Fitness Testing in the Fibromyalgia Diagnosis: The al-Ándalus Project

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ABSTRACT

APARICIO, V. A., V. SEGURA-JIMÉNEZ, I. C. ÁLVAREZ-GALLARDO, A. SORIANO-MALDONADO, J. CASTRO-PIÑERO, M. DELGADO-FERNÁNDEZ, and A. CARBONELL-BAEZA. Fitness Testing in the Fibromyalgia Diagnosis: The al-Ándalus Project. *Med. Sci. Sports Exerc.*, Vol. 47, No. 3, pp. 451–459, 2015. **Purpose**: This study aimed to determine the ability of a set of physical fitness tests to discriminate presence or absence of fibromyalgia in women. **Methods**: The sample comprised 487 women with fibromyalgia (52.1 ± 8 yr) and 250 control women (49.3 ± 9 yr). We assessed physical fitness using the arm curl, 30-s chair stand, handgrip strength, 8-ft up and go, 6-min walk, chair sit and reach, and the back scratch tests. The revised fibromyalgia impact questionnaire was used to assess fibromyalgia severity and symptomatology. **Results**: Patients with fibromyalgia performed worse than control women in all the fitness tests studied (all, $P < 0.001$). The receiver operating characteristic analysis showed that all the fitness tests were able to discriminate between presence and absence of fibromyalgia (all, $P < 0.001$). The area under the curve ranged from 0.708 to 0.910 (all, $P < 0.001$). Among the fitness tests studied, the arm curl test, followed by the 30-s chair-stand and handgrip strength tests, showed the highest capacity discriminating between the presence and absence of fibromyalgia. An arm curl test score of <20 repetitions was associated with increased odds of having fibromyalgia (odds ratio (OR), 35.6; 95% confidence interval, 12.6–101) in women age 35–44 yr. An arm curl test score of <16 repetitions was associated with increased odds of having fibromyalgia (OR, 23.7; 95% confidence interval, 10.3–54.0) in women age 35–44 yr. In the group of women age 55–65 yr, the highest OR was observed for the handgrip strength test and the odds of having fibromyalgia was 17 times greater than that in patients who performed less than 19 kg. **Conclusions**: The arm curl, 30-s chair stand, and handgrip strength tests powerfully discriminated women with fibromyalgia from healthy women. Identification of women who fail to meet the suggested standards can help to easily, quickly, and cheaply rule out the presence of the disease, especially in primary care settings. **Key Words:** ARM CURL, 30-S CHAIR STAND, HANDGRIP STRENGTH, WOMEN, FUNCTIONAL CAPACITY

Fibromyalgia is a complex multidimensional disorder with pain as its main symptom but with other relevant non-pain symptoms, such as fatigue, stiffness, memory and cognitive difficulties, among others (1,32,39). An equally important feature of fibromyalgia is low physical capacity and functionality, which limit the patients' daily activities and reduces their quality of life (25,31). The prevalence of comorbidities among patients with fibromyalgia is extremely high (38), which increases the patients' needs for appropriate clinical management. This increases health care system use and implies high treatment consuming and economic burdens (21). Therefore, fibromyalgia has become a recurring health condition with a high prevalence among females between the ages of 40 and 59 yr (25).

Fibromyalgia is challenging to diagnose, especially in primary care settings (12,17,24). Since the first diagnosis criteria, developed by the American Colleague of Rheumatology (ACR) in 1990 (which was mainly based on the identification of tender points) (39), the diagnosis of fibromyalgia is still a dynamic process where different clinical, psychosocial, and functional assessments are implicated; (9,17,29,32,37,40). Indeed, as time has passed, several objections to the first ACR criteria were noted, highlighting the

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fact that tender points cannot be an objective assessment of whole bodily pain (2,37). Moreover, it became increasingly clear that the tender points count was rarely performed in primary care settings where most fibromyalgia diagnoses occurred and were oftentimes performed incorrectly (17). Furthermore, digital palpation instead of algometry was the most widely used method among examiners (17). Therefore, without an objective instrument, the application of equal pressure of 4 kg is doubtful (17,29). For this reason, in 2010, the ACR released new diagnostic criteria avoiding the requirement of tender point examination (37). Therefore, various instruments and criteria are currently being used for fibromyalgia diagnosis and monitoring. Although fibromyalgia remains an integral part of rheumatology, it is not an exclusive rheumatic condition and spans a broad range of medical disciplines (18).

In 2006, Mannerkorpi et al. (23) suggested that fitness testing (especially the handgrip strength and the 6-min walk tests) might complement the previously used tools employed in the clinical examination when planning treatment for patients with fibromyalgia. In 2007, Busch et al. (11) highlighted the importance of better characterization of physical fitness/functional capacity levels of patients with fibromyalgia. Consequently, our group studied the usefulness of fitness testing for the assessment and monitoring of fibromyalgia (3,6) and its relation with fibromyalgia severity and symptomatology (14,15). We concluded that worse functional capacity is associated to the fibromyalgia-related symptomatology (14,15) and that the handgrip strength and the 30-s chair stand tests are useful complementary tools for the diagnosis and monitoring of the disease (3,6). However, we did not propose fitness cutoff points for different age groups. Because older age is associated with lower fitness levels (8), we hypothesize that the cutoff points might differ across age ranges.

Practitioners need practical tools for the correct diagnosis of fibromyalgia to complete the patient's overall health status and to test the effectiveness of specific treatments. Therefore, we have replicated our preliminary study (3,6) with a larger sample size and with age-specific analyses to establish new cutoff points capable of enhancing the current diagnosis accuracy. Therefore, the present study aimed to determine the ability of a set of seven physical fitness tests to discriminate between the presence and absence of fibromyalgia in women of different ages.

