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Original Investigation

A comparison of core muscle endurance of females with fibromyalgia versus healthy females: An observational study

Dewanshu Sindwani, Manjyot Kaur *

Department of Physiotherapy, T.D.T.R. D.A.V. Institute of Physiotherapy and Rehabilitation, Yamuna Nagar, India

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ABSTRACT

Introduction: Despite the numerous benefits of core muscle strengthening in improving symptoms of fibromyalgia (FM), limited studies have quantified core muscle function in FM patients.

Objective: To compare the core muscle endurance of FM females with age-matched healthy females and determine whether a correlation exists between core muscle endurance and FM severity.

Materials and methods: Pre-diagnosed female FM patients ($n = 7$) and age-matched healthy females ($n = 19$) were assessed using McGill's core endurance tests in four positions – flexion, extension, and bilateral side-bridge. The longest contraction holding time (in seconds) in each position was noted and compared in both groups. Additionally, patient-reported Fibromyalgia Impact Questionnaire (FIQ) scores were obtained to determine disease severity.

Results: The mean holding time for trunk extensors (26.14 ± 7.7 s), right lateral flexors (20.14 ± 8.3 s), and left lateral flexors (20.86 ± 5.3 s) was significantly lower in the FM females than the healthy females (trunk extensors = 55.21 ± 17.1 s; right lateral flexors = 36.05 ± 13.2 s; left lateral flexors = 35.11 ± 13.8 s). The endurance of trunk flexors was statistically similar in both groups (FM females = 52.14 ± 27.9 s; healthy females = 74.37 ± 37.7 s). Lastly, core muscle endurance was not correlated with the FIQ scores in FM patients ($p > 0.05$).

Conclusion: The results of this preliminary study revealed that core extensor and lateral flexor endurance in FM females was lower than their healthy female counterparts. Larger sample studies are needed to further substantiate our findings.

* *Corresponding author.*
E-mail address: kaurmanjyot311@gmail.com (M. Kaur).

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Una comparación de la resistencia muscular central de las mujeres con fibromialgia vs. mujeres sanas: un estudio observacional

Palabras clave:
Resistencia física
Estabilidad central
Fibromialgia
Prueba de McGill
Medidas de resultado informadas por el paciente

RESUMEN

Introducción: A pesar de los numerosos beneficios del fortalecimiento de los músculos centrales para mejorar los síntomas de la fibromialgia (FM), investigaciones limitadas han cuantificado la función de estos en pacientes con FM.

Objetivo: Comparar la resistencia de los músculos centrales de mujeres con FM con mujeres sanas de la misma edad y determinar si existe una correlación entre la resistencia de los músculos centrales y la gravedad de la FM.

Materiales y métodos: Se evaluaron pacientes femeninas con FM prediagnosticadas (n = 7) y mujeres sanas de la misma edad (n = 19), para lo cual se utilizaron las pruebas de resistencia central de McGill en cuatro posiciones: flexión, extensión y puente lateral bilateral. Se anotó el tiempo de mantenimiento de la contracción más largo (en segundos) en cada posición y se comparó en ambos grupos. Además, se obtuvieron las puntuaciones del Cuestionario de Impacto de la Fibromialgia (FIQ) informado por el paciente para determinar la gravedad de la enfermedad.

Resultados: El tiempo medio de retención para los extensores del tronco (26,14 ± 7,7 s), flexores laterales derechos (20,14 ± 8,3 s) y flexores laterales izquierdos (20,86 ± 5,3 s) fue significativamente menor en las mujeres FM que en las sanas (extensores de tronco = 55,21 ± 17,1 s, flexores laterales derechos = 36,05 ± 13,2 s y flexores laterales izquierdos = 35,11 ± 13,8 s). La resistencia de los flexores del tronco fue estadísticamente similar en ambos grupos (mujeres FM = 52,14 ± 27,9 s; mujeres sanas = 74,37 ± 37,7 s). Por último, la resistencia muscular central no se correlacionó con las puntuaciones FIQ en las pacientes con FM (p > 0,05).

