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Full Length Research Paper

Evaluation of the results obtained from isokinetic muscle test in patients with primary fibromyalgia syndrome

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The aim of this study was to investigate whether the subjective muscle skeleton complaints of patients with fibromyalgia have an objective basis and the usability of muscle test results for diagnosis of fibromyalgia. 20 patients having primer fibromyalgia syndromes (PFS) who conforms to the criteria suggested by the American Rheumatism Association and a control group of 20 healthy people performed isokinetic muscle test over the right quadriceps and hamstring muscle group by Cybex 6000. In this study, maximum torque (MT), the ratio of maximum torque over body weight (MTWA), torque acceleration energy (TAE), total work (TW), set total work (STW), average power (AP) and endurance ratio (ER) were measured for muscle performance. A significant difference was found between the tests showing the muscle performance between the patients and the control group except the ER parameter. This difference was smaller in patients with fibromyalgia. As a result, it is decided that the objective low values in the muscle tests which are observed in patients with fibromyalgia are significant and isokinetic quantitative muscle test is a quite reliable method which can assist the doctor for the diagnosis of fibromyalgia. There exists a connection between the general fatigue and pain complaints of the patients with PFS and muscle deficiency. This muscle deficiency can be measured numerically by objective isokinetic methods. We argue that these measures should be utilized in the diagnosis and follow-up of patients.

Key words: Isokinetic testing, fibromyalgia, muscle.

INTRODUCTION

Primary Fibromyalgia Syndrome (PSF) is a non-inflammatory, painful musculoskeletal disease, accompanied by fatigue and many somatic complaints. It affects approximately 5% of the population, especially young women aged between 20 and 50 (Wolfe et al., 1995; Kuran et al., 1994). PFS is the most common reason of the disability claims (Bennet, 1993; Yunus, 2012). In this disease, which has important individual, social and economic outcomes, routine laboratory analyses and rheumatologic analyses are normal (Yunus and Masi, 1993; Ang et al., 2011; Alnigenis and Barland, 2001). In the cases of PFS, the results of the scintigraphic and electromyographic examinations are normal (Maquet et al., 2002; Hooten et al., 2012).

In all the patients with fibromyalgia, there are widespread pain and many tender points. In many patients, varying degrees of fatigue, morning stiffness, depression, non-relaxing sleep and post-activity pain exists (Thomas, 2011; Buskila, 2009; Alok et al., 2011; Ang and Wilke, 1999). In approximately one third of the patients, irritable bowel syndrome, headache, premenstrual syndrome, female urethral syndrome, numbness and tingling, sicca symptoms and Raynaud phenomenon are observed

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(Bennet, 1993; Tuna, 1994; Yunus and Masi, 1993). PFS is diagnosed by detecting the tender points based on the physical examination.

More than 20 parameters may be used during the isokinetic tests. Here, we will review the most commonly used parameters (Davies, 1992; Miskioğlu, 1995).

1. Torque: This is the tendency of a force to rotate an object around a rotational axis. Torque, which can be briefly defined as “rotational momentum”, is equal to the product of the force and distance.
2. Maximum Torque (MT): This is the maximum value for the torque that is obtained in all the points and in all the repetitions within the range of motion. This is the most commonly used parameter.
3. Maximum Torque to Body Weight Ratio (MTWA %): This is calculated by the device by multiplying maximum torque/body weight ratio by 100.
4. Torque Acceleration Energy (TAE): It is the energy spent within the first 1/8 second of the torque formation or, in other words, it is the total work produced.
5. Total work (TW): It is the total volume that remains under the torque curve at each repetition, regardless of the velocity, ROM or time.
6. Set Total Work (STW): It is expressed as joule.
7. Power: It is the work produced in one unit of time. It is expressed as Watt or Newton-meter/second. It is the total volume that remains under the torque curve at each repetition, regardless of the time.
8. Average Power (AP): Total work/time.
9. Endurance ratio (ER): It is the ratio of the number of repetitions that the patient does at the beginning and at the end of the exercise. It is the ratio of the work produced at the first 20% of the total repetitions to the work produced at the last 20% of the total repetitions.
10. Comparison of agonist/antagonist: It is the ratio of maximum torque of total work parameters. The result is expressed as percentage.

The aims of the isokinetic test include objective recording, athletic and industrial screening, test to build up a data bank, conversion of the objective data to numeric data, the determination of whether a person really has the disease, the detection of compensated cases or the cases with disability, the demonstration of the pathologic conditions using torque curves and the determination of the normal values.