MATERIALS AND METHODS

Study Sample and Design

Patients with fibromyalgia were recruited from different fibromyalgia associations via e-mail, letter, or telephone. We also recruited a representative group of control women and men with similar ages, sociodemographic characteristics, and demographic area via e-mail and internet advertisements to carry out appropriate comparisons between groups. All interested participants signed a written informed consent after receiving detailed information about the aims and study procedures. The inclusion criteria for fibromyalgia participants were as follows: 1) to be previously diagnosed by a rheumatologist (patients were asked to provide their medical records to confirm their previous diagnosis); 2) to meet the 1990 ACR fibromyalgia criteria—widespread pain for more than 3 months and pain $\leq$4 kg·cm^{-2} of pressure for 11 or more of 18 tender points (39); 3) not to have acute or terminal illness (such as cancer, stroke, recent cardiopathy, severe coronary disease, schizophrenia, or any other disabling injury), or severe dementia (mini mental state examination (MMSE) <10) (33); and 4) to meet age criteria, 35–65 yr old. The inclusion criteria for control women were as follows: 1) not to meet the 1990 ACR fibromyalgia criteria; 2) not to have acute, terminal illness, or severe dementia (MMSE <10) (33); and 3) to meet age criteria, 35–65 yr old. From an initial sample of 960 participants, the following subjects were excluded: 38 participants with fibromyalgia had not been previously diagnosed by a rheumatologist, one woman with fibromyalgia presented severe dementia, 101 participants with fibromyalgia did not meet the 1990 ACR criteria, whereas seven control participants met them. Finally, we decided to exclude 65 men (21 with fibromyalgia and 44 control men) from the present data analysis because of the small sample size of the recruited males with fibromyalgia. To ensure that all tests had the same statistical power, only those subjects who had valid data in all physical fitness tests were included in the analyses. Therefore, the final study sample was composed of 487 (52.1 ± 8.0 yr) female patients with fibromyalgia versus 250 (49.3 ± 9.9 yr) region-matched control women.

All the measurements were performed by the same trained research team to reduce interexaminer error. The present project was reviewed and approved by the ethics committee of the Hospital Virgen de las Nieves, Granada, Spain. Moreover, the present study has been conducted in conformance with the policy statement of the American College of Sports Medicine as published by *Medicine and Science in Sports and Exercise*.

Material and Procedures

Anthropometry and body composition. We used a portable eight-polar tactile-electrode impedanciometer (InBody R20; Biospace, Seoul, Korea) to measure body weight (kg), body fat (kg and %), and skeletal muscle mass (kg). Height (cm) was measured using a stadiometer (Seca 22, Hamburg, Germany). Body mass index (BMI) was calculated as weight (kg) divided by squared height (m^2). Waist circumference (cm) was measured with the participant standing at the middle point between the ribs and iliac crest (Harpenden anthropometric tape; Holtain Ltd).

Sociodemographic and clinical data acquisition. Sociodemographic information was recorded using a self-report instrument that included date of birth, marital status, educational status, current occupational status, and time since fibromyalgia diagnosis, among other questions. Participants received instructions on how to complete such self-administered questionnaire. Smoking status and questions regarding pharmacology or the presence of other diseases were asked to all the participants by an examiner through an initial survey.

The MMSE. The Spanish version of the MMSE (33) was administered to participants confidentially by trained interviewers to assess cognitive function and severity of dementia. Five areas of cognitive functioning were assessed, as follows: orientation, immediate memory, attention/concentration, delayed recall, and language.

The modified 2010 ACR fibromyalgia diagnostic criteria. This questionnaire (36) is composed of two scales, as follows: 1) the widespread pain scale asking participants to grade whether (or not) they had pain or tenderness in the previous week in 19 body areas and 2) the symptom severity scale asking participants to indicate the severity of fatigue, trouble thinking or remembering, and waking up tired (unrefreshed) over the previous week. Patients were also asked to answer whether they had had pain or cramps in the lower abdomen, depression, or headache during the previous 6 months. The widespread pain index and the symptom severity scale were subsequently summed into an index called "polysymptomatic distress scale" (35). We used the Spanish version, which has shown high sensitivity and specificity for fibromyalgia diagnosis (30).

Tenderness. We assessed 18 tender points according to the 1990 ACR criteria for classification of fibromyalgia (39) using a standard pressure algometer (FPK 20; Wagner Instruments, Greenwich, CT). The mean of the two measurements at each tender point was used for the analysis. A tender point was scored positive when the patient noted pain at pressure $\leq 4\ kg \cdot cm^{-2}$. The total count of positive tender points (tender point count) was recorded for each participant. An algometer score was calculated as the sum of the minimum pain pressure values obtained for each tender point. The average score of two measurements for each tender point was used in the analysis.

Fibromyalgia impact. The Revised Fibromyalgia Impact Questionnaire (FIQR) (22) is a self-administered questionnaire composed of 21 individual questions with a rating scale of 0 to 10. These questions compose three different domains, as follows: function, overall impact and symptoms (ranging from 0 to 30, 0 to 20, and 0 to 50, respectively). The FIQR total score ranges from 0 to 100, with higher score indicating greater impact of the disease.

Physical fitness testing. The Functional Senior Fitness Test battery was used because it is relatively easy to administer, safe, and requires minimal equipment and space (27). It has shown no ceiling and floor effects, which is a relevant aspect for this study because of the heterogeneity of patients with fibromyalgia (34). Therefore, the tests used are feasible to perform in clinical and community settings. In addition, we also measured the handgrip strength test, which is commonly used in patients with fibromyalgia (13). The main functional capacity components studied were as follows:

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 the back straight and the feet flat on the floor, without pushing off with the arms. The arms were crossed at the chest level (27).

Upper body muscular strength. The handgrip strength was assessed using a hand dynamometer with adjustable grip (TKK 5101 Grip D; Takey, Tokyo, Japan). The subject continuously and gradually squeezes for at least 2 s using optimal grip-span, which was calculated using the formula by Ruiz-Ruiz et al. (28), as follows: $y = x/5 + 1.5$; x being the hand size and y, the grip length. Each patient completed two attempts with each hand, with the arm fully extended, forming an angle of 30° with respect to the trunk (28). The maximum score in kilograms for each hand was recorded, and the mean score of the left and right hands was used in the analyses. We also included the "arm curl test," which measures the number of times that, with the person seated, a hand weight (2.3 kg for women) can be curled through full range of motion within 30 s (27). Patients performed one trial with both hands, and the average was used in the analyses.

Lower body flexibility. In the "chair sit and reach test," the patient seated with one leg extended, slowly bends forward, sliding the hands down the extended leg in an attempt to touch (or pass) the toes (27). The number of centimeters short of reaching the toe (minus score) or reaching beyond it (plus score) was recorded. Two trials with each leg were performed, and the best value for each leg was recorded. The average of both legs was used in the analysis.

