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The relationship between cervical proprioception and balance in patients with fibromyalgia syndrome

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Abstract
Proprioceptive abnormalities, balance, and postural disorders have been previously reported in fibromyalgia syndrome (FMS). Unlike previous research, the aim of this study was to compare the proprioception of the cervical region of patients with FMS with a healthy control group. The relationship between cervical proprioception impairment and loss of balance was also examined. A total of 96 female FMS patients and 96 female healthy control subjects were enrolled in this case–control study. The cervical joint position error test (CJPET) was administered to the patient and control groups for cervical proprioception evaluation. FMS patients were assessed with a visual analogue scale (VAS), fibromyalgia impact questionnaire (FIQ), and fatigue severity scale (FSS). Balance tests were applied to both groups. FMS patients had significantly impaired CJPET results in all directions ($p<0.001$). There were significant positive correlations between FIQ scores and CJPET results ($r=0.542$ and $p<0.001$ for right rotation; $r=0.604$ and $p<0.001$ for left rotation; $r=0.550$ and $p<0.001$ for flexion; $r=0.612$ and $p<0.001$ for extension). Significant correlations were found between CJPET measurements and balance tests (for sit-to-stand test; $r=0.510$ and $p<0.001$ for right rotation; $r=0.431$ and $p<0.001$ for left rotation; $r=0.490$ and $p<0.001$ for flexion; $r=0.545$ and $p<0.001$ for extension), (for timed up and go test; $r=0.469$ and $p<0.001$ for right rotation; $r=0.378$ and $p<0.001$ for left rotation; $r=0.410$ and $p<0.001$ for flexion; $r=0.496$ and $p<0.001$ for extension) and (for one-legged balance test; $r=-0.479$ and $p<0.001$ for right rotation; $r=-0.365$ and $p<0.001$ for left rotation; $r=-0.392$ and $p<0.001$ for flexion; $r=-0.469$ and $p<0.001$ for extension). Cervical proprioception and balance were impaired in FMS patients. As the disease activity and fatigue level increased, so the deterioration in cervical proprioception became more evident. There were correlations that demonstrated an association between impaired cervical proprioception and poor balance tests. Therefore, proprioception and balance assessments should be integrated into the physical examination processes of FMS patients.

Keywords Fibromyalgia · Proprioception · Postural balance

Introduction

FMS is a disorder in which prolonged widespread musculoskeletal pain is at the center of the symptom complex and can be accompanied by fatigue, stiffness, cognitive deterioration, a feeling of insufficient sleep, and psychiatric symptoms [1, 2]. All these complex symptoms have profound-negative effects on social and occupational activities and trigger a deterioration in the quality of life [3].

The proprioceptive system contributes to the coordination and stability of joint position and movement patterns after the afferent receptors in peripheral structures involving muscles, joints, and ligaments have presented the information to the central nervous system [4]. Impaired proprioception causes a diminishing of the capability to arrange essential

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protective reflexes, joint motions, balance, and postural stability [5].

Different approaches, including the cervical joint position error test (CJPET), three-dimensional FASTRAK procedures, and ultrasound-assisted kinesthetic systems, can be used to assess proprioception in the neck region [6]. Although not the gold standard, CJPET is the most widely used method in research. The CJPET requires a laser headpiece, a target, and an eye patch so is easily accessible in clinical and research environments [7]. Position sensation of a cervical joint is a substantial part of proprioception, and primarily mirrors the afferent signals of cervical receptors located in muscles, joints, discs, and ligaments. Joint position error has been demonstrated to be influenced by pain, fatigue, and injury [4]. It has been demonstrated that the test has moderate to perfect intra- and inter-rater reliability values in participants with and without cervical pain [8]. Revel et al. [9] reported 86% sensitivity and 93% specificity values in the study conducted on healthy controls.

FMS has been linked to proprioceptive system abnormalities and balance disorders in previous research [10–13]. CJPET was used as a proprioception assessment instrument in the current study, unlike previous FMS studies. The aim of this study was to determine whether there is a difference in cervical proprioception by comparing the CJPET scores of FMS patients with those of healthy control subjects. A secondary aim was to examine the relationship between disease activity, pain and fatigue level, and CJPET scores in the FMS group, and to compare the static and dynamic balance tests between the FMS and control groups. Finally, the relationship was evaluated between cervical proprioception parameters and static and dynamic balance in FMS patients.

