160
29. Schlüssel MM, dos Anjos LA, de Vasconcellos MT, Kac G (2008) Reference values of handgrip dynamometry of healthy adults: a population-based study. Clin Nutr 27(4):601–607
30. Goes SM, Bento PCB, Stefanello JMF, El Tassa KOM, Homann D, Leite N, Rodacki ALF (2013) Muscle and functional parameters of mid-age women with fibromyalgia and healthy elderly. JEPOnline 16(3):20–29
31. Mitchell WK, Williams J, Atherton P, Larvin M, Lund J, Narici M (2012) Sarcopenia,dynapenia, and the impact of advancing age on human skeletal muscle size and strength; a quantitative review. Front Physiol 3(260):1–18
32. Latorre PÁ, Santos MA, Heredia-Jiménez JM, Delgado-Fernández M, Soto VM, Mañas A, Carbonell-Baeza A (2013) Effect of a 24-week physical training programme (in water and on land) on pain, functional capacity, body composition and quality of life in women with fibromyalgia. Clin Exp Rheumatol 31(6):S72–S80
33. Segura-Jiménez V, Álvarez-Gallardo IC, Carbonell-Baeza A, Aparicio VA, Ortega FB, Casimiro AJ, Delgado-Fernández M (2014) Fibromyalgia has a larger impact on physical health than on psychological health, yet both are markedly affected: the al-Ándalus project. Semin Arthritis Rheum. doi: 10.1016/j.semarthrit.2014.09.010