Effect of fibromyalgia on demographic, biochemical, metabolic and inflammatory profiles: a single-centre retrospective study

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Abstract

Objective

The objective of this study is to ascertain the disparities in demographic features and biochemical profiles between individuals diagnosed with fibromyalgia (FM) and a control group of healthy individuals.

Methods

This retrospective, cross-sectional study compared the demographic, biochemical, metabolic, and inflammatory indexes and rates of 174 FM patients diagnosed using the American College of Rheumatology 2016 diagnostic criteria between January 2023 and January 2024, and 186 healthy control groups.

Results

There was no difference between the FM and control groups in terms of alcohol consumption, marital status, or diabetes mellitus. The smoking rate is higher, and the educational level was found to be lower for FM versus the control. There was no significant difference between FM and controls regarding waist-height ratio, triglyceride-glucose index, plasma atherogenic index, vitamin B12, and folate levels. Monocyte HDL ratio, cardiometabolic index, magnesium, HbA1c, and ferritin levels were significantly higher in the control than in FM ($p<0.001$, $p=0.039$, $p=0.007$, $p<0.001$, $p<0.001$, respectively). C-reactive protein, erythrocyte sedimentation rate, systemic immune-inflammatory index, neutrophil-lymphocyte rate, platelet lymphocyte rate, and vitamin D levels were found to be higher in FM compared to control ($p=0.001$, $p=0.032$, $p=0.003$, $p=0.030$, $p=0.003$, $p<0.001$, respectively). A weak positive correlation was observed between the fibromyalgia impact questionnaire (FIQ) score and disease duration, as well as between pain degree and ESR, and pain degree and CRP. The study revealed a weak inverse relationship between Widespread Pain Index (WPI) and waist circumference.

Conclusion

This study highlights fthe association f ibromyalgia with elevated inflammatory markers, altered metabolic parameters, and specific demographic characteristics.

Key words

fibromyalgia, biochemical parameters, demographic parameters, inflammation, metabolic parameters

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Introduction

Fibromyalgia (FM) is a multifaceted and persistent pain disease that is distinguished by the presence of extensive musculoskeletal pain, exhaustion, sleep disturbances, memory impairments, and mood disturbances (1). FM, as reported by the World Health Organisation (WHO), is a prevalent health issue, particularly among women, impacting around 2–4% of the population (2). This prevalent ailment, affecting a substantial number of individuals globally, has the potential to greatly diminish the overall well-being of individuals and impose a considerable strain on healthcare systems. FM diagnosis mainly relies on subjective symptoms and patient self-reports, with a comprehensive understanding of its aetiology or pathophysiological mechanism still lacking (3). The diagnostic process for FM is challenging due to the absence of precise laboratory testing or biomarkers. The presence of uncertainty adds complexity to the diagnostic and therapeutic procedures for FM. While the precise pathophysiology of the disease remains incompletely elucidated, empirical evidence suggests that it arises from a confluence of diverse variables (4). FM, while predominantly impacting women, has the potential to affect individuals across all age groups and genders (5). There is a growing body of research indicating that there may be a correlation between specific demographic and biochemical characteristics and the development and advancement of FM. This suggests potential opportunities to gain insights into the causes of FM and enhance diagnostic approaches (6). Nevertheless, a shortage of thorough comprehension of the demographic aspects of the condition and its impact on laboratory test outcomes exists.

The primary objective of the present study is to elucidate the disparities between individuals diagnosed with FM and a control group of healthy individuals, focusing on demographic attributes and regular laboratory test outcomes. The intention is to find potential patterns and associations that could be valuable in diagnosing and treating this condition. Demographic factors encompass a range of characteristics, including age, gender, marital status, and education level. On the other hand, standard laboratory test results encompass indicators such as blood count, biochemical parameters, metabolic markers, and inflammatory markers. The primary objective of this study is to provide a valuable contribution toward the advancement of tactics aimed at enhancing the identification and treatment of individuals who have FM. Within this particular context, the findings f the study have the potential to offer significant insights that can educate therapeutic practices and facilitate future research endeavours in the realm of FM care.

Subjects and methods

Study design and ethical approval

The present study encompasses a sample size of 360 individuals, comprising 176 individuals diagnosed with FM and 184 individuals without the condition. The research design employed in this study is retrospective, descriptive and cross-sectional. The sample size required for conducting the Student's t-test in our investigation was a minimum of 173 for both groups, with a power of 95%, a type 1 error of 0.02, and an effect size of 0.4. The objective of the study is to analyse the demographic attributes and biochemical profiles of individuals with FM, as well as the correlation between these factors and the severity of the condition. Additionally, the study attempts to compare these data with those of a healthy control group.

The participants for this study were chosen based on a rigorous clinical evaluation and adherence to diagnostic criteria. The selection process involved individuals who had submitted applications to Recep Tayyip Erdogan University, Training, and Research Hospital from January 2023 to January 2024. The cohort of patients with FM comprises those who sought medical attention at the Rheumatology Outpatient Clinic and received a diagnosis based on the criteria established by the American College of Rheumatology (ACR) (7). The control group was chosen from persons who sought routine evaluation

at the internal medicine outpatient clinic and did not exhibit any symptoms of FM or chronic pain syndrome.