Materials and methods

This cross-sectional study was conducted in the Physical Medicine and Rehabilitation Clinic between March 2020 and August 2020. A total of 96 female FMS patients and 96 female healthy volunteers between the ages of 18 and 45 years were included in the study. The diagnosis of FMS was based on the 2010 American College of Rheumatology criteria [14]. Exclusion criteria were defined as cervical disc herniation, cervical spondylosis, cervical spondylolisthesis, history of operation in the cervical region, being included in a physical therapy and rehabilitation program in the last year due to cervical region problems, central and peripheral vertigo, vestibular disorders, neurological disorders leading to balance problems, cognitive dysfunction, diabetes mellitus, polyneuropathy, pregnancy, or visual impairment. All participants were questioned and examined for cervical pathologies. Neck pain, spasm in the neck and surrounding muscle groups, and difficulty in moving the neck were questioned. Additionally, complaints such as pain, numbness, tingling, and burning radiating from the neck to the arm were assessed. All participants were evaluated by physical examination. Radiological imaging methods were used to evaluate patients with suspected cervical pathology based on the anamnesis and physical examination. When suspicion was confirmed, that patient was excluded from the study. Blood samples were taken from all participants on the day of the evaluation. The blood tests of the participants were evaluated and those with infection, anemia, hypothyroidism, osteomalacia or B12 deficiency were excluded. Participants taking medicines that could affect cervical proprioception and balance tests were also excluded from the study. Patients who were actively using medicines such as pregabalin, serotonin noradrenaline reuptake inhibitors and tricyclic antidepressants were excluded from the study since the outcomes could be influenced. The control group consisted of healthy volunteers who applied as blood donors.

A record was made of age, body mass index (BMI), educational status, occupational status, income level, marital status, and exercise status for all subjects, and the duration of symptoms in FMS patients was questioned.

Prior to the study, ethics approval was obtained from the Clinical Research Ethics Committee of our university dated 19.02.2020 and numbered 2020-04/10.

Visual analogue scale

A 10-cm visual analogue scale (VAS) was used to quantify the overall pain of the patients, where 0 indicates no pain, and a score of increasing toward 10 indicates the level of intensifying pain [15].

Fibromyalgia impact questionnaire

The fibromyalgia impact questionnaire (FIQ) is a tool for determining clinical severity in FMS. The FIQ consists of ten subsections, each of which is scored between 0 and 10 points, to give a potential maximum score of 100, with higher values indicating a greater effect of FMS on the patient [16, 17].

Fatigue severity scale

The fatigue severity scale (FSS) is a nine-item self-reported scale that assesses the severity of fatigue in various conditions over the previous week. Each item is scored between 1 and 7, with 1 being strongly disagree and 7 being strongly agree. The total score is calculated as the average of the nine items. The maximum score is 7, and a higher score indicates a higher level of fatigue [18, 19].

Sit-to-stand test

This test measures the time taken to accomplish five repetitions of the sit-stand maneuver. All sit-to-stand actions were performed using a chair without armrests with a height of 43 cm and a depth of 47.5 cm. The participants are seated on the chair with their back against the chair back. The practitioner starts the test with the following instruction: Please cross your arms and place your hands on the opposite shoulders, then sit-to-stand five times as fast as you can, without stopping [20, 21]. The time taken for five repetitions of sit-to-stand was recorded using a stopwatch.

Timed up and go test

The timed up and go (TUG) test is a reliable and easily applicable method for evaluating balance and mobility. The participant is instructed to get up from the chair without holding on to the chair arms, walk 3 m, then turn around and return to the chair and sit. The test instructions were explained before performance and comfortable shoes were recommended. The test completion time is measured in seconds. The test was repeated three times and the average value was obtained [22, 23].

One-legged balance test

Static balance was assessed with the one-leg balance test. Each subject was instructed to stand on their preferred leg with arms folded across the chest, then to lift one foot off the ground and flex the knee to approximately 45°. On taking this position, the stopwatch is started and continued until the leg is moved out of position and the arms or opposite leg are used for support; the stopwatch is stopped and the time is recorded. For this study, 120 s was defined as the limit and if participants continued, the test was terminated at that time [24, 25].