Conclusión: Los resultados de este estudio preliminar revelaron que la resistencia de los extensores centrales y flexores laterales en las mujeres con FM fue menor que en sus contrapartes sanas. Se necesitan estudios con muestras más grandes para corroborar aún más nuestros hallazgos.

Introduction

Fibromyalgia (FM) or fibromyalgia syndrome is a chronic pain disorder characterized by widespread incessant non-inflammatory pain as the primary musculoskeletal complaint and accompanied by other symptoms like fatigue, insomnia, morning stiffness, anxiety, mood disturbances, and cognitive impairment.[1,2] With a 2% prevalence in the general population, the disease is reportedly more common in females (ratio 4.8:1) as per 2010 American College of Rheumatology criteria.[1] Pathologically, FM has been linked to the phenomena of central sensitization to pain and deficient endogenous pain inhibitory mechanisms resulting in low pain threshold, hyperalgesia, and allodynia – the characteristic features of FM.[3]

Physiotherapy exercises, including muscle stretching, strengthening, aerobic exercises, yoga, Pilates, and balance exercises, have been extensively used for managing pain and improving physical function in FM patients.[4,5] Numerous studies have reported satisfactory results with core strengthening, Pilates and balance training exercises in reducing pain and improving the quality of life in FM patients.[6–9] Notably, strengthening the core musculature is at the heart of many of these exercise regimes. Core muscles of the trunk offer both static and dynamic trunk muscle control that is essential in both upper and lower limb activity.[10] They form an important link in the neuromuscular mechanism responsible for integrating sensory information and motor output while performing a motor task effectively.[10] A consequent improvement in FM symptoms reported in these patients through these exercises indicates a possible role of weak core musculature; however, this association has not been explored yet.

A variety of methods are used for testing core stability which includes strength testing, flexibility testing, functional tests, and endurance tests.[11] Of these tests, core muscle endurance testing tools, such as the McGill's test, are the most reliable ones as described upon healthy adults.[11,12] A few studies have explored the relationship between core musculature and functional performance or balance in other populations (athletic, inactive, and postmenopausal women).[10,12,13] Additionally, there is ample literature corroborating a reduction in physical capacity and functional performance in patients with FM resulting from decreased muscle strength in both upper and lower limb muscles; however, there is a dearth of evidence on the endurance of core muscles in FM patients which may be essential in designing specific exercise regimens focused at core muscle rehabilitation in these patients. Therefore, the primary objective of this study was to compare the core mus-

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cle endurance of females with FM and age-matched healthy females. A secondary objective was to determine whether a correlation exists between the core muscle endurance in FM patients and the severity of FM assessed using the Fibromyalgia Impact Questionnaire (FIQ).

Material and methods

This cross-sectional study was carried out at our Department of Physiotherapy. The study was approved by the Ethics Committee of Pt. B.D. Sharma University of Health Sciences, Rohtak, Haryana (dated: October 2020). All participants signed a voluntary informed consent for participation.

Participants

Female patients (aged 30–60 years) diagnosed with FM[14] and age-matched healthy females in the institution and neighborhood (self-reported absence of any pain or painful illness) were approached to be included in the study. FM was diagnosed by a rheumatologist based on the ACR 2016 diagnostic criteria – (a) Widespread Pain Index (WPI) $\geq$ 7 and Symptom Severity Score (SSS) $\geq$ 5 or WPI 4–6 and SSS $\geq$ 9; (b) generalized pain in 4 out of 5 regions (left upper region, right upper region, left lower region, right lower region, and axial region); (c) symptoms present for more than 3 months.[15] Those having an uncontrolled systemic illness (like diabetes mellitus or systemic arterial hypertension), diagnosed cases of neurological or musculoskeletal conditions that may directly interfere in the evaluation (cognitive deficits, sensory alterations, advanced joint diseases, infections), urinary incontinence, and pregnant females were excluded from both groups.[14]