Upper body flexibility. The "back scratch test," a measure of overall shoulder range of motion, involves measuring the distance between (or overlap of) the middle fingers behind the back with a ruler (27). This test was assessed twice, alternately with both hands, and the best value was recorded. The average of both hands was used in the analysis.

Motor agility/dynamic balance. The "8-ft up and go" test" consists of standing from a chair, walking 8 ft (2.44 m) to and around a cone, and returning to the chair in the shortest possible time (27). The best time (s) of two trials was recorded and used in the analysis.

Aerobic endurance/cardiorespiratory fitness. This test was assessed by the "6-min walk test." This test involves determining the maximum distance (m) that can be walked in 6 min along a 45.7-m rectangular course (27).

Statistical Analysis

The comparisons between women with fibromyalgia and controls were performed using one-way ANCOVA after adjustment for age and BMI. We adjusted all the models for age and BMI because both are inversely related to fitness and fibromyalgia symptomatology (4,5,20). The occupational and educational status and the intake of painkillers, stimulants, and antidepressants were further added as covariates to test their potential confounding effect on body composition and physical fitness. Differences in categorical variables were assessed with the chi-square test. The relations between all fitness tests and FIQR, the modified 2010 ACR fibromyalgia diagnostic criteria, and tenderness in patients with fibromyalgia were analyzed by partial correlations after adjustment for age and BMI.

We further categorized the sample by age-specific groups (women age 35–44, 45–54, and 55–65 yr old). The fitness test thresholds that best discriminated between presence and absence of fibromyalgia for the entire sample and for each age-specific group were determined using receiver operating characteristic (ROC) curve analysis (41). To identify the best threshold, the distance between the perfect test and each sensitivity and one minus specificity pair was calculated, and then, the pair closest to one was chosen. We also calculated the area under the curve (AUC) and 95% confidence intervals (CI). The AUC represents the ability of the specific fitness test to correctly classify subjects as having versus not having fibromyalgia. The values of AUC range between 1 (perfect test) and 0.5 (worthless test). Binary logistic regression was used to further study the relation between fitness testing and presence/absence of fibromyalgia for the entire sample and for each age-specific group after adjustment for age and BMI. All the analyses were performed using the Statistical Package for Social Sciences (SPSS Statistics for Windows, version 20.0; IBM, Armonk, NY), and the level of significance was set at $P < 0.05$.

TABLE 1. Sociodemographic and clinical characteristics of the study sample by groups.

	Patients with Fibromyalgia	Healthy Women	
	Mean (SD)	Mean (SD)	P
Age (yr)	51.9 (8.3)	49.3 (9.9)	<0.001
Tender point count (kg·cm^{-2})	16.8 (1.9)	2.8 (2.9)	<0.001
Algometer score	42.8 (13.4)	109.9 (22.3)	<0.001
FIQR	64.5 (16.7)	27.0 (8.5)	<0.001
	n (%)	n (%)	
Marital status			
Married	367 (75.5)	175 (70.3)	0.138
Single	40 (8.2)	34 (13.7)	
Separated	15 (3.1)	13 (5.2)	
Divorced	38 (7.8)	16 (6.4)	
Widow	26 (5.3)	11 (4.4)	
Educational status			
No studies	53 (10.9)	17 (6.8)	0.022
Primary school	233 (47.9)	93 (37.2)	
Professional training	75 (15.4)	39 (15.6)	
Secondary school	59 (12.1)	43 (17.2)	
University medium degree	42 (8.6)	32 (12.8)	
University higher degree	24 (4.9)	26 (10.4)	
Current occupational status			
Working	121 (24.9)	100 (40.0)	<0.001
Unemployed	85 (17.5)	40 (16.0)	
Sick leave	35 (7.2)	2 (0.8)	
Retired/pensioner	85 (17.5)	15 (6.0)	
Student	5 (1.0)	8 (3.2)	
Housewife	155 (31.9)	85 (34.0)	
Medication (last 2 wk)			
Painkillers	435 (89.7)	132 (53.2)	<0.001
Laxatives	99 (20.4)	22 (8.9)	<0.001
Antidepressants	280 (57.7)	25 (10.1)	<0.001
Stimulants	35 (7.2)	1 (0.4)	<0.001
Contraceptives	13 (2.7)	11 (4.4)	0.134
Hormonal replacement for menopause	12 (2.5)	8 (3.2)	0.539
Medication for losing weight	12 (2.5)	4 (1.6)	0.533
Time since diagnosis			
Less than 1 yr	33 (6.8)	—	
Between 1 and 5 yr	166 (35.3)	—	
More than 5 yr	274 (57.9)	—	
Smoking everyday	121 (24.9)	51 (20.6)	0.902

RESULTS

Sociodemographic and clinical characteristics of the study sample by groups are presented in Table 1. No differences on marital status and smoking status were observed between groups. Age, tender point count, FIQR, educational status, and current occupational status differed between groups (all, $P < 0.001$). Regarding medication, patients with fibromyalgia consumed more painkillers, laxatives, antidepressants, and stimulants in the last 2 wk than the control group (all, $P < 0.001$).

Anthropometric and fitness characteristics of the study sample by presence/absence of fibromyalgia after adjustment for age are shown in Table 2. BMI, waist circumference, and fat percentage were higher, whereas height was lower in the group with fibromyalgia compared with that in the control group (all, $P < 0.001$). The fibromyalgia group performed worse in all the fitness tests compared with their healthy peers (all, $P < 0.001$). After further adjustment for age, educational status, occupational status, BMI, and medication, the results remained unchanged (all, $P < 0.001$).

Partial correlations between fitness testing and the FIQR, the modified 2010 ACR fibromyalgia diagnostic criteria, and tenderness among patients with fibromyalgia are shown in Table 3. Most fitness tests were inversely correlated with the FIQR total score, the modified 2010 ACR fibromyalgia diagnostic criteria, and all the FIQR dimensions (except for the tenderness level). The 30-s chair stand and the arm curl tests were the most correlated with the FIQR total score and the FIQR dimensions, the Widespread Pain Index, the Symptom Severity, and the Polysymptomatic Distress Scale. The arm curl test, followed by the 30-s chair stand, the chair sit and reach, and the handgrip strength were those more strongly associated to the tender point count and the algometer score (all, $P < 0.001$).