The present study received approval from the local ethical committee of Recep Tayyip Erdogan University (approval no.: E64960800-799-235135532, approval date: 25.01.2024). It adhered to the principles outlined in the Declaration of Helsinki, ensuring that participants' anonymity and personal data were safeguarded in compliance with international data protection regulations. The study also adhered to the standards of scientific research ethics during the data collection, analysis, and reporting procedures.

Participants and eligibility criteria

The objective of the diagnosis and criteria employed for the identification and inclusion of FM patients in the study is to establish a cohesive cohort of FM patients and enhance the dependability of the findings. Their determination was based on adherence to the following criteria:

Fibromyalgia criteria for diagnosis:

The study included individuals with FM who were selected based on the diagnostic criteria for FM published by the ACR in 2010 and then revised in 2016 (7). The premise for diagnosing patients with FM and including them in the study was based on these criteria.

Pain Management Index (WPI):

This measure assesses the frequency of pain experienced in various body regions, with the number of body parts affected by pain within the past month measured on a scale of 0 to 19 (6).

Severe Symptom Score (SSS):

Subjective assessment of fatigue, insomnia, cognitive problems, and general health status. Each is scored between 0 (none) and 3 (severe), and the total score is calculated between 0 and 12 (6).

Symptom duration and severity:

Patients' symptoms must have continued for at least three months and cannot be explained by another health condition (7).

Other criteria:

An experienced rheumatologist (O.C.) diagnosed the FM patients participating in the study, taking into account their clinical examination and medical history. In addition, necessary laboratory tests and imaging studies were performed to confirm that the patients symptoms were unrelated to other medical conditions.

Inclusion criteria

Individuals who are 18 years old or older, who satisfy the diagnostic criteria for FM as outlined in the ACR 2010 and 2016, and who have experienced FM symptoms for a minimum duration of 3 months. No additional systemic or mental diseases are present.

The control group was comprised of individuals who were randomly selected and reported being in good health, without any history of FM or other chronic pain syndromes.

Exclusion criteria

The following factors were considered for excluding patients from the study:

Other chronic pain conditions:

Individuals with other conditions that cause chronic pain (*e.g.* rheumatoid arthritis, lupus, osteoarthritis);

Serious psychiatric diseases:

Individuals with severe psychiatric diseases such as major depression, bipolar disorder, and schizophrenia;

Chronic inflammatory diseases:

Individuals with chronic inflammatory diseases (*e.g.* inflammatory bowel disease, chronic hepatitis);

Acute infections:

Individuals who had any acute infection or showed signs of infection at the beginning of the study;

Metabolic diseases:

Individuals with metabolic diseases such as diabetes and thyroid diseases;

Medication use:

Individuals with chronic or regular use of medications (*e.g.* corticosteroids, immunosuppressive medications) that may affect the results of the study;

Active treatment:

Among patients with FM, those who were actively treated during the study period or had started a medication regimen that required changes;

Pregnancy and breastfeeding:

Pregnant or breastfeeding women;

Age criteria:

Individuals under the age of 18 years.

Data collection methods

The researchers retrospectively obtained demographic information about the participants, including age, gender, education level, and work status, from the clinical records stored in the hospital computerised database system. The biochemical study utilised data obtained from blood samples collected from participants in the past. The dataset encompassed many biochemical characteristics, such as complete blood count, inflammatory markers, hormone levels, and other pertinent factors. Blood samples were subjected to biochemical analysis using established methodologies in a controlled laboratory setting. The pain severity and other symptoms were assessed by examining the existing records of the questionnaires given to the participants.

Laboratory findings and inflammation markers

The study investigated various health parameters of the participants, including anthropometric parameters [*i.e.* body mass index (BMI), waist circumference (WC), height/weight ratio (WHR)], and cardiometabolic parameters [*i.e.* triglyceride-glucose index (TGI), plasma atherogenic index (PAI), C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), systemic immune-inflammatory index (SII), neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), monocyte-to-HDL ratio (MHR), and cardiometabolic index (CMI)] for the assessment of the systemic inflammation and disease activity. Biochemical parameters of nutritional status were also measured [*i.e.* magnesium (Mg), HbA1c, ferritin, vitamin B12, folate, and vitamin D levels].

The BMI was calculated by dividing weight (kg) by height squared (m^2). Waist circumference (WC) was measured in centimetres (cm) at the midpoint of the waist, the narrowest section, at the midpoint during inhalation and exhalation. The waist-to-height ratio (WHR) was determined by dividing the waist circumference by the height. The formula for calculating the triglyceride-glucose Index (TGI) is

[Serum triglyceride (mg/dL) × fasting blood glucose (mg/dL)/2] (8). The calculation of PAI was performed as logarithm of the ratio TG and HDL cholesterol (log TG/ HDL cholesterol) (9). Monocyte-to-HDL-C ratio (MHR) is a novel indicator of the balance between the oxidative stress and inflammation of monocytes and HDL-C (10). CMI is determined by multiplying the ratio of TG/HDL-C to WHtR (11).