In this study, we aimed to discuss the utility of the results obtained from isokinetic muscle test in the diagnosis of fibromyalgia.

MATERIALS AND METHODS

We enrolled to the study of 20 patients with primary fibromyalgia syndrome (PFS) according to 1990 criteria of the American College of Rheumatology and 20 healthy subjects with same demographics to form a control group. All patients had systemic examination and routine laboratory analyses. The patients with an additional systemic or local problem were excluded from the study. As the test was performed on the knee articulation, special attention was paid to select the patient without knee pain to include in the study. All patients were questioned for age, gender, body weight, life style and disease-related characteristics. The subjects who were doing more activity, including sport-intended jogging for half an hour per day, were considered as active, whereas others were considered as sedentary. We built our study group from the sedentary patients. Control group was built by ensuring the consistency with the patient group in terms of age, gender, weight and life style.

Strength analysis of the flexor and extensor muscles of the knee was performed using Cybex 6000 isokinetic dynamometer (1991 to 1993 Cybex 6000 Testing & Rehabilitation System; CYBEX Division of LUMEX, Inc., Ronkonkoma, New York). The device was calibrated before the testing. Before beginning the tests, the patients were comprehensively instructed about how and why the test would be performed. Before the test, the patients and the controls did exercise using bicycle ergometry for 15 min in order to warm up. The test was administered within an articular range of motion of 0 to 90°, by considering full extension of the knee articulation as the anatomical zero point. While trunk and hip stabilization was ensured using the trunk belt provided with the device, the articulation was stabilized using a Velcro band that was passed through the proximal of the knee, by keeping the trunk perpendicular to the floor and the hip articulations at 90° flexion. Transverse line that passes through the femoral condyles was accepted as the axis for the knee articulation and the axis of the dynamometer was set to this position. All tests were performed by the same operator. Similar auditory and visual stimuli were given.

In this study, the following parameters were used: Maximum torque (MT), Maximum torque to body weight ratio (MTWA), Torque acceleration energy (TAE), Total work (TW), Set total work (STW), Average power (AP), Endurance ratio (ER). Data were evaluated using “Statistica” software loaded on the computer. As the groups did not meet the parametric test requirements, non-parametric Mann-Whitney U test was used. Significance level was considered as $p < 0.05$.

RESULTS

This study was performed on a total of 40 people, including 20 patients with PFS and 20 normal healthy people. Each group included 19 women and 1 man. Demographics of the patient and control groups are shown in Table 1. As seen in the table, patient and control groups were very close to each other in terms of age, height and weight and there was no statistically significant difference ($P > 0.05$). Both groups were sedentary in terms of physical activity. Table 2 shows the answers that the patients gave to the questions that we asked through forms. Of these questions, seven concerned the clinical signs of the disease, one concerned the relation of these symptoms with the climate and one concerned whether they underwent a surgical operation.

In this study, we used seven parameters. We constructed a table for each parameter. In the tables, mean, standard deviation and “p values” of the patients and of the controls for each data are presented.

Table 1. The characteristics of patients and control group.

Parameter	Patient group	Control group
Male	1	1
Female	19	19
Age (Mean)	36 (17-47)	35.8 (17-48)
Height (cm)	157 (148-165)	162 (150-172)
Weight (kg)	64 (48-80)	67 (50-90)
Physical activity	Sedentary	Sedentary
Duration of disease (year)	3.3	-

Table 2. Clinical symptoms of patients.

Clinical symptom	No. of patients	%
Fatigue in the morning	15	75
Stiffness in the morning	16	80
Insomnia	16	80
Chronic headache	16	80
Irritable bowel	12	60
Relationship between climate	16	80
Numbness in extremities	16	80
Decreased libido	9	45
The history of operation	5	25

DISCUSSION

Majority of the patients present in the clinics of rheumatology had fibromyalgia. When these patients were evaluated by several functional disability indexes, it was seen that the diseases restricted the activity of the person as much as rheumatoid arthritis. As seen in Table 3, the incidence rates of the clinical symptoms exhibited by the patients enrolled to our study are consistent with previous studies. In the patients that we examined in our study, 20% had a history of surgical operation, which was a rate that should not be ignored. The patients with fibromyalgia complained of widespread musculoskeletal pains. However, the muscular biopsies performed for this purpose did not reveal a specific finding belonging to the disease, except small non-specific changes (Tuna, 1994; Goldenberg, 2009). There are limited numbers of studies to investigate blood test in the patients with fibromyalgia (Ang et al., 2011). In these studies, only one or two parameters were used. In our study, we also used some other parameters that showed muscular performance.