Table 4 shows the capacity of each fitness test to discriminate between presence and absence of fibromyalgia. The ROC analysis showed that all the studied fitness tests were able to discriminate between presence and absence of fibromyalgia for the entire sample and for age-specific groups. The AUC for the whole study sample ranged from 0.741 to 0.893. The age-specific analyses revealed an AUC ranging from 0.793 to 0.910 for women age 35–44 yr, from 0.726 to 0.901 for women age 45–54 yr, and from 0.708 to 0.846 for women age 55–65 yr.

The arm curl, followed by the 30-s chair stand and the handgrip strength tests, showed the highest capacity to discriminate presence or absence of fibromyalgia for the entire

TABLE 2. Anthropometric and functional capacity of the study samples.

	Patients with Fibromyalgia (*n* = 487)	Healthy Women (*n* = 250)	*P*[a]	*P*[b]
Weight (kg)	71.3 (14.0)	67.8 (12.7)	0.049	0.002
Height (m)	157.8 (6.0)	159.8 (6.2)	<0.001	<0.001
BMI (kg·m^{-2})	28.6 (5.4)	26.5 (4.6)	<0.001	<0.001
Muscle mass (kg)	22.7 (3.3)	23.0 (3.3)	0.050	0.064
Fat mass (%)	40.1 (7.7)	36.7 (7.5)	<0.001	<0.001
Waist circumference (cm)	90.6 (13.1)	85.4 (12.5)	<0.001	<0.001
Physical fitness tests				
Arm curl (repetitions)	14.3 (4.96)	22.7 (4.62)	<0.001	<0.001
30-s chair stand (repetitions)	10.3 (3.32)	15.3 (3.05)	<0.001	<0.001
Handgrip strength (kg)	19.7 (7.59)	29.6 (8.06)	<0.001	<0.001
8-ft up and go[c](s)	7.02 (2.34)	5.27 (1.03)	<0.001	<0.001
6-min walk (m)	483.5 (89.6)	586.3 (73.3)	<0.001	<0.001
Chair sit and reach (cm)	−11.4 (12.1)	2.49 (10.7)	0.001	<0.001
Back scratch (cm)	−14.5 (12.7)	−5.70 (9.82)	<0.001	<0.001

Values are expressed as mean (SD).
[a]*P* values are shown after adjusting the model for age.
[b]*P* values shown for model adjusted for age, occupational status, educational status and medication. Physical fitness was further adjusted for BMI.
[c]Lower scores indicate better performance.

study sample (AUC = 0.89, 0.87, and 0.83, respectively; all, $P < 0.001$). The same trend was observed for the age-specific groups, except for the handgrip strength test, that showed lower capacity than other tests for the group of women age 35–44 yr but high ability in identifying fibromyalgia in women age 55–65 yr.

Table 5 shows the cutoff points, odds ratios (OR), and 95% CI of the physical fitness tests to identifying fibromyalgia presence or absence after adjusting for age and BMI. The arm curl and 30-s chair stand tests showed the highest ability to discriminate fibromyalgia presence or absence. The optimal cutoff point to discriminate between fibromyalgia presence and absence with the arm curl test in women age 35–44 yr was <20 repetitions. An arm curl test <20 repetitions was associated with increased odds of having fibromyalgia (OR, 35.6; 95% CI, 12.6–101) in women age 35–44 yr. The optimal cutoff point to discriminate between fibromyalgia presence and absence with the 30-s chair stand test in women age 35–44 yr was <13 repetitions. A 30-s chair stand test <13 repetitions was associated with increased odds of having fibromyalgia (OR, 22.0; 95% CI, 7.6–63.8) in women age 35–44 yr. The optimal cutoff point to discriminate between presence and absence of fibromyalgia for the arm curl test in women age 45–54 yr was <16 repetitions. An arm curl test <16 repetitions was associated with increased odds of having fibromyalgia (OR, 23.7; 95% CI, 10.3–54.0) in women age 45–54 yr. The optimal cut-off to discriminate between presence and absence of fibromyalgia for the 30-s chair stand test in women age 45–54 yr was <12 repetitions. A 30-s chair stand test <12 repetitions was associated with increased odds of having fibromyalgia (OR, 19.9; 95% CI, 9.4–42.1) in women age 45–54 yr. In the group of women age 55–65 yr, the higher OR values were observed for the handgrip strength test. A handgrip

TABLE 3. Partial correlations between fitness testing and the FIQR, the modified ACR 2010 fibromyalgia diagnostic criteria, and tenderness in the group of patients with fibromyalgia.

	Chair Sit and Reach	Back Scratch	Handgrip Strength	Chair Stand	8-ft Up and Go[a]	Arm Curl	6-min Walk
FIQR							
FIQR total score	−0.318*	−0.291*	−0.221*	−0.357*	−0.245*	−0.336*	−0.344*
FIQR symptoms	−0.307*	−0.303*	−0.230*	−0.315*	−0.229*	−0.277*	−0.307*
FIQR overall impact	−0.270*	−0.226*	−0.119**	−0.275*	−0.177*	−0.267*	−0.278*
Pain rating	−0.233*	−0.223*	−0.180*	−0.224*	−0.168*	−0.225*	−0.232*
Energy rating/fatigue	−0.225*	−0.212*	−0.207*	−0.301*	−0.195*	−0.253*	−0.253*
Stiffness rating	−0.282*	−0.239*	−0.146*	−0.180*	−0.123**	−0.167*	−0.174*
Sleep quality/problems	−0.198*	−0.161*	−0.155**	−0.157**	−0.132**	−0.106*	−0.132**
Depression level	−0.262*	−0.251*	−0.159*	−0.246*	−0.220*	−0.232*	−0.287*
Memory problems	−0.166*	−0.188*	−0.122**	−0.210*	−0.109***	−0.165*	−0.214*
Anxiety level	−0.195*	−0.230*	−0.125**	−0.153**	−0.155**	−0.184*	−0.196*
Tenderness level	−0.037	−0.053	−0.040	−0.134**	−0.083	−0.101***	−0.099***
Balance problems	−0.195*	−0.192*	−0.185*	−0.259*	−0.183*	−0.210*	−0.240*
Environmental sensitivity	−0.131**	−0.134**	−0.144**	−0.105***	−0.040	−0.075	−0.056
Modified ACR-2010 fibromyalgia diagnostic criteria							
Widespread pain index	−0.150**	−0.134**	−0.110***	−0.132**	0.145**	−0.123**	−0.121**
Symptom severity score	−0.192*	−0.186*	−0.120**	−0.228*	0.176*	−0.209*	−0.187*
Polysymptomatic distress	−0.201*	−0.178*	−0.135**	−0.202*	0.187*	−0.189*	−0.175*
Tenderness							
Number of tender points	−0.178*	−0.113*	−0.177*	−0.169*	−0.103***	−0.204*	−0.129**
Algometer score	0.224*	0.125**	0.178*	0.245*	0.207*	0.271*	0.173*