The SII, NLR, PLR, and MHR are derived from the blood cell counts and lipid profile analysis and are calculated as following: SII=(neutrophil count × platelet count)/lymphocyte count; NLR=neutrophil count/lymphocyte count; PLR=platelet count/lymphocyte count (12). The participants' venous blood samples were drawn after a 12-hour fast in the morning. The laboratory analysis was conducted using established protocols in a centralised laboratory setting. The amounts of magnesium and HbA1c were determined using atomic absorption spectrophotometry and high-performance liquid chromatography, respectively. The immunochemiluminescence method was employed to determine the amounts of vitamin B12, folate, and vitamin D.

Diagnosis of hepatosteatosis

An expert radiologist utilised a high-resolution ultrasound instrument to assess hepatosteatosis. The examination of ultrasonographic observations established a fatty liver, which included heightened echogenicity of the liver, diminished diaphragmatic and intrahepatic vascular structures and augmented contrast between the liver and renal cortex. The degree of hepatosteatosis was determined using values of normal (0), mild (1), moderate (2), and severe (3).

Statistical analysis

The data acquired from demographical, biochemical, inflammatory, and metabolic parameter analyses were assessed for normal distribution suitability using the Shapiro-Wilkinson test, Skewness-Kurtosis values, Q-Q plot, and Levene's tests. The parametric data were computed by adding the mean to the standard deviation. For the comparison

Table I. Comparison of demographic variables in groups.

Demographic variables	Patients (n=176)	Controsl (n=184)	*p*
Gender			
Female (n, %)	168 (95.5)	119 (64.7)	0.000*
Male (n, %)	8 (4.5)	65 (35.3)	
Smoking			
Yes (n, %)	63 (35.8)	38 (21.0)	0.004*
No (n, %)	113 (64.2)	146 (79.0)	
Alcohol			
Yes (n, %)	1 (0.56)	3 (1.63)	0.194
No (n, %)	175 (99.4)	181 (98.4)	
Marital status			
Yes (n, %)	161 (91.5)	165 (90.1)	0.150
No (n, %)	15 (8.5)	14 (7.7)	
Widow (n, %)	0	3 (2.2)	
Diabetes mellitus			
Yes (n, %)	11 (6.3)	17 (9.2)	0.329
No (n, %)	165 (93.8)	167 (90.8)	
Education status			
Primary (n, %)	85 (48.3)	44 (24.3)	0.000*
Middle (n, %)	16 (9.1)	27 (15)	
High (n, %)	54 (30.7)	44 (24.3)	
University (n, %)	21 (11.9)	69 (36.4)	
BMI (kg/m^2)			
<25 (n, %)	34 (19.4)	43 (23.4)	0.005*
25-29.9 (n, %)	71 (40.3)	45 (24.5)	
≥30 (n, %)	71 (40.3)	96 (52.1)	
Steatosis hepatitis			
Grade 0 (n, %)	92 (52.1)	37 (20.2)	0.000*
Grade 1 (n, %)	55 (31.1)	62 (33.9)	
Grade 2 (n, %)	28 (16.2)	66 (35.8)	
Grade 3 (n, %)	1 (0.6)	19 (10.1)	

BMI: body mass index.

Table II. Comparison of biochemical parameters in groups.

Parameters	Patients (n=176)	Controls (n=184)	*p*
Age (years)	44.74 ± 8.5	42.6 ± 10.9	0.038*
BMI (kg/m^2)	28.9 (18-46)	30 (20-47)	0.128
WC (cm)	95 (58-149)	97 (75-138)	0.248
WHR	0.58 (0.37-0.97)	0.57 (0.43-0.81)	0.857
TGI	3.72 ± 0.27	3.75 ± 0.27	0.369
PAI	0.32 ± 0.29	0.38 ± 0.30	0.074
CRP (mg/L)	2.9 (0.2-9.9)	2.1 (0.1-10.2)	0.001*
ESR (mm/h)	9 (1-38)	8 (2-34)	0.032*
SII	485 (91-991)	409 (56-1996)	0.003*
NLR	1.74 (0.4-3.8)	1.67 (0.6-7.5)	0.030*
PLR	0.12 (0.0-0.2)	0.11 (0.0-0.34)	0.003*
MHR	7 (3-21)	8 (1-24)	0.000*
CMI	1.28 (0.24-12.3)	1.40 (0.22-12.3)	0.039*
Mg (mg/dL)	1.90 (1.40-2.47)	1.98 (0.80-2.93)	0.007*
HbA1c (%)	5.6 (4.8-12)	5.8 (4.6-7.4)	0.000*
Ferritin (ng/mL)	20 (3-222)	40 (2-679)	0.000*
B12 (pg/mL)	348 (127-881)	361 (130-777)	0.431
Folate (ng/mL)	8.62 (3-24)	8.82 (2-24)	0.829
Vitamin D (ng/mL)	14.4 (4-39)	10 (4-42)	0.000*

BMI: body mass index; WC: waist circumference; WHR: waist-height ratio; TGI: triglyceride-glucose index; PAI: atherogenic index of plasma; CRP:C-reactive protein; ESR: erythrocyte sedimentation rate; SII: systemic immune inflammatory index; NLR: neutrophil to lymphocyte ratio; PLR: platelet to lymphocyte ratio; MHR: monocyte to HDL ratio; CMI: cardiometabolic index; Mg: magnesium; HbA1c: haemoglobin A1c.

of categorical variables, the Pearson Chi-square test was used for 2x2 comparisons when the expected value was >5. The Chi-Square Yates test was used when the estimated value was in the range of 3–5. The Fisher's exact test was used when the expected value was less than 3. The comparison of categorical variables with dimensions greater than 2x2, the Pearson Chi-Square test was used when the expected value was >5. The Fisher-Freeman-Halton test was used when the predicted value was below 5. The Fisher-Freeman-Halton test was used when the expected value was below 5. *p*-values less than 0.05 were considered significant.