As done in other studies, we chose quadriceps and hamstring muscle groups which are the second biggest muscle of the body, and right side, which is the dominant Side, because during direct or indirect muscular pathologies, the likelihood that the first symptoms appear in these muscles is relatively higher.

Muscular strength examination (manual muscle test), which is done within routine physical examination, is a qualitative method, which provides quite subjective data. Additionally, it may result to evaluation errors depending on the muscular performance and experience of the person who administers the test. Especially in mildly affected cases, it may be difficult to reveal a mild motor deficit. Similarly, some inadequacies may be observed in the detection of minor changes that occurred during the follow-up of the patient (Karataş, 1994; Byl et al., 1991).

Cybex 6000 isokinetic dynamometer that we used in our study allowed us to perform a completely quantitative and extremely reliable muscular strength test. This system provides the possibility to individually examining the isolated muscles or muscle groups or to investigate them in terms of reciprocal muscular activities. It is easy to monitor the progress and to evaluate the data. With these features, it may be suggested that the method used is among the most reliable quantitative methods that have been used to date in the literature (Gross et al., 1991; Molczyk et al., 1991; Kannus, 1994).

For the functional evaluation of the muscles surrounding the knee, different isokinetic test protocols were used in several studies. Several parameters were investigated by using different angular velocities. In our study, we used MT and MTWA parameters to determine muscular strength because MT was the most commonly used and best-studied parameter in the isokinetic strength tests to date (Miskioğlu, 1995). In the literature, for MTWA parameters that we used in addition to MT, it was stated that MTWA provided a different point of view in the interpretation of the test results. Occasionally, although bilateral comparisons or a unilateral rate of the person is normal, the relation of torque by body weight may be different (Li et al., 1996; Norregaard et al., 1994). As body weight varies, it is more appropriate to use MTWA to perform interpersonal muscular performance comparisons.

While isokinetic muscular strength negatively regresses with advanced age, it increases proportionally to body area and body surface area (Avin and Law, 2011). When isokinetic parameters are globally considered, the observation that angular velocity increases with decreasing MT and MTWA values in all groups is impressive. The aforementioned feature applies to both extensor and flexor muscles. Again, the results obtained from all the tests performed in this study were parallel to this. This relationship is consistent with many isokinetic investigations conducted on the muscles that surrounded the knee which have been cited in literature (Jacobsen and Danneskiold-Samsoe, 1992; Maquet et al., 2002; Norregaard et al., 1994; Hooten et al., 2012).

Another fact related to known isokinetics is that MT will be formed later in ROM (range of motion) with increasing angular velocity. This is especially important when a study is conducted with the muscle groups with strength loss because, as MT will occur at a late stage, when higher

Table 3. The common symptoms of PFS.

Parameter	Yunus (33)	Goldenberg (32)	Uslu (31)	Our study
Total number	113	118	30	20
Average age	40	43	38	36
Female (%)	94	87	83.3	95
Disease duration (year)	6.9	5	-	3.3
Morning stiffness (%)	76	76	-	80
Fatigue (%)	85	92	80	85
Sleep disturbances (%)	62	80	67	80
Feeling of swelling (%)	40	50	63	80
Irritable bowel (%)	41	53	37	60
Headache (%)	58	55	60	80
Decreased libido (%)	-	-	-	45
Relation of climate (%)	-	-	-	80
Previous operation (%)	-	-	-	20
Raynoud phenomenia (%)	12	-	-	-

higher velocities are used, optimal articulation position for MT will be passed over and the real muscular performance of the patient will not be determined (Osternig, 1986; Lord et al., 1992; Kannus and Beynnon, 1998). Therefore, the reliability of the test decreases at high velocities such as 300°/sn. On the other hand, low velocity of 60°/sn and intermediate velocity of 180°/sn are not problematic in terms of reliability. We can tell it by observing the isokinetic graphics.

Lower velocities place higher loads on the articulation compared to higher velocities. In 1970s, Cybex proposed 30°/sn to perform a test on the knee. Today, it proposes 60°/sn, because 30°/sn is not a natural velocity and increases the load placed on the articulation and inhibits the strength. Additionally, the test conducted at 30°/sn does not provide any additional information upon the test conducted at 60°/sn (Sole et al., 2007). The velocity should be selected by taking into account the patient characteristics and the goal of the therapy. Many investigators reported high reliability of neuromuscular parameters such as work and power as well as concentric maximum torque (Steiner et al., 1993; Adsuar et al., 2011). In the study performed by Barbee and Landis (1984), the investigators reported that MT, work and power values resulting from knee flexor and extensor muscles could be reliably measured in the normal subjects using Cybex II device, but TAE values were less reliable.