[a]Lower score indicates better performance; model was adjusted for age and BMI.
*$P < 0.001$
**$P < 0.01$.
***$P < 0.05$

TABLE 4. Ability (ROC curve analysis) of different fitness tests to discriminate between presence and absence of fibromyalgia.

Presence/Absence of Fibromyalgia	All Age Groups (487 Patients with Fibromyalgia vs 250 Control Women)		Women Age 35–44 yr (102 Patients with Fibromyalgia vs 72 Control Women)		Women Age 45–54 yr (211 Patients with Fibromyalgia vs 114 Control Women)		Women Age 55–65 yr (174 Patients with Fibromyalgia vs 64 Control Women)	
Fitness Tests	**AUC (SEM)**	**95% CI**	**AUC (SEM)**	**95% CI**	**AUC (SEM)**	**95% CI**	**AUC (SEM)**	**95% CI**
Arm curl	0.893 (0.01)	0.869–0.916	0.910 (0.02)	0.865–0.955	0.901 (0.02)	0.866–0.935	0.846 (0.03)	0.786–0.906
30-s chair stand	0.866 (0.01)	0.839–0.894	0.919 (0.02)	0.879–0.959	0.863 (0.02)	0.822–0.904	0.825 (0.03)	0.763–0.888
Handgrip strength	0.834 (0.01)	0.806–0.862	0.798 (0.03)	0.730–0.866	0.855 (0.02)	0.813–0.897	0.811 (0.03)	0.752–0.870
8-ft up and go	0.832 (0.02)	0.802–0.860	0.871 (0.02)	0.817–0.925	0.858 (0.02)	0.815–0.901	0.778 (0.03)	0.711–0.845
6-min walk	0.820 (0.02)	0.791–0.846	0.816 (0.02)	0.753–0.880	0.838 (0.02)	0.794–0.882	0.748 (0.03)	0.674–0.822
Chair sit and reach	0.811 (0.02)	0.778–0.844	0.836 (0.03)	0.775–0.896	0.799 (0.03)	0.745–0.852	0.796 (0.03)	0.729–0.862
Back scratch	0.741 (0.02)	0.703–0.779	0.793 (0.02)	0.724–0.863	0.726 (0.02)	0.668–0.783	0.708 (0.03)	0.634–0.783

All, $P < 0.001$.

strength test score <19 kg was associated with increased odds of having fibromyalgia (OR, 17.0; 95% CI, 6.4–44.8).

DISCUSSION

The main findings of the present study indicate that fitness testing is a powerful tool to discriminate between presence and absence of fibromyalgia in women regardless of the age range of the women. These results support our previous findings and highlight the importance of implementing fitness testing as a complementary tool for the diagnosis and monitoring of fibromyalgia (3,6). The arm curl, 30-s chair stand, and handgrip strength tests were those that more potently discriminated women with fibromyalgia from healthy women. An arm curl test score of <20 repetitions was associated with 36 times greater odds of having fibromyalgia in women age 35–44 yr. An arm curl test score <16 repetitions was associated with 24 times greater odds of having fibromyalgia in women age 45–54 yr. In the group of women age 55–65 yr, the highest OR values were observed for the handgrip strength test. The odds of having fibromyalgia was 17 times greater in those patients who performed <19 kg. In agreement with previous studies from our group (3,6), we recommend the use of fitness testing in clinical setting as a quick and complementary tool for fibromyalgia diagnosis.

As expected, we observed patients with fibromyalgia to have lower functional capacity than healthy women in all the studied physical fitness tests. Therefore, we confirm that physical fitness is clearly decreased in people with fibromyalgia compared with that in their age-matched healthy peers (14,23,31) and is similar to that in healthy older adults (14,26). Hence, patients with fibromyalgia have impaired functional capacity with high risk of disability and difficulties on doing tasks associated with staying physically independent (26). Patients with chronic pain reduce their physical activity and thus display a deconditioned fitness status (10,14). Indeed, in the recent study by Bjornsdottir et al. (10), the authors studied the consequences of chronic pain in 5906 Icelanders age 18–79 yr reporting chronic low back pain, chronic neck symptoms, and/or fibromyalgia, with the aim of analyzing the global burden imposed by chronic pain conditions. Several symptoms and functional limitations in daily life were strongly associated with chronic pain, including deficient energy and muscular discomfort, physical mobility limitations, lifting groceries, climbing stairs, and stooping (10). The authors also found that women, but not men, with chronic pain tended to refrain from physical activity (10).

Pain is the more predominant symptom in fibromyalgia and can be on the basis of the lower functional capacity observed (10,14). Our group previously examined the association between pain and functional capacity levels in a smaller sample of similar age and region (14). We observed inverse association of tender point count with the 30-s chair stand and the distance covered in the 6-min walk tests and positive association of the algometer score with the 30-s chair stand, the 6-min walk, and the back scratch tests. However, we did not assess the arm curl test and we found that weight status seems to play a role in these associations. This is the reason why all the analysis performed in the present study related to fitness

TABLE 5. Binary logistic regression statistics testing the predictive capacity of the fitness testing thresholds derived from the ROC curve analysis for presence/absence of fibromyalgia.