Results

This research investigated various demographic, biochemical, inflammatory, and clinical variables in persons diagnosed with FM and a control group comprising individuals without any health conditions. The research consisted of a sample size of 176 individuals diagnosed with FM (168 females, eight males) and 184 individuals without any health conditions (119 females, 65 males). A comparative assessment was performed to evaluate the two groups using various indicators, including gender, smoking habits, alcohol consumption, marital status, education level, diabetes mellitus (DM), fatty liver, BMI, TGI, PAI, WC, WHR, ESR, SII, NLR, PLR, MHR, CMI, Mg, vitamin B12, folic acid, ferritin levels, vitamin D levels, HbA1c levels, and CRP levels.

Demographic characteristics

The mean age of those diagnosed with FM is 44.74±8.5 years, while the mean age of the control group is 42.6±10.9 years (Table I). This difference is statistically significant but at a low level (p=0.038). Females constitute the majority of individuals diagnosed with FM, exhibiting a notable gender predominance in comparison to the control group consisting of healthy individuals (p<0.001). The study found that individuals diagnosed with FM exhibited a significantly lower level of education compared to the control group (p<0.001) (Table I).

Table III. Comparison of biochemical parameters and fibromyalgia scores of smoking and non-smoking fibromyalgia patients.

Parameters	Smokers (n=63)	Non-smokers (n=113)	*p*
Age (years)	44 ± 8.5	44 ± 8.5	0.958
BMI (kg/m^2)	28.7 ± 5.2	29.6 ± 5.5	0.287
WC (cm)	94 (58-122)	95 (60-149)	0.725
WHR	0.58 (0.37-0.77)	0.59 (0.38-0.97)	0.732
TGI	3.79 ±0.30	3.68 ± 0.25	0.009*
PAI	0.42 ±0.29	0.26 ± 0.28	0.001*
CRP (mg/L)	2.80 (0.2-9.9)	3.4 (0.2-9.7)	0.130
ESR (mm/h)	8 (2-30)	9 (1-38)	0.452
SII	506 (91-991)	480 (173-953)	0.445
NLR	1.79 (0.44-3.39)	1.73 (0.88-3.80)	0.266
PLR	0.11 (0.04-0.22)	0.13 (0.08-0.25)	0.001*
MHR	8 (3-21)	7 (3-15)	0.001*
CMI	1.66 (0.30-12.3)	1.11 (0.24-11.7)	0.001*
Mg (mg/dL)	1.94 (1.56-2.47)	1.90 (1.4-2.4)	0.296
Hba1c (%)	5.6 (5-11.9)	5.6 (4.8-12)	0.368
Ferritin (ng/mL)	20 (4-175)	20 (3-222)	0.548
B12 (pg/mL)	330 (178-790)	364 (127-881)	0.086
Folate (ng/mL)	8 (3-24)	8.9 (4-24)	0.065
Vitamin D (ng/mL)	14.5 (5-34)	14.3 (4-39)	0.456
FIQ score	72 (18-91)	66 (24-92)	0.105
FPD	8 (1-10)	8 (2-10)	0.271
Disease duration (months)	60 (12-360)	36 (5-276)	0.010*

BMI: body mass index; WC: waist circumference; WHR: waist-height ratio; TGI: triglyceride-glucose index; PAI: atherogenic index of plasma; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; SII: systemic immune inflammatory index; NLR: neutrophil lymphocyte ratio; PLR: platelet lymphocyte ratio; MHR: monocyte HDL ratio; CMI: cardiometabolic index; Mg: magnesium; HbA1c: haemoglobin A1c; FIQ: fibromyalgia impact questionnaire; FPI: fibromyalgia pain degree.

Lifestyle factors

The prevalence of smoking is notably elevated among individuals diagnosed with FM compared to the control group (p=0.004). Nevertheless, the alcohol intake and marital status of the groups did not exhibit any statistically significant disparities (p=0.194, p=0.150, respectively) (Table I).

Clinical findings

While the BMI of FM patients and the control group showed no significant difference (p=0.128), the control group had a considerably greater prevalence of obesity (p=0.005). No significant difference was observed in WC or DM between the groups (p=0.248, p=0.329, respectively). According to ultrasonography, there is a statistically significant difference in the rate of fatty liver disease between the control group and FM patients (p<0.001) (Table I).