Procedure

Demographic details of all participants were obtained after recruitment using a screening form for eligibility. This included the clinical and physical re-evaluation of the FM participants as per the ACR 2016 criteria and they were asked to fill the FIQ questionnaires. We used McGill's core endurance test to assess the endurance of four primary trunk muscle groups – flexors, bilateral side flexors, and extensors, by recording the time (in seconds) for which the participant can hold the trunk position.[16] The test has excellent reliability coefficients for trunk flexors (r = 0.93), trunk side flexors (Right: 0.96, Left: 0.99), and trunk extensors (0.99).[16] A single physical therapist conducted the testing; a detailed explanation and demonstration of the test procedure were done for the participant's understanding. For trunk flexion, the participants were seated with hips and knees flexed at 90–90° (so the hips, knees, and the second toe were aligned) leaning against a board positioned at a 60° incline and arms folded across the chest with hands on the opposite shoulder and head in neutral. They were asked to maintain this position throughout; the board was then moved back 10 cm and the participant was asked to maintain this position; one practice trial was allowed. The stopwatch was started when the board was moved back and the test was terminated when there was a noticeable change in this trunk position (a deviation from the neutral spine or an increase in the low-back arch [the back should not touch the backrest]).

Next, the endurance of lateral trunk flexors (Right and Left) was assessed; the participant was in a side-lying position (on the floor or couch) with legs extended and the feet on top of each other or in tandem (heel-to-toe). They were instructed to assume a full side-bridge position keeping both legs extended and the sides of their feet on the floor/couch. The elbow of the lower arm was positioned directly under the shoulder and the upper arm across the chest with the hand on the opposite shoulder and hips elevated off the mat so the head, torso, hips, and legs were in straight alignment. The timing was started as the participant moved into this position and terminated when the trunk deviated from the neutral spine position (hips dropping forward), hips shifted forward or backward, or hips fell back to the floor.[16] The test was performed for both sides.

The fourth position was for measuring the trunk extensor endurance. The participant was positioned prone with the iliac crests resting at the edge of the couch while the upper limbs were supported by placing them on the floor. The lower legs were strapped to the table using a belt. The participant was asked to maintain a prone horizontal position keeping arms across the chest as long as possible. The timing was noted from the point they lifted their torso parallel to the floor till they could no longer maintain this position (the torso falls below horizontal).

One practice trial and two recording trials were performed for each position (assessed in random order). The participants in both groups were instructed to maintain each position for as long as possible and the larger value from among the two trials was recorded. The average session time was 30–40 min. No adverse events (exacerbation or reproduction of symptoms, exhaustion) occurred during the testing.

In addition to McGill's test, the FIQ was used to assess the severity of FM and the associated quality of life in FM patients. FIQ is a patient-reported outcome measure with a score ranging from 0 to 100; higher scores indicate more severity; the average score is around 50. This scale has been widely used in FM patients for studying the effect of drug and rehabilitation interventions and in epidemiological and physiological studies. It demonstrates good validity and reliability in this population and takes around 3–5 min to administer.[17]

Sample size

The sample size was calculated as a priori using G*Power software (version 3.1.9.4, Franz Faul, Germany) using an α level of significance as 5%, $1-\beta$ power = 0.80, large estimated effect size (d = 0.8) between the groups, and an equal allocation ratio, $N2/N1$ = 1:1. A target sample size of 21 was determined for each group. The large estimated effect size meant that the groups were hypothesized to be essentially different from each other.[18]

Statistical analysis

The collected data were analyzed using SPSS (version 23.0; IBM Corp., Armonk, NY). Mean and standard deviation (SD) were calculated for all four positions using the highest recorded time for both groups. Additionally, the mean difference and 95% confidence intervals (CIs) were calculated using an online calculator (available at www.pedro.org.au) subtracting the val-