Cervical joint position error test (CJPET)

The CJPET is a method that is used to assess cervical cephalic proprioception and neck position sensation. CJPET requires a laser device on the subject head, a fixed target on the wall, and an eye patch (Fig. 1). It is based on the principle that the participant can blindly direct the laser to its target. The subject is seated on a chair with the head in a neutral position and eyes closed at a distance of 90 cm from the target, which is a 40 cm-diameter circle enclosing five smaller circles that allow scoring to be applied. The small circles are coded as 1°, 2°, 3°, 4.5°, and 6°, allowing assessment of deviation from the neutral position. When the head is in the neutral position, the laser headpiece is attached to the subject's head and the height of the target from the ground is adjusted according to the subject's height, so that the laser is at the 0 point of the target. The eyes of the subject are covered with a black eye patch, and the subject is then instructed to perform maximal active flexion, extension, right and left rotation. Following the joint movement, the subject is instructed to return the head to a neutral posture. The global error is defined as the difference between the position to which the head returns and the neutral point. An increase in global error is associated with neck proprioception deterioration. CJPET is performed ten times for flexion, extension, right and left rotation movements. The first four repetitions are used to familiarize the subject with the method and are

Fig. 1 Equipments of the cervical proprioception error test. *: Laser headlamp; **: Eye patch; ***: 40-cm-diameter target with 5 circles

not included in the calculations. For each movement, the average of the remaining six measurements was calculated (Fig. 2) [7, 26].

Balance tests and cervical proprioception measurements were performed by another physician who did not know about the characteristics of the participants.

Statistical analysis

Data were analyzed using SPSS vn. 20.0 software (The Statistical Package for the Social Sciences, SPSS Inc. Chicago, IL, USA). The results obtained from the statistical analyses were expressed as number, percentage, and median (minimum–maximum) values. The Shapiro–Wilk test was used to determine normality, and the analyses were guided by the results. Comparisons between two groups of continuous variables were performed using the Mann–Whitney U test, depending on the normality check. Categorical variable comparisons were made using the Chi-squared test. Correlation analyses were performed with Spearman's rho. Rho value > 0.50 was set as strong, 0.35–0.50 as moderate, and less than 0.35 as weak correlation [7]. The statistical significance level was set at 0.05.

Fig. 2 Cervical proprioception error test sample. Three green circles are designated as 1°, 2°, 3° in order from inside to outside. The yellow and red circles are designated as 4.5° and 6°, respectively

Results

The evaluation was made of 96 female FMS patients and 96 female healthy control subjects, and the median age of the patient and control groups was 38 years(range, 19–45 years) and 35 years (range, 22–45 years), respectively ($p > 0.05$). No significant difference was detected between the baseline features of the patient and control groups ($p > 0.05$) (Table 1).

In the proprioceptive assessment of the neck region, the CJPET scores were significantly higher in all directions (right rotation, left rotation, flexion, and extension) in the FMS group ($p < 0.001$) (Table 2). These results revealed that deviation from neutral was more pronounced in FMS patients and neck proprioception was more impaired.

When the patient and control groups were compared in terms of balance tests, significant impairments were determined in FMS patients. The results of the sit-stand and TUG tests were significantly higher in FMS patients ($p < 0.001$), and the single leg balance test was significantly lower ($p < 0.001$) (Table 3).

Correlation analyses were conducted between CJPET scores and various clinical parameters in FMS patients. Age was weakly and positively correlated with CJPET scores except left rotation ($p < 0.05$ for right rotation, flexion and extension; $p = 0.470$ for left rotation). Symptom duration was significantly correlated with CJPET-flexion results ($p = 0.018$ for flexion; $p > 0.05$ for right rotation, left rotation and extension).

There were strong positive correlations between FIQ scores and CJPET measurements in all directions ($p < 0.001$). Weak-moderate positive correlations were detected between FSS scores and CJPET results ($p < 0.05$). The VAS scores were weakly-moderately correlated with CJPET results ($p < 0.05$).

The sit-to-stand test results and CJPET measurements were strongly moderately correlated in all directions ($p < 0.001$). Moderate and positive correlations were determined between the timed up and go test scores and the CJPET values ($p < 0.001$). Moderate and negative correlations were detected between the one-legged balance test results and CJPET scores ($p < 0.001$). All correlation analysis data are presented in Table 4.

Discussion

The following main results emerged from this study: female FMS patients had impaired cervical proprioception and poor static and dynamic balance measurements compared to the healthy control group. In addition, there were