Laboratory findings and inflammation markers

The study found no statistically significant difference in WHR, TGI, PAI, vitamin B12, and folic acid levels between FM patients and healthy controls (p=0.857, p=0.369, p=0.074, p=0.431, p=0.829, respectively). The findings suggest that the two cohorts need more definitive differentiation about their overall metabolic profile and some cardiometabolic risk measures. In contrast, the healthy control group had significantly elevated levels of MHR, CMI, Mg, HbA1c, and ferritin in comparison to FM patients (p<0.001, p=0.039, p=0.007, p<0.001, p<0.001, respectively). The results of this study indicate that the control group may be susceptible to atherosclerotic or metabolic impairments concerning these specific parameters. Significant elevations in CRP, ESR, SII, NLR, PLR, and vitamin D levels were seen in individuals diagnosed with FM (p=0.001, p=0.032, p=0.003, p=0.030, p=0.003, p<0.001, respectively). The results of this study indicate that individuals with FM exhibit heightened levels of inflammatory activity, potentially contributing significantly to the underlying mechanisms of the condition (Table II).

Table IV. Descriptive statistics of questionnaire scores in fibromyalgia patients.

Patients' scores (n=176)	Mean ± SE	Median	Min-max
FIQ score	65.58 ± 1.23	67.4	18-92
Pain degree (0-10)	7.46 ± 0.17	8	1-10
Morning stiffness (0-10)	6.82 ± 0.22	7	0-10
Fatigue	2.52 ± 0.04	3	1-3
Waking unrefreshed	2.13 ± 0.07	2	0-3
Symptom severity score	7.46 ± 0.15	7	3-12
Widespread pain index	9.92 ± 0.29	9	4-45
Cognitive symptom score	1.32 ± 0.07	1	0-3

FIQ: fibromyalgia impact questionnaire score.

Comparison of biochemical parameters and fibromyalgia scores of smoking and non-smoking fibromyalgia patients

This study examines the differences in age, BMI, WC, WHR, TGI, PAI, CRP, ESR, SII, NLR, PLR, MHR, CMI, Mg, Hba1c, ferritin, B12, folate, vitamin D, FIQ score, FPD, and disease duration between FM patients who smoke and those who do not smoke. There was no difference between the two groups in terms of age, BMI, WC, WHR, CRP, ESR, SII, NLR, Mg, Hba1c, Ferritin, B12, Folate, Vitamin D, FIQ score, and FPD (p=0.958, p=0.287, p=0.725, p=0.732, p=0.130, p=0.452, p=0.445, p=0.266, p=0.296, p=0.368, p=0.548, p=0.086, p=0.065, p=0.456, p=0.105, p=0.271, respectively). Smokers exhibited significantly greater levels of TGI, PAI, MHR, CMI, and disease duration. Conversely, non-smokers had higher PLR levels (p=0.009, p0.001, p0.001, p0.001, p=0.010) (Table III).

Relationship between questionnaire scores and metabolic, inflammatory and biochemical parameters in fibromyalgia patients

FIQ score, pain degree (0-10), morning stiffness (0-10), fatigue, waking unrefreshed, symptom severity score, widespread pain index, and cognitive symptom scores of FM patients are shown in Table IV. A weak positive correlation was observed between the FIQ score and disease duration (r=0.202, p=0.003), as well as between pain degree and ESR (r=0.241, p=0.001), and pain degree and CRP (r=0.154, p=0.042). The study revealed a weak inverse relationship between WPI and WC (r=-0.220, p=0.003) (Table V).

Discussion

The present study conducted a comparative analysis of metabolic, inflammatory, and cardiovascular risk factors in individuals diagnosed with FM and a control group consisting of healthy individuals. The results indicate that although patients with FM exhibit similar characteristics in specific parameters, there are variations in the health status of specific parameters when compared to the control group. These findings underscore the importance of conducting thorough clinical assessments and implementing tailored management approaches that consider individuals' inflammatory and metabolic profiles.

The higher proportion of women, higher prevalence of smoking, and lower level of education among FM patients align with earlier research indicating

Table V. Spearman correlation analysis between questionnaire scores and biochemical parameters in fibromyalgia patients.