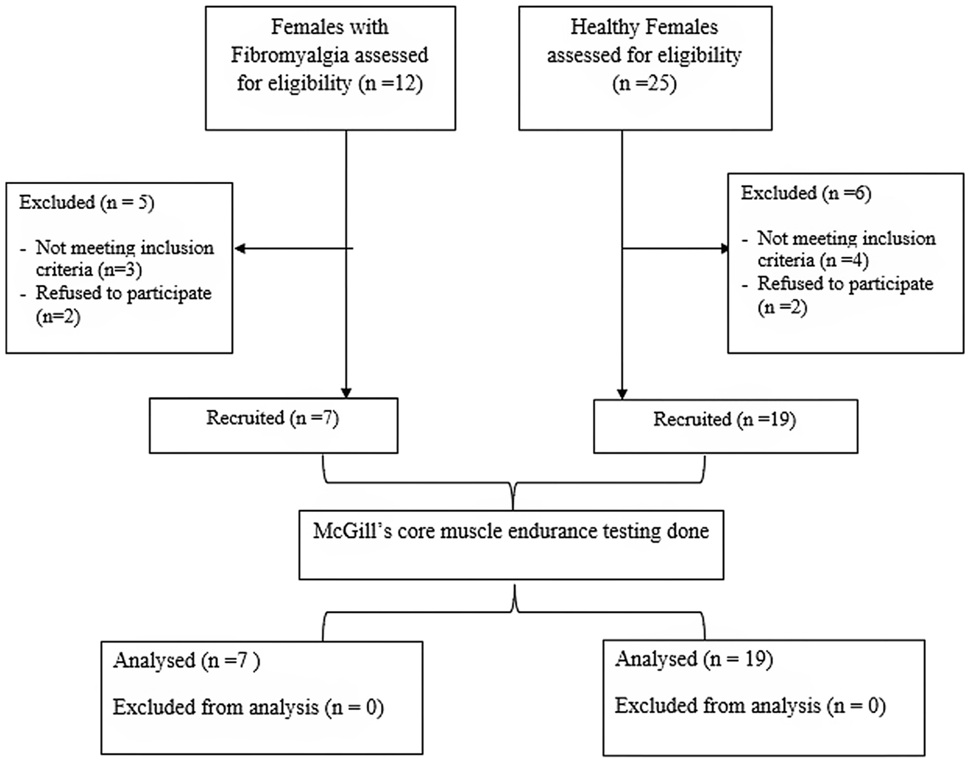

Fig. 1 – Participant flowchart for the study (as per STROBE guideline).

ues for FM females from healthy females' values for McGill's core endurance test. Further, correlation analysis was done for McGill's core endurance test values and the FIQ score of the FM group.

Results

Due to the ongoing COVID-19 pandemic resulting in restrictions for travel and physical interaction in the country, the number of patients agreeing to participate was less than the target sample size. Among the healthy females who volunteered to participate, 19 females matched the inclusion criteria; female patients with FM were approached through nearby hospitals and only seven participants met the eligibility criteria. Fig. 1 shows the participant flow during the study. Analysis was done for the available complete data, and no imputation was done for missing data (to avoid bias).

The mean age of the FM and the healthy participants was 37.86 ± 6.3 years and 37.84 ± 7.6 years, respectively; there was no statistically significant difference between the groups in terms of age ($p = 0.996$) (Table 1). Both study groups were normally distributed as per the Shapiro–Wilk test for normality ($p > 0.05$). All participants (both groups; $n = 26$) were at least high school educated.

The mean holding time for trunk flexors was 52.14 ± 27.9 s for the FM group and 74.37 ± 37.7 s for healthy females; there were a mean difference (95% CI) of 22.23 (−10.17 to 54.63) seconds (see Table 2). The group-wise comparison revealed that both groups were comparable in terms of trunk flexor endurance ($p = 0.17$).