Table 1 Comparison of the baseline features of the patient and control groups

	Patient ($n=96$)	Control ($n=96$)	p
Age[a] (year)	38 (19–45)	35 (22–45)	0.134
BMI[a] (kg/m^2)	27.88 (18.22–35.65)	27.45 (21.45–40.27)	0.762
Income level (n) (%)			
Below minimum wage	18 (18.75)	19 (19.79)	
Minimum wage	34 (35.42)	31 (32.29)	0.900
Above minimum wage	44 (45.83)	46 (47.92)	
Marital status (n) (%)			
Married	78 (81.25)	76 (79.17)	0.717
Single/divorced	18 (18.75)	20 (20.83)	
Educational status (n) (%)			
Literate	3 (3.12)	4 (4.17)	
Primary school	45 (46.88)	43 (44.79)	
Middle school	12 (12.50)	14 (14.58)	0.926
High school	11 (11.46)	8 (8.33)	
University or above	25 (26.04)	27 (28.13)	
Occupational status (n) (%)			
Working	24 (25.0)	27 (28.13)	0.624
Not working/Housewife	72 (75.0)	69 (71.87)	
Exercise status (n) (%)			
Never	22 (22.92)	19 (19.79)	
1–2 days a week	33 (34.38)	37 (38.54)	0.922
3–4 days a week	28 (29.16)	28 (29.17)	
More than 4 days a week	13 (13.54)	12 (12.50)	

BMI body mass index; *kg* kilogram; m^2 square meter; n number; %: percentage

[a]Data are expressed as median (minimum–maximum)

Table 2 Comparison of neck proprioception scores between the patient and control groups

CJPET[b]	Patient	Control	p
Right rotation[a]	2.50 (1.50–4.50)	2 (1–3.50)	< 0.001
Left rotation[a]	3 (1.50–6)	2.50 (1–3.50)	< 0.001
Flexion[a]	2.75 (1.20–4.50)	2.05 (1.20–3.10)	< 0.001
Extension[a]	3 (1.50–5)	2.10 (1.20–4)	< 0.001

[a]Data are expressed as median (minimum–maximum)

[b]The score is in the range of 1–6; *CJPET* cervical joint position error test

Table 3 Comparison of balance tests between the patient and control groups

	Patient	Control	p
Sit-to-stand test (second)[a]	13 (7–28)	11 (7–18)	< 0.001
Timed up and go test (second)[a]	10 (8–17)	8 (6–12)	< 0.001
One-legged balance test (second)[a]	22 (6–110)	52.5 (18–120)	< 0.001

[a]Data are expressed as median (minimum–maximum)

significant correlations between cervical proprioception measurements and disease activity, fatigue, and balance test results in FMS patients.

The correct positional sense plays a critical role in the movement action of individuals and allows daily living actions, various exercises, and sports activities to proceed in a certain order [27]. The current study results showed that FMS patients had worse cervical proprioception scores in cervical rotation, flexion, and extension, which suggests that cervical proprioception is impaired in FMS patients. There are studies in the literature that have focused on joint position sense in FMS patients. In those studies, proprioceptive assessments were performed on the knee joint and neck region [25, 28]. Although proprioceptive impairment was not observed in the study focusing on the knee joint, cervical proprioceptive deterioration was reported in the other study, which is consistent with the current study results. In another study, FMS patients were found to have poor trunk position sense [11]. There may be various reasons for deterioration in cervical proprioception in FMS patients. It has previously been shown that muscle pain and fatigue can trigger proprioceptive problems [29, 30]. Studies have revealed that muscle fatigue in the neck region causes changes in the sensory

Table 4 Correlation analyzes between the CJPET scores and clinical parameters in fibromyalgia patients

	Right rotation	Left rotation	Flexion	Extension
Age (year)				
rho	0.207	0.075	0.294	0.342
p	0.043	0.470	0.004	< 0.001
Symptom duration (month)				
rho	0.149	0.018	0.242	0.135
p	0.147	0.860	0.018	0.191
FIQ				
rho	0.542	0.604	0.550	0.612
p	< 0.001	< 0.001	< 0.001	< 0.001
FSS				
rho	0.313	0.460	0.336	0.462
p	0.002	< 0.001	0.001	< 0.001
VAS				
rho	0.222	0.362	0.288	0.279
p	0.030	0.002	0.004	0.006
Sit-to-stand test (second)				
rho	0.510	0.431	0.490	0.545
p	< 0.001	< 0.001	< 0.001	< 0.001
Timed up and go test (second)				
rho	0.469	0.378	0.410	0.496
p	< 0.001	< 0.001	< 0.001	< 0.001
One-legged balance test (second)				
rho	−0.479	−0.365	−0.392	−0.469
p	< 0.001	< 0.001	< 0.001	< 0.001

CJPET cervical joint position error test; FIQ fibromyalgia impact questionnaire; FSS fatigue severity scale; *VAS* visual analogue scale

receptors of the muscles, affects the level of muscle spindle sensitivity, and ultimately leads to loss of proprioception [31]. Neck pain can disrupt the muscular coordination and influence the specificity of muscle activation by decreasing the activation of deep segmental muscles while increasing the activation of superficial muscles. Since the proprioceptive network is mainly centered in the deep muscle group, reduced activity in this group has been linked to impaired proprioception [32]. Pain can influence the nervous system at different points, thereby altering muscle spindle sensitivity and regulation of the central nervous system to cervical afferent stimuli. Moreover, the accumulation of various metabolites, including potassium, lactic acid, and arachidonic acid can trigger inaccurate proprioceptive signals [29]. Considering all these mechanisms and the presence of chronic pain and fatigue in the neck region and shoulder girdle in FMS patients, the emergence of cervical proprioception disorder is an expected result.