		Low Fitness (Based on the Cutoff)											
		All Age Groups (487 Patients with Fibromyalgia vs 250 Control Women)			Women Age 35–44 yr (102 Patients with Fibromyalgia vs 72 Control Women)			Women Age 45–54 yr (211 Patients with Fibromyalgia vs 114 Control Women)			Women Age 55–65 yr (174 Patients with Fibromyalgia vs 64 Control Women)		
	Fitness Test	**Cutoff Point**	**OR**	**95% CI**	**Cutoff Point**	**OR**	**95% CI**	**Cutoff Point**	**OR**	**95% CI**	**Cutoff Point**	**OR**	**95% CI**
Presence/absence of fibromyalgia	Arm curl (repetitions)	<16	20.4	11.9–34.7	<20	35.6	12.6–101	<16	23.7	10.3–54.0	<16	12.6	5.3–27.7
	30-s chair stand (repetitions)	<12	16.7	10.2–27.3	<13	22.0	7.6–63.8	<12	19.9	9.4–42.1	<11	12.9	5.2–31.8
	Handgrip strength (kg)	<20.9	14.7	8.9–24.6	<22.1	17.3	6.1–49.1	<21.6	17.5	8.2–37.0	<19.1	17.0	6.4–44.8
	8-ft up & go[a](s)	≥5.3	9.9	6.8–14.4	≥5.1	12.0	5.6–25.8	≥5.3	12.6	6.9–23.1	≥5.9	7.3	3.9–13.7
	6-min walk (m)	<510	8.3	5.3–12.8	<551	8.1	3.3–19.6	<504	12.5	5.9–26.5	<500	5.3	2.7–10.5
	Chair sit and reach (cm)	<−6.7	10.4	6.8–15.7	<−5.7	19.2	7.3–50.1	<−6.7	9.9	5.3–18.3	<−9.7	12.1	5.3–27.5
	Back scratch (cm)	<−10	4.7	3.2–6.8	<−8.7	7.5	2.8–19.8	<−8.9	3.7	2.1–6.5	<−11.7	4.5	2.3–8.9

High fitness was used as reference.
[a]A score above the threshold indicates lower fitness, opposite to the rest of the tests.

were adjusted for BMI. Our results concur with these studies, suggesting that the higher the muscle strength, the lower the pain and symptomatology reported (7,19). Hooten et al. (19) found that higher knee extensor isometric and isokinetic strength was associated with lower pressure pain threshold. Similarly, Assumpção et al. (7) observed that muscle strength (knee and elbow extension) was related to pain threshold and pain on a visual analog scale. However, the association of aerobic fitness with pain and symptomatology in women with fibromyalgia is not clear, with some studies reporting a certain degree of association (14,15), while others reporting lack of relation (19).

Our first study analyzing the use of physical fitness testing for the diagnosis and monitoring of fibromyalgia was solely performed, assessing the handgrip strength test in 81 female patients with fibromyalgia and 44 control women (6). We observed that a score lower than 23 kg was associated with 34 times higher odds of having fibromyalgia after adjustment for age (6). In the present study, this association was lower but we have included higher sample size and further adjusted for age, BMI, and medication and, thus, gained in accuracy. In our subsequent study (3), the sample comprised 94 female patients with fibromyalgia and 66 healthy controls. That time, we assessed the same physical fitness tests battery than in the present study, except for the inclusion of the arm curl test and the exclusion of the 30-s blind flamingo test (static balance) this time. We observed that all fitness tests, except the back scratch test, were able to discriminate between presence and absence of fibromyalgia (3). We found that the 30-s chair stand test showed the highest ability to discriminate presence and absence of fibromyalgia (we did not assess the arm curl test) (3). A chair stand test lower than 10 repetitions was then associated with 52 times higher odds of having fibromyalgia, whereas in the present study, we have modified the cutoff up to <12 repetitions for the entire sample size. This time, we have also proposed a cutoff point <13 for women age 35–44 yr and <11 for women age 55–65 yr. Therefore, the 30-s chair stands test showed remarkable discriminative capacity to identify fibromyalgia presence (now being the second proposed test). Indeed, the arm curl, the 30-s chair stand, and the handgrip strength tests, which measure muscle strength, seem to be the most discriminative fitness tests to establish fibromyalgia presence or absence.

As recently shown, patients with fibromyalgia might not necessarily fulfill the tender point criteria to be diagnosed (9,37), which concurs with our proposal of including new clinical tools for the diagnosis of fibromyalgia. In fact, in an attempt to avoid the requirement of the tender point examination, the ACR released new diagnostic criteria in 2010 (37), which is gaining widespread acceptance. Recently, a study displayed that the combination of the 1990 criteria and the modified 2010 ACR criteria showed higher sensitivity and specificity for fibromyalgia diagnosis than the 1990 or the modified 2010 ACR criteria independently (30). Because of the unknown etiology of fibromyalgia, there is not a gold standard instrument for its diagnosis. Consequently, the study by Segura-Jimenez et al. (30) showed that the use of different validated diagnostic tools together might enhance the accuracy of fibromyalgia diagnosis. This highlights the need for additional diagnostic tools in fibromyalgia. In this context, fitness testing assessment might improve the diagnostic accuracy of fibromyalgia syndrome and supplement current diagnostic tools, which in turn might also help identify more heterogeneous subgroups of patients (e.g., those fulfilling only ACR 1990 or ACR 2010 or both criteria). In the present study, we found positive relation between better fitness tests scores and lower global score of FIQR, FIQR dimensions, and the modified 2010 ACR criteria. Furthermore, most of the studied tests were also correlated with tender point count and algometer score, which reinforces the use of fitness testing instead of the classical, and more complicated, tender point assessment (17).

Fatigue has been shown as the second most reported symptom in fibromyalgia (32). We have observed the highest correlations between FIQR energy rating/fatigue and fitness testing thorough the 30-s chair stand test (lower body muscle strength), followed by the arm curl test (upper body muscle strength), which strengthen the idea that the muscle strength tests proposed in the present study are also sensitive to other important fibromyalgia's key symptoms.