Özaras et al. (1995) performed isokinetic test for right and left knee extensor and flexor at 60°/sn and 180°/sn in 15 female patients with primary fibromyalgia and they could not find a statistically significant difference in terms of maximum torque values. In our opinion, this result demonstrated that there was no temporary or unilateral muscular involvement in the patients with fibromyalgia. Jacobsen and Danneskiold (1992) conducted a study on and Brodie, 1989; Holmes and Alderink, 1984).

In the study performed by Jacobsen et al. (1991), mean duration of disease was reported to be 11.5 years. When the angular velocity of 60°/sn that led to more load on the articulation and to more strain of the muscle, along with the duration of the disease was taken as basis for the endurance test, it would not be surprising that the patients with widespread musculoskeletal pain would leave the test during the first repetitions. When we evaluated the total work and average power values in our study, we saw that these values were very low in the patients (Tables 4 and 5). This demonstrated that in the real life, despite the inadequate muscular performance of the patients, because of the deficiency of the motivation required for the maximum voluntary muscle contraction, the patients began the test with the contractions that produced less work and they were less tired at the end of the test when they showed to have produced nearly the same work or more work compared to controls. In other words, here, we may see the disadvantage in question for the endurance test. In another saying, the patients have the problem of compliance to motivation. In this regard, we remember other literature studies that mentioned the central effect in the patients with fibromyalgia, because these results supported these studies.

Jacobsen et al. (1991) measured combined isokinetic and isometric muscle strength in the patients with fibromyalgia using transdermal electric muscle stimulation and they revealed that submaximal force was applied during the maximum voluntary muscle contraction of the patients. In the study performed by Margerata et al. (1994), voluntary muscle contraction was lower in the patients with fibromyalgia compared to controls. Again, submaximal values were found to be lower with the use

Table 4. The comparison of the knee flexor and extensor muscles isokinetic TW value at different angular velocities in the patient and the control group.

TW	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	60	42.75	13.41	69.2	18.29	7E-06
	180	31.9	9.73	49	14.67	0.00015
Extensor	60	61.7	15.5	93.1	19.9	3E-06
	180	39	12.1	59.7	13.3	3.1E-05

Table 5. The comparison of the knee flexor and extensor muscles isokinetic AP value at different angular velocities in the patient and the control group.

AP	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	60	27.35	8.8	44.7	11.8	9E-06
	180	57.45	17.3	85.55	25.6	0.00048
Extensor	60	39.4	8.8	60.4	13.2	3E-06
	180	70.6	23.5	111.7	25.9	3.3E-05

of superimposed electric stimulation. They suggested that decreased voluntary maximum muscle performance might result from an impairment of control mechanisms at supraspinal level. In our opinion, there is another study that would support this insight. Johnson (1982) measured dynamic force and endurance in the left quadriceps of 15 subjects aged between 20 to 29 and 15 subjects aged between 50 to 80 using Cybex II isokinetic dynamometer, and they showed that the force was decreased in the elderly, despite the endurance that remained constant. Probably, the elderly subjects could continue to the test because they made a submaximal effort.

In our literature search, we could not detect other parameters that showed muscular performance in the patients with fibromyalgia. The results about other parameters that we used in our study are summarized as below. In this study, isokinetic MTWA value, TAE value and STW value, at different angular velocities were significantly lower in the patient group in both knee extensor and flexor muscles at both 60 and 180° (Tables 7, 8, 9 and 10). This finding showed that fast muscular performance of the patients was weak. Total work (TW) and average power (AP) values were significantly lower in the patient group in both extensor and flexor muscles at both 60 and 180°. These latter parameters are somewhat the complements and providers of the other parameters. The results that we obtained from all the parameters that we used in our study were integrated and consistent. 15 patients with primary fibromyalgia and 15 healthy people. In these people, the strength of the knee extensors was isometrically and isokinetically measured using Cybex 2 dynamometer and as a result, muscular strength was found to be significantly lower in the patient group. The same investigators found that the isokinetic measurement was more reliable than isometric measurement because it provided more detailed information.