For trunk side flexors, the mean holding time for a right-side bridge was 20.14 ± 8.3 s for FM females and 36.05 ± 13.2 s for healthy females. The mean difference (95% CI) was statistically significant (15.91 (4.81–27.01) seconds; $p = 0.007$). The left side bridge also showed similar results – the FM females were able to hold it for a mean of 20.86 ± 5.3 s while healthy females had better endurance (35.11 ± 13.8 s). This difference was statistically significant (mean difference (95% CI): 14.25 (3.08–25.42) s; $p = 0.014$).

The mean trunk extensor endurance for FM females was significantly lower than the healthy females (FM: 26.14 ± 7.7 s; healthy: 55.21 ± 17.1 s; mean difference (95% CI): 29.07 (15.11–43.03) s; $p < 0.000$).

Lastly, the FIQ scores of FM females did not show a statistically significant correlation with endurance in three of the four positions, except for left side-flexion (flexion: $p = 0.127$; right side-flexion: $p = 0.327$; left side-flexion: $p = 0.012$; extension: $p = 0.968$; see Table 3).

Discussion

The results of this preliminary study revealed that the core muscle endurance of trunk side-flexors and extensors in females with FM is significantly lower than their healthy female counterparts. However, the endurance of trunk flexors was comparable to that of healthy females. Interestingly, McGill et al., while documenting normative values using their endurance testing protocol, found that even healthy females had lower flexor endurance values as compared to other testing positions.[16] In our study, the FM females also had lower

Table 1 – Demographic and clinical characteristics of the participants.

	Females with FM (n = 7)	Healthy females (n = 19)
Age (years)		
Mean (SD)	37.86 (6.3)	37.84 (7.6)
Minimum	32	30
Maximum	48	53
Residence		
Rural (*n*)	0	0
Urban (*n*)	7	19
FIQ score (mean, min.–max.)	48.8 (46.9–50.2)	–

Table 2 – Mean (standard deviation) values of core muscle endurance time measured using McGill's procedure in four positions for females with Fibromyalgia (FM) and healthy females. Between-group differences are represented as mean differences (95% confidence intervals).

	Females with FM (n = 7)	Healthy females (n = 1 9)	Mean difference, MD (95% confidence intervals)	t-Test value	p-Value
Trunk flexor test (seconds), mean (SD)	52.14 (27.9)	74.37 (37.7)	22.23 (-10.17–54.63)	1.40	0.17
Right side-bridge test (seconds), mean (SD)	20.14 (8.3)	36.05 (13.2)	15.91 (4.81–27.01)	2.86	**0.007**
Left side-bridge test (seconds), mean (SD)	20.86 (5.3)	35.11 (13.8)	14.25 (3.08–25.42)	2.57	**0.014**
Trunk extensor test (seconds), mean (SD)	26.14 (7.7)	55.21 (17.1)	29.07 (15.11–43.03)	4.07	**0.0002**

$p < 0.05$ is statistically significant; *t*: *t*-score of the unpaired Student's *t*-test.

Table 3 – Results of correlation analysis between the Fibromyalgia Impact Questionnaire (FIQ) scores and McGill's core muscle endurance test values.

Mean FIQ score = 48.8 (n = 7)	Correlation coefficient (r)	p-Value
Trunk flexor test	0.633	0.127
Right side bridge test	−0.437	0.327
Left side bridge test	−0.866	**0.012**
Trunk extensor test	0.019	0.968

$p < 0.05$ is statistically significant; *r*: Pearson's correlation coefficient.

trunk flexor endurance values, which were not statistically different from their healthy counterparts. A recent study evaluated the isokinetic strength of trunk flexors and extensors in housewives with FM, along with the correlation between isokinetic strength and FM severity and depression.[19] They reported that the trunk extensor isokinetic strength in FM housewives was lower than in healthy active females; trunk flexor values, although lower, were not statistically different from healthy active females. While isokinetic strength is not equal to the endurance of a muscle, the trend of reduced muscle function of the extensor muscle group in patients of FM was also observed in our study, i.e., our results reiterate their thought that extensor muscles may be more affected than flexor muscles in FM females. Notably, the authors also found a negative correlation between trunk extensor muscle strength and FIQ scores.[19] The McGill's core endurance test battery used in our study also included side bridge tests for lateral trunk muscles, which were not evaluated by the said study. Further evaluation with a larger sample and defined protocols to evaluate core strength and endurance in FM patients is essential.