Some limitations need to be mentioned. First, the male sample size was too small to perform the present statistical approach and most of the statistical analysis tests would not be powerful to detect significant effects (i.e., partial correlations, AUC and ROC analysis, binary logistic regression analysis, and of course classifications by age groups), so this study was carried out only in women, and future studies should replicate this analysis in larger samples in men with fibromyalgia. Moreover, because physical fitness levels clearly differ between genders, we could not merge both groups. Second, the higher pain observed in the participants with lower fitness levels could have been influenced by the fear of pain phenomena (16). Third, we have not objectively assessed physical activity levels among the sample. Finally, in the same way that tender points and the new 2010 diagnosis criteria may erroneously classify people with fibromyalgia when they are healthy, fitness testing can also make that error, classifying a healthy person with little fitness as a person with fibromyalgia. Therefore, the proposed tests should be used just as additional tools for the diagnosis and not as the only sources of criteria. On the other hand, compared with previous literature, the present study involved a large and representative sample (almost 500 female patients with fibromyalgia and 250 age-matched control women from the same geographical area). Furthermore, this study examined a complete range of functional capacity parameters in a single report, which allowed us to make comparisons between fitness tests. Finally, because of the high sample size recruited in the present replication study, we could further establish age-specific fitness cutoff points (i.e., for women age 35–44, 45–54, and 55–65 yr old).

Clinical Implications

The present study has several clinical implications to highlight. These results reinforce our previous hypothesis that physical fitness could be set as a complementary tool for the diagnosis and monitoring of fibromyalgia in clinical settings. The high capacity of the proposed fitness tests to discriminate between presence and absence of fibromyalgia and the fact that they are inexpensive and easily accessible facilitate the inclusion of fitness testing as a complementary fibromyalgia diagnostic tool. This, in turn, might also assist the clinician in targeting treatment. Particularly, the arm curl and the 30-s chair stand tests have great potential in a clinical setting for several reasons: First, a dumbbell or a chair and a stopwatch are all the equipment needed to perform them, so they are extremely cheap. Second, the time needed to perform these tests is just 30 s (2–3 min in total), which is a fundamental issue for clinicians who are usually under time constraints. Third, other fitness tests, such as the 6-min walk test, require larger spaces, whereas the arm curl and the 30-s chair stand tests can be performed in any room without any special requirement. Fourth, the procedures for these tests are simple and do not require any particular training. In addition to these tests, we suggest the use of the handgrip strength test for women age 55–65 yr old (but a hand dynamometer is required).

CONCLUSIONS

We observed that physical fitness in general, and particularly the arm curl and the 30-s chair stand tests, powerfully discriminates the presence or absence of fibromyalgia in women. We found other tests able to discriminate between presence and absence of fibromyalgia; and on the basis of the results, we also suggest the use of the handgrip strength test for more thorough evaluation, mainly among women age 55–65 yr old. Fitness testing can serve as a complement to the current fibromyalgia diagnosis criteria to achieve better discrimination between healthy status and fibromyalgia presence. Identification of women who fail to meet the proposed cutoff points can help to easily, quickly, and cheaply discriminate and rule out the presence of the disease, especially in primary care settings.

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REFERENCES

1. Abeles AM, Pillinger MH, Solitar BM, Abeles M. Narrative review: the pathophysiology of fibromyalgia. *Ann Intern Med*. 2007;146(10):726–34.
2. Aparicio VA, Carbonell-Baeza A, Ortega FB, Estevez F, Ruiz JR, Delgado-Fernandez M. Usefulness of tenderness to characterise fibromyalgia severity in women. *Clin Exp Rheumatol*. 2011;29(6 Suppl 69):S28–33.
3. Aparicio VA, Carbonell-Baeza A, Ruiz JR, et al. Fitness testing as a discriminative tool for the diagnosis and monitoring of fibromyalgia. *Scand J Med Sci Sports*. 2013;23(4):415–23.
4. Aparicio VA, Ortega FB, Carbonell-Baeza A, et al. Fibromyalgia's key symptoms in normal-weight, overweight, and obese female patients. *Pain Manag Nurs*. 2013;14(4):268–76.
5. Aparicio VA, Ortega FB, Carbonell-Baeza A, Camiletti D, Ruiz JR, Delgado-Fernandez M. Relationship of weight status with mental and physical health in female fibromyalgia patients. *Obes Facts*. 2011;4(6):443–8.
6. Aparicio VA, Ortega FB, Heredia JM, Carbonell-Baeza A, Sjostrom M, Delgado-Fernandez M. Handgrip strength test as a complementary tool in the assessment of fibromyalgia severity in women. *Arch Phys Med Rehabil*. 2011;92(1):83–8.
7. Assumpção A, Sauer J, Mango P. Physical function interfering with pain and symptoms in fibromyalgia patients. *Clin Exp Rheumatol*. 2009;28(6 Suppl 63):S57–63.
8. Barbat-Artigas S, Pion CH, Leduc-Gaudet JP, Rolland Y, Aubertin-Leheudre M. Exploring the role of muscle mass, obesity, and age in the relationship between muscle quality and physical function. *J Am Med Dir Assoc*. 2014;15(4):303.e13–303.e20.
9. Bennett R, Friend R, Marcus D, et al. Criteria for the diagnosis of fibromyalgia: validation of the modified 2010 preliminary ACR criteria and the development of alternative criteria. *Arthritis Care Res (Hoboken)*. 2014;66(9):1364–73.
10. Bjornsdottir SV, Jonsson SH, Valdimarsdottir UA. Functional limitations and physical symptoms of individuals with chronic pain. *Scand J Rheumatol*. 2013;42(1):59–70.
11. Busch AJ, Barber KA, Overend TJ, Peloso PM, Schachter CL. Exercise for treating fibromyalgia syndrome. *Cochrane Database Syst Rev*. 2007 Oct 17;(4):CD003786.
12. Buskila D, Neumann L, Sibirski D, Shvartzman P. Awareness of diagnostic and clinical features of fibromyalgia among family physicians. *Fam Pract*. 1997;14(3):238–41.
13. Carbonell-Baeza A, Aparicio VA, Ortega FB, et al. Does a 3-month multidisciplinary intervention improve pain, body composition and physical fitness in women with fibromyalgia? *Br J Sports Med*. 2011;45(15):1189–95.
14. Carbonell-Baeza A, Aparicio VA, Sjostrom M, Ruiz JR, Delgado-Fernandez M. Pain and functional capacity in female fibromyalgia patients. *Pain Med*. 2011;12(11):1667–75.
15. Carbonell-Baeza A, Ruiz JR, Aparicio VA, Ortega FB, Delgado-Fernandez M. The 6-minute walk test in female fibromyalgia patients: relationship with tenderness, symptomatology, quality of life, and coping strategies. *Pain Manag Nurs*. 2013;14(4):193–9.
16. de Gier M, Peters ML, Vlaeyen JW. Fear of pain, physical performance, and attentional processes in patients with fibromyalgia. *Pain*. 2003;104(1):121–30.
17. Fitzcharles MA, Boulos P. Inaccuracy in the diagnosis of fibromyalgia syndrome: analysis of referrals. *Rheumatology (Oxford)*. 2003;42(2):263–7.
18. Fitzcharles MA, Shir Y, Ablin JN, et al. Classification and clinical diagnosis of fibromyalgia syndrome: recommendations of recent evidence-based interdisciplinary guidelines. *Evid Based Complement Alternat Med*. 2013;2013:528952.
19. Hooten WM, Rosenberg CJ, Eldrige JS, Qu W. Knee extensor strength is associated with pressure pain thresholds in adults with fibromyalgia. *PLoS One*. 2013;8(4):e59930.