Norregaard et al. (1994) performed a study on 20 female patients with primary fibromyalgia where they found a significant decrease in the muscular strength. Therefore, they thought that exercise had an important place in the rehabilitation of these patients. Margaretta et al. (1994) conducted a study on 25 patients with primary fibromyalgia and on 22 healthy people and they found a marked decrease in the maximum voluntary muscle contraction of the patients. In our study, the results that we found for MT and MTWA indicating muscle strength showed a parallelism with the above-mentioned studies.

Jacobsen et al. (1991) conducted a comparative study to compare the muscle endurance between the patients with fibromyalgia and the patients with chronic myofacial pain. In this study, the last two knee extensions in which baseline contraction-related work value obtained at an angular velocity of 60°/sn using isokinetic dynamometer came up to 70% or below and the number of repetitions was used to determine the endurance. In addition, it was statistically demonstrated that the strength was decreased in the patients with fibromyalgia.

Table 6. The comparison of the knee flexor and extensor muscles isokinetic ER value at different angular velocities in the patient and the control group.

ER	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	180	92.8	18.7	88.7	13.8	0.54228
Extensor	180	87	18.9	79	12.2	0.12257

Table 7. The comparison of the knee flexor and extensor muscles isokinetic MT value at different angular velocities in the patient and the control group.

MT	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	60	39	10.7	60.6	14.1	0.000009
	180	31.6	8	43.1	11.2	0.000550
Extensor	60	68.5	14.5	103.1	22.3	0.000001
	180	40.5	12.3	60.4	12.3	0.000039

Table 8. The comparison of the knee flexor and extensor muscles isokinetic MTWA value at different angular velocities in the patient and the control group.

MTWA	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	60	64.5	20.3	90	24.7	0.0015
	180	50.2	12	63.6	17.8	0.0246
Extensor	60	110.5	28.7	152.3	34.6	0.0004
	180	64.1	17.6	88.5	16.6	0.0001

Table 9. The comparison of the knee flexor and extensor muscles isokinetic TAE value at different angular velocities in the patient and the control group.

TAE	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	60	2	0.6	3.8	1.7	0.000036
	180	8.8	2.1	12.7	3.6	0.000259
Extensor	60	2.8	0.8	5.8	2.6	0.000005
	180	10.3	2.9	16.7	4.6	0.000015

Norregaard et al. (1994) performed an endurance test in 20 female patients with fibromyalgia and found a slightly low endurance. The patients continued to the test until being exhausted or up to a maximum of 40 min, with 4 min contraction with half of the real muscle strengths and 6 s resting. Mean endurance time was found to be 22 min in the patient group and 29 min in the control group.

In our study, we measured the muscle endurance in the patients to whom we applied the test by asking them to do 20 repetitions at 180°/sn. We compared the work that occurred during the last 20% of the repetitions with the wok that occurred during the first 20% of the repetitions. We expressed the difference as percentage. We obtained a result that could initially seem inconsistent with the aforementioned studies, but in reality we obtained a result that was consistent with above mentioned studies by one aspect and that opened new horizons. Although there was no statistical significance, we obtained a higher rate of endurance in the patient group (Table 6). Traditionally recommended original endurance test is

Table 10. The comparison of the knee flexor and extensor muscles isokinetic STW value at different angular velocities in the patient and the control group.

STW	Angular velocity (°/sn)	Patient group		Control group		P
		Average	SS	Average	SS	
Flexor	60	192.1	70.1	315.1	86	0.000013
	180	535.2	164.5	798.1	254.9	0.000189
Extensor	60	262.5	77.6	42.4	95.9	0.000005
	180	625.95	202.43	929.25	209.8	0.000074

performed in a muscle group at the velocities of 180 or 240°/sn. Test is terminated upon a decrease of strength by 50%. However, as a disadvantage, the patient should be motivated during all testing period to obtain a maximum effort. Testing data should be supported with the values of total work and average power (Baltzopoulos

Conclusion

Consequently, it was concluded that objectively lower values observed in the muscle tests of the patients with fibromyalgia were significant and that isokinetic quantitative muscle test was an extremely reliable method that is helpful for the doctor to diagnose the fibromyalgia. General fatigue and pain complaints which are subjectively felt by the patients with primary fibromyalgia, are associated with muscular weakness. This muscular weakness may be numerically measured using objective isokinetic methods. We believe that these measurements will be useful in the diagnosis and in the monitorization of the patients. Decreased muscular performance observed in the patients may result from an impairment of the control mechanism at supraspinal level or may have a peripheral origin, whether related to above-mentioned impairment or not. Further studies should be conducted to elucidate this issue.

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