Muscle function has been widely studied in FM patients on different muscles of the upper and lower limbs; accordingly, different explanations have been proposed. There are ample reports highlighting a tendency of physical activity avoidance and exercise intolerance in patients with FM which is associated with activity-induced pain.[20] This may reduce the time for which the patient can hold a muscle contraction by triggering pain-induced reflex inhibition of muscle. The technique used for testing muscle endurance in our study involved holding a muscle contraction for a prolonged time. Hence, the reduced endurance during extensor and side-bridge tests may have resulted from a decrease in microcirculation of the muscle during dynamic and static muscle work in FM patients.[20] Another study suggested that reduced aerobic endurance in FM patients may be due to diminished blood flow and abnormal distribution of oxygen in their muscles.[21] Other pathological muscle changes, such as atrophy of type-II muscle fibers, increase in lipid droplets with mitochondrial proliferation in type-I muscle fibers, and the development of degenerative changes in muscle membrane, mitochondria, and capillary vessels causing defective oxidative metabolism and ATP synthesis, may manifest as muscle weakness and fatigue.[21] Furthermore, a reduction in the phosphorylation potential of FM muscles compounded by low oxidative capacity and reduced work/energy-cost ratio could translate to a clinically discernible decrease in endurance.[21] These alter-

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ations at the cell level could explain our findings of reduced endurance of the extensor and lateral flexor group in FM patients. Nevertheless, a detailed examination of core muscle function is required to address the functional issues in these patients.

Santos et al. reported that core muscle endurance influenced the performance and quality of functional movements in sedentary individuals, with higher muscle endurance linked to better functional movements like sitting, standing, and lifting tasks.[12] Thus, objective quantification of core muscle endurance may be beneficial in identifying and predicting a person's ability to perform activities of daily living. Our study is the first step in assessing the state of core muscles in FM patients. Identifying the extent of core muscle involvement in FM may help design optimal treatment strategies for strengthening the core muscles in these patients, especially focusing on the weak muscle groups, to improve functional independence and quality of life.

In our study, FIQ scores and core muscle endurance values were not found to be correlated significantly, however the FM severity of the participants in our study was average (since the mean FIQ score obtained was close to 50). These results concur with Henriksen et al. who reported the absence of any correlation between FIQ scores, tender point count, and knee muscle strength in a large cohort of female FM patients.[22] Notably, they concluded that self-reported measures of disease severity and clinical measures of strength in FM patients were weakly associated.

There were certain limitations to this study. We were only able to recruit a small sample of FM participants due to logistic and administrative restraints. Data regarding anthropometric measures (like body mass index), disease history (such as the time since the diagnosis of FM and the patient's drug history), and other sociodemographic variables were not available. These factors may have influenced the disease process and should be evaluated in future studies using a multivariate analysis.

Nevertheless, this study provides novel preliminary data to objectively quantify core endurance in females with FM and establish a link between deficient core muscle endurance and recovery after a core-stability-based exercise regimen in this population. In addition, the testing procedure could be used as an effective outcome measure for core stability exercises and balance deficits in this population. Future studies may examine the association between core muscle endurance assessment and training and balance in patients with FM.

Conclusion

Females with FM have reduced endurance in the core extensor and lateral flexor muscles compared to their age-matched healthy counterparts; the flexor muscle endurance was lower than healthy females but the difference was not statistically significant. Furthermore, the decrease in endurance was not correlated with patient-reported severity of disease (FIQ scores). Our results provide preliminary insight into the changes in core muscle function of patients suffering from a chronic illness like FM; however, further research with a large sample of FM patients is warranted to validate our results.

Conflict of interests

The authors declare that they have no conflict of interest.

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