20. Jiao J, Vincent A, Cha SS, Luedtke CA, Oh TH. Relation of age with symptom severity and quality of life in patients with fibromyalgia. *Mayo Clin Proc*. 2014;89(2):199–206.
21. Lachaine J, Beauchemin C, Landry PA. Clinical and economic characteristics of patients with fibromyalgia syndrome. *Clin J Pain*. 2010;26(4):284–90.
22. Luciano JV, Aguado J, Serrano-Blanco A, Calandre EP, Rodriguez-Lopez CM. Dimensionality, reliability, and validity of the revised fibromyalgia impact questionnaire in two Spanish samples. *Arthritis Care Res*. 2013;65(10):1682–9.
23. Mannerkorpi K, Svantesson U, Broberg C. Relationships between performance-based tests and patients' ratings of activity limitations, self-efficacy, and pain in fibromyalgia. *Arch Phys Med Rehabil*. 2006;87(2):259–64.
24. Martin SA, Coon CD, McLeod LD, Chandran A, Arnold LM. Evaluation of the fibromyalgia diagnostic screen in clinical practice. *J Eval Clin Pract*. 2014;20(2):158–65.
25. Mas AJ, Carmona L, Valverde M, Ribas B. Prevalence and impact of fibromyalgia on function and quality of life in individuals from the general population: results from a nationwide study in Spain. *Clin Exp Rheumatol*. 2008;26(4):519–26.
26. Panton LB, Kingsley JD, Toole T, et al. 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*. 2006;86(11):1479–88.
27. Rikli RE, Jones J. Development and validation of a functional fitness test for community residing older adults. *J Aging Phys Act*. 1999;7:129–61.
28. Ruiz-Ruiz J, Mesa JL, Gutierrez A, Castillo MJ. Hand size influences optimal grip span in women but not in men. *J Hand Surg Am*. 2006;27(5):897–901.
29. Salaffi F, Sarzi-Puttini P. Old and new criteria for the classification and diagnosis of fibromyalgia: comparison and evaluation. *Clin Exp Rheumatol*. 2012;30(6 Suppl 74):3–9.
30. Segura-Jimenez V, Aparicio VA, Alvarez-Gallardo IC, et al. Validation of the modified 2010 American College of Rheumatology diagnostic criteria for fibromyalgia in a Spanish population. *Rheumatology (Oxford)*. 2014;53(10):1803–11.
31. Sener U, Ucok K, Ulasli AM, et al. Evaluation of health-related physical fitness parameters and association analysis with depression, anxiety, and quality of life in patients with fibromyalgia. *Int J Rheum Dis*. 2013; doi: 10.1111/1756-185X.12237.
32. Silverman SL, Harnett J, Zlateva G, Mardekian J. Identifying fibromyalgia-associated symptoms and conditions from a clinical perspective: a step toward evaluating healthcare resource utilization in fibromyalgia. *Pain Pract*. 2010;10(6):520–9.
33. Tapias-Merino E, Puertas-Martin V, Vera-Garcia C, Lora-Pablos D, Revuelta-Alonso A, Bermejo-Pareja F. Test-retest and interobserver reliability of a Spanish version (MMSE-37) of the Folstein minimental test, adapted to populations with a low level of schooling [in Spanish]. *Rev Neurol*. 2010;50(11):646–52.
34. Wilson HD, Robinson JP, Turk DC. Toward the identification of symptom patterns in people with fibromyalgia. *Arthritis Rheum*. 2009;61(4):527–34.
35. Wolfe F, Brahler E, Hinz A, Hauser W. Fibromyalgia prevalence, somatic symptom reporting, and the dimensionality of polysymptomatic distress: results from a survey of the general population. *Arthritis Care Res*. 2013;65(5):777–85.
36. Wolfe F, Clauw DJ, Fitzcharles MA, et al. Fibromyalgia criteria and severity scales for clinical and epidemiological studies: a modification of the ACR preliminary diagnostic criteria for fibromyalgia. *J Rheumatol*. 2011;38(6):1113–22.
37. Wolfe F, Clauw DJ, Fitzcharles MA, et al. The American College of Rheumatology preliminary diagnostic criteria for fibromyalgia and measurement of symptom severity. *Arthritis Care Res*. 2010; 62(5):600–10.
38. Wolfe F, Michaud K, Li T, Katz RS. Chronic conditions and health problems in rheumatic diseases: comparisons with rheumatoid arthritis, noninflammatory rheumatic disorders, systemic lupus erythematosus, and fibromyalgia. *J Rheumatol*. 2010;37(2): 305–15.
39. Wolfe F, Smythe HA, Yunus MB, et al. The American College of Rheumatology 1990 criteria for the classification of fibromyalgia. Report of the Multicenter Criteria Committee. *Arthritis Rheum*. 1990;33(2):160–72.
40. Wolfe F, Walitt B. Culture, science and the changing nature of fibromyalgia. *Nat Rev Rheumatol*. 2013;9(12):751–5.
41. Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. *Clin Chem*. 1993;39(4):561–77.