Weak positive correlations between age and cervical proprioception assessment were determined in this study. Decreased neck muscle strength and motor impairment with increasing age may induce cervical proprioception disorder. In addition, with increasing age, there may be micro-level degeneration that is not reflected in the radiographs and this will affect the proprioceptive system.

Significant positive correlations were detected between FIQ, FSS, and VAS scores and cervical proprioception measurements in all directions. This result indicates that there are substantial links between increased disease activity, higher fatigue-pain level, and cervical proprioception disorder. Taking into account the negative effects of pain and fatigue on cervical proprioception as discussed above, it is reasonable to assume that increasing disease activity, as well as higher pain and fatigue levels, will amplify these effects.

In the current study, static and dynamic balance disorders were detected in FMS patients compared to the healthy control group. There were also moderate to strong correlations between the balance test results and the cervical proprioception measurements. Therefore, these results suggest a link between impaired cervical proprioception and poor balance. Balance disorders and the effect of various exercise programs on this condition in FMS patients have been researched in earlier studies [33–35]. Balance disorder and increased risk of falling were also detected in drug-free FMS patients [36]. Poor balance status in FMS has been attributed to various factors, including decreased muscle strength and performance, cognitive dysfunction, impairment in the sensory or motor system, and the existence of trigger points [35]. The spatial position of the head must be perceived correctly to maintain proper balance and posture. It has been shown that the cervical region has a sensitive proprioceptive structure that indicates the location of the head relative to the trunk, coordinates the vestibular and visual systems, and plays a substantial role in posture and balance control [37, 38]. Cervical proprioception disorder has a negative effect on this entire interaction network and causes deterioration in static-dynamic balance.

The limitations of the study can be listed as follows. Although CJPET is one of the most commonly utilized methods, it is not the gold standard. Computer-aided systems can provide more detailed analyses. Evaluation of only female patients is another limitation, which can be considered an obstacle to the generalization of the results. Although balance was evaluated, data on the frequency of falls could not be presented. This was not a prospective study, the FMS patients were not included in a rehabilitation program for cervical proprioception disorder, and the results of rehabilitation intervention were not assessed.

Conclusion

In conclusion, the results of this study demonstrated that FMS patients had impaired cervical proprioception compared to healthy control subjects. Cervical proprioception deteriorated in FMS patients with increasing disease activity and fatigue levels. In comparison to the healthy control group, FMS patients had poor balance test results. In addition, these balance test results were moderately to strongly correlated with CJPET measurements. FMS patients should be assessed in terms of cervical proprioception and rehabilitation applications should be recommended if there is deterioration. Considering the relationship between cervical proprioception and balance, rehabilitation recommendations on this topic may be beneficial for patients in respect of daily living, motor performance, and sporting activities. In addition, if rehabilitation programs focusing on proprioception and balance disorders are neglected, the risk of falling can increase and compliance with exercise, which is one of the main components of treatment in FMS, can decrease. Nevertheless, there is a need for further prospective studies assessing the efficacy of rehabilitation programs on cervical proprioception disorder to be able to confirm this in FMS patients.

Author contributions BG, BFK, and VN designed the study; BG collected the data; BFK, EB, VN, and TTK supported the data collection process; BG and BFK provided the data; BFK and AA made the statistical analyses; VN, EB and TTK contributed the analysis tools; BG, BFK, VN, EB, TTK, and AA authored and reviewed drafts of the paper; BG, BFK, and AA prepared the tables and figures; BG, BFK, VN, EB, TTK, and AA approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Declarations

Conflict of interest Authors declare no conflicts of interest.

Ethics statement Prior to the study, approval was obtained from the Clinical Research Ethics Committee of our university dated 19.02.2020 and numbered 2020-04/10. The study was conducted in accordance with the Helsinki Declaration criteria, with participation in the study on a voluntary basis. The "Informed Voluntary Consent Form" was explained to the participants, and all necessary information about the study was described and their consent was obtained.

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