	FIQ score		Pain degree		Morning stiffness		Fatigue		Waking unrefreshed		Symptom severity score		Widespread Pain Index		Cognitive symptom score	
	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
Age	-0.014	0.855	0.089	0.241	-0.011	0.703	-0.102	0.179	-0.029	0.703	-0.078	0.304	-0.019	0.800	-0.080	0.290
FM duration	0.202	0.007*	0.128	0.090	-0.002	0.979	0.059	0.436	-0.006	0.934	0.096	0.205	0.115	0.129	0.115	0.128
BMI	-0.011	0.882	0.074	0.330	-0.074	0.330	-0.046	0.544	0.050	0.506	0.048	0.531	-0.051	0.501	0.033	0.666
WC	-0.066	0.386	0.041	0.591	-0.137	0.069	-0.076	0.315	-0.032	0.675	-0.088	0.245	-0.220	0.003*	-0.121	0.109
SII	0.015	0.844	0.015	0.839	-0.061	0.423	0.088	0.248	-0.053	0.487	-0.011	0.888	-0.029	0.705	0.070	0.358
NLR	0.022	0.777	0.031	0.678	-0.022	0.776	0.108	0.153	-0.067	0.376	-0.023	0.765	-0.060	0.427	0.084	0.267
PLR	-0.085	0.262	-0.015	0.843	-0.061	0.422	0.023	0.766	-0.022	0.772	-0.061	0.418	-0.028	0.716	0.036	0.632
ESR	0.111	0.144	0.241	0.001*	-0.041	0.591	0.036	0.639	-0.041	0.591	-0.072	0.342	0.0870	0.252	-0.019	0.801
CRP	0.094	0.216	0.154	0.042*	0.11	0.886	0.053	0.483	0.022	0.777	0.081	0.285	0.042	0.576	-0.017	0.824
MHR	0.117	0.126	-0.009	0.911	0.022	0.773	0.068	0.379	-0.053	0.489	-0.028	0.716	0.027	0.727	-0.111	0.146
CMI	0.001	0.986	0.022	0.777	0.027	0.723	-0.023	0.758	-0.135	0.074	-0.030	0.689	-0.001	0.986	-0.006	0.941
PAI	0.018	0.809	0.014	0.854	0.054	0.473	-0.001	0.994	-0.134	0.075	-0.020	0.797	0.045	0.557	0.003	0.970
TGI	0.038	0.616	0.031	0.679	0.083	0.273	0.023	0.766	-0.083	0.276	0.029	0.705	0.046	0.548	0.054	0.479
HbA1c	0.031	0.679	0.069	0.363	0.022	0.772	-0.027	0.718	0.197	0.009*	0.086	0.257	-0.045	0.550	0.008	0.920
Ferritin	0.003	0.971	-0.038	0.616	-0.009	0.904	-0.149	0.048*	-0.079	0.299	-0.167	0.026*	-0.127	0.092	-0.143	0.059
Vitamin B12	-0.001	0.989	-0.033	0.668	0.036	0.638	0.005	0.946	-0.123	0.105	-0.053	0.487	0.014	0.849	-0.049	0.516
Folate	-0.115	0.129	-0.055	0.469	-0.032	0.676	-0.130	0.086	0.024	0.752	-0.042	0.579	-0.167	0.027	-0.042	0.582
Vitamin D	0.074	0.331	0.019	0.801	0.138	0.067	0.053	0.484	-0.003	0.974	-0.041	0.591	-0.081	0.284	-0.027	0.719

FM: Fibromyalgia; BMI: body mass index; WC: waist circumference; WHR: waist-height ratio; TGI: triglyceride-glucose index; PAI: atherogenic index of plasma; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; SII: systemic immune inflammatory index; NLR: neutrophil lymphocyte rate; PLR: platelet lymphocyte rate; MHR: monocyte HDL ratio; CMI: cardiometabolic index; Mg: magnesium; HbA1c: haemoglobin A1c; FIQ: fibromyalgia impact questionnaire; FPI: fibromyalgia pain degree.

that FM patients are predominantly women and individuals who smoke (6, 13-15). The prevalence of FM in women suggests a potential gender-related association with this ailment. This finding potentially lends support to the concept that the development of the disease may be influenced by hormones or genetic predisposition (5). FM patients exhibit a higher prevalence of smoking, indicating that this population faces a heightened health hazard. Furthermore, smoking may potentially impact pain perception or pain management strategies (16-21). The higher prevalence of lower education levels among FM patients suggests that socioeconomic variables may exert a substantial influence on the risk and management of FM. The impact of education levels on individuals' access to health-related information, ability to utilise healthcare services, and adoption of healthy lifestyle choices may have an indirect influence on the intensity and management of symptoms associated with FM (19). Conversely, there were no notable disparities observed between the two groups regarding alcohol consumption, marital status, or the prevalence of diabetes mellitus. This implies that the influence of these factors on the risk of FM may be less prominent or that our study population may be similar in terms of these attributes. In addition, the control group exhibited higher levels of obesity and fatty liver, as revealed by ultrasonography, in comparison to FM patients. The observation that the control group had greater levels of obesity and fatty liver may indicate that, in contrast to existing data, these characteristics do not exert a direct influence on the onset of FM (13, 22). In addition, it is vital to acknowledge that obesity has the potential to impact pain perception and overall health. Therefore, it is crucial to prioritize the management of these diseases in individuals with FM. One potential explanation for the elevated prevalence of fatty liver disease in the control group can be attributed to the higher rates of obesity observed among the participants in our control group, given the tight relationship between obesity and fatty liver disease (23).

The absence of a statistically significant disparity in anthropometric measurements, including BMI, WC, and WHR, as well as metabolic risk markers such as TGI and PAI, vitamin B12, and folic acid, between the two groups, suggests that persons with FM disease do not exhibit distinctive characteristics about these criteria. This suggests that people with FM disease do not have any unique traits in these areas. This observation contradicts several results presented in the literature (24). Nevertheless, the elevated levels of MHR, CMI, and HbA1c observed in the control group indicate that these individuals may face an increased susceptibility to specific metabolic and cardiovascular ailments as a result of their elevated prevalence of obesity. Elevated levels of cardiovascular risk markers, such as MHR and CMI, can indicate atherosclerotic risk (10, 11). Conversely, the elevated levels of inflammatory markers (CRP, ESR, SII, NLR, and PLR) in individuals with FM suggest that FM has an inflammatory aspect and may involve an augmented immune activation state. The findings of the present investigation, as well as prior research, challenge the prevailing notion that FM is a disorder devoid of inflammation (25-30). Moreover, despite the higher obesity rates in our control group, a higher level of inflammation was detected in FM. It is widely recognised that obesity is indicative of a subclinical chronic inflammatory condition (31). Specifically, the rise in markers such as SII and NLR suggests a heightened inflammatory and immunological reaction in people with FM (26, 27). The presence of inflammation in the body may have a significant impact on the development and progression of FM, potentially affecting the intensity and diversity of FM symptoms (32, 33). Our study's findings indicate that inflammatory markers can serve as a screening tool for individuals exhibiting a positive clinical presentation and lacking any apparent cause of inflammation. To develop a more precise approach for diagnosing and screening FM, forthcoming research should prioritize the examination of markers that are more specific to inflammatory mechanisms, such as cytokines and autoantibodies, in individuals who are thought to have FM.

The results collected from this study indicate that individuals diagnosed with FM exhibit reduced levels of serum magnesium and ferritin compared to the healthy individuals. This offers valuable insights into the involvement of mineral and iron metabolism in the development of FM. These findings align with the outcomes reported in other research (34-36). Bagis *et al*. observed that FM patients had low serum magnesium levels and that magnesium was more efficacious than amitriptyline in ameliorating FM symptoms (35). Magnesium is significant in numerous biological processes within the human body, serving as a crucial cofactor for numerous enzyme reactions. Moreover, it is important in muscular functioning and nerve transmission (37, 38). While serum magnesium levels may not provide a comprehensive assessment of magnesium levels throughout the body, it is hypothesised that reduced serum magnesium levels may be linked to common symptoms observed in individuals with FM, including muscle pain, cramps, and exhaustion (36). Moreover, due to its calming properties on the neurological system, a shortage of magnesium may potentially elicit other symptoms commonly linked with FM, including sleep disturbances and anxiety (35, 36).

Ferritin is a marker for the presence of iron in the body, and reduced levels can indicate iron deficiency anaemia (39). Iron plays a crucial role in essential physiological functions, including oxygen transportation and cellular energy creation. The presence of diminished ferritin levels in individuals diagnosed with FM could serve as a contributing factor to the manifestation of symptoms such as fatigue, weakness, and impaired concentration (34). Iron deficiency has been found to hinder the proper functioning of the immune system potentially, hence heightening vulnerability to infections that are frequently encountered in individuals with FM (40). Potential intervention areas in the therapy of FM include low levels of magnesium and ferritin. For

instance, magnesium supplementation could be efficacious in alleviating symptoms of FM. Nevertheless, it is imperative to conduct randomised controlled trials to assess the efficacy and safety of these supplements. Similarly, administering iron supplements to address low ferritin levels could be therapeutic. Nevertheless, the use of these supplements may only be appropriate for some individuals, and it is imperative that a healthcare practitioner thoroughly assesses their advantages and drawbacks. Furthermore, further extensive research is required to ascertain the potential direct correlation between magnesium and ferritin levels and the severity of FM symptoms.

High vitamin D levels in FM patients have resulted in our study's contradictory findings compared to some studies in the literature (1, 41). Nevertheless, it is worth noting that specific investigations in the existing body of literature have indicated a need for more correlation between FM and vitamin D (41). The existing data on the association between FM and vitamin D levels and their cause-and-effect relationship needs to be revised due to the limited statistical power and methodological mistakes in most literature studies. The elevated levels of vitamin D observed in this study could perhaps be attributed to the prevalent utilization of vitamin D supplements among individuals with FM or a potential modification in the metabolism of vitamin D. Moreover, the elevated prevalence of obesity in our control group can be attributed to the reduced physical activity levels of these obese individuals, resulting in less exposure to sunshine. Elevated vitamin D levels could be construed as a supplementary or compensating mechanism in reaction to persistent pain and inflammation among individuals with FM. However, it is imperative to do additional research to validate this idea. Nevertheless, our study also underscores the necessity of screening these individuals for vitamin D deficiency. It emphasises the potential significance of vitamin D supplementation in treating FM.

This study elucidates the impact of smoking on several biochemical indicators and the duration of the disease in individuals with FM. The study found that 35.8% of patients with FM are smokers, which aligns with the literature's findings that 22-39% of FM patients are smokers (14, 17, 19, 20). The prevalence of smoking among patients with FM is notably high, standing at 35.8%. This indicates that smoking presents a significant clinical challenge in FM. The absence of notable disparities between the smoker and non-smoker cohorts across the majority of measures investigated suggests that FM symptoms and biochemical indicators may exhibit variability irrespective of smoking behaviour. While smoking has been linked to increased pain and impairment in individuals with FM, potentially due to depression, there is no evidence to suggest that smoking is associated with pain or functioning in people with FM in our study (21). Nevertheless, smokers had significantly elevated levels of TGI, PAI, MHR, CMI, and disease duration, suggesting that smoking could potentially elevate metabolic and cardiovascular risk factors in these individuals (42). Specifically, heightened levels of TGI, PAI, MHR, and CMI could potentially serve as indicators of heightened cardiovascular risk among those with FM who engage in smoking. The characteristics mentioned above are indicative of the adverse impacts of smoking on lipid metabolism and the cardiovascular process. The results of this study indicate that smoking could potentially have detrimental effects on the cardiovascular well-being of individuals with FM. Hence, it is crucial to underscore the significance of providing smoking cessation assistance in the therapy and management approaches for individuals with FM. Additionally, assessing these patients for potential cardiovascular hazards is imperative. Conversely, non-smoking patients exhibit elevated PLR levels, indicating a correlation between inflammation and thrombotic activity. PLR is a marker for the connection between inflammation and thrombosis, suggesting that specific inflammatory processes may be more prominent in individuals who do not smoke (26). Simultaneously, this underscores that elevated rates of smoking cannot account for the disparity observed in individuals with FM. Regrettably, due to the absence of data on smoking time and the quantity of cigarettes consumed, our study cannot establish any meaningful comparisons in these aspects.

Our study also investigated the correlations among several metrics employed to assess the impacts of FM on individuals with FM. The results of our research demonstrate many associations between distinct metrics used to evaluate the effects of FM and various metabolic, inflammatory, and biochemical factors. Initially, we saw a positive correlation between the FIQ score, utilised to assess the impact and the disease length of FM. This research demonstrates that the effect on a patient's quality of life increases when the disease progresses into a chronic state. This underscores the need to effectively manage symptoms and implement supportive interventions for individuals with chronic FM. Nevertheless, it is crucial to consider the intricacy of this association and the impact of other variables. Identifying a significant correlation between pain intensity and ESR and CRP suggests that the heightened pain intensity observed in individuals with FM may be associated with inflammatory mechanisms. This finding provides evidence in favour of the notion that the inflammatory response could play a crucial role in the manifestation of FM symptoms, hence emphasising the need for further exploration into the possible advantages of anti-inflammatory interventions. Furthermore, a correlation was seen between WPI and waist circumference, suggesting that body composition, specifically central obesity, could potentially influence the intensity of FM symptoms (22). This underscores the need to implement lifestyle modifications in the management of FM. Nevertheless, the precise mechanism underlying this association remains incomplete, necessitating additional research.

The findings of this study elucidate intricate associations among metabolic, nutritional status, and inflammatory indicators. The elevated levels of inflammatory and immune system markers observed in patients with FM under-

score the significance of inflammation in the pathogenesis of this condition. The control group has elevated metabolic and cardiovascular risk markers, suggesting that the two groups possess distinct underlying health profiles.

In summary, this research illustrates that individuals with FM exhibit distinct health conditions in comparison to those without the condition. This underscores the importance of conducting thorough clinical assessments and implementing tailored management approaches that include each patient's distinct inflammatory and metabolic characteristics. The presence of elevated levels of inflammatory markers in individuals with FM presents a promising avenue for identifying and addressing inflammation in both diagnostic and therapeutic contexts. Nevertheless, it is imperative to establish the threshold values for these indices and ratios in research endeavours that encompass a substantial cohort of individuals diagnosed with FM. Nonetheless, the control group exhibited heightened metabolic and cardiovascular risk markers, suggesting that people typically seen as healthy may also be susceptible to these hazards. Consequently, it is imperative to adopt proactive measures to minimise these risks. These findings indicate that additional research is necessary better to understand the connections between FM and healthy populations.

In the present study there are many limitations that necessitate careful consideration when interpreting and generalising the findings. There is a significant difference in gender distribution and obesity status between examined groups, suggesting that future studies are needed to diminish such confounding factors as much as possible. The potential limitations of surveying a single centre may restrict the extent to which the findings may be applied to diverse geographical, socioeconomic, and ethnic populations. By conducting comparable investigations across diverse groups, the generated data can be assessed within a more comprehensive context. The retrospective and cross-sectional design of the study imposes constraints on establishing causal links. Furthermore, it is essential to acknowledge that the retrospective design of our research may introduce certain limits and shortcomings in the data-gathering process. This could result in the absence or inaccuracy of some demographic or biological data. Including multiple parameters in a study can result in an elevation of the type I error rate. Furthermore, the study may need more statistical power, mainly in subgroup analysis. The results may be significantly affected by the failure to control variables such as individuals' lifestyles, food habits, and environmental exposures. Significant interactions may be observed between these factors and the biochemical and demographic characteristics that were studied. Future research can enhance the comprehensiveness and precision of information regarding the demographic and biochemical profiles of FM patients by addressing these shortcomings.

Conclusion

In summary, this investigation has provided evidence that fibromyalgia exerts various impacts on the demographic, inflammatory, and biochemical profiles of patients. The disparities are notably pronounced in serum ferritin, magnesium concentrations, and inflammatory indicators. Furthermore, it was observed that fibromyalgia displayed elevated prevalence rates among female patients and individuals who smoke. The significance of personalised strategies for the management and treatment of fibromyalgia is underscored by its association with biochemical, inflammatory, and demographic factors. The findings of our study indicate that fibromyalgia is a multifaceted condition that necessitates a multidisciplinary approach. To enhance patients' quality of life, it is imperative to implement a comprehensive evaluation and treatment strategy. Nevertheless, it is crucial to corroborate these results with larger sample sizes and conduct long-term follow-up studies. Subsequent investigations have the potential to yield comprehensive insights that can enhance the advancement of personalised methodologies for the identification and management of fibromyalgia.

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