MUSCULAR KINETICS AND FATIGUE EVALUATION OF KNEE USING BY ISOKINETIC DYNAMOMETER IN PATIENTS WITH ANKYLOSING SPONDYLITIS

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Abstract

Objective: Ankylosing Spondylitis (AS) is an inflammatory disease that is observed with arthritis, sacroiliitis and disability. The aim of the study was to compare the strength and fatigue of knee extensor/flexor muscle group usage by isokinetic in patients with AS with controls.
Methods: Twenty-six AS diagnosed patients and twenty-six healthy volunteers with similar age, height, body weight and gender were included in this study. In both groups the isokinetic tests are conducted by isokinetic dynamometer for every subject. Knee extension/flexion patterns;peak torque, agonist/antagonist ratio and work fatigue isokinetic parameters were evaluated during the knee 60º/s,180º/s and 240º/s angular velocities.
Results: Knee extension/flexion muscle strength in patient group was significantly lower compared to the control group in all angular velocities ($p< 0.05$).
Conclusions: The study showed knee muscle weakness and fatigue in patients with AS compared to the control group.

Keywords: Muscle strength; Dynamometer; Knee; Ankylosing spondylitis; fatigue

Introduction

Ankylosing Spondylitis (AS) is an inflammatory disease of unknown etiology. Inflammation primarily affects the joints and causes secondary changes in these regions. The spine is the fundamentally affected region in AS[1]. In most of the patients, the peripheral joints are mildly affected without showing any deformity. In time, impaired spinal mobility may cause articular instability and force the patients to use their knee muscles more for postural control and for activities of daily living[2,3]. Furthermore, changes in spine give rise to deformities in peripheral joints. Peripheral joint involvement may also affect posture and thus cause disability[3]. Patients suffering from hip joint involvement rarely develop mild knee flexion pattern in knees during walking in order to make the walk more comfortable[2]. Peripheral joint involvement can be present in about 25% of patients as an asymmetrical oligoarthritis predominantly in lower extremities, particularly affecting the knees[4]. On the other hand, systemic inflammation may also affect the knee muscles. Marcora *et al.*, found reduced appendicular muscle mass in patients with long-standing AS compared to healthy controls. This muscle wasting is significantly associated with reduced knee extensors muscle strength and grip strength of the dominant hand[5]. Local inflammation (achilles tendon enthesitis), frequently seen in seronegative spondyloarthritis patients, may affect the knee muscle[6]. Consequently, strength of knee muscles may be affected due to some reasons in AS patients who have a long-standing disease and impaired posture of spine. However, it is not yet clear whether strength of knee muscles may have an effect on AS patients who have no postural disorders.

In addition, for the chance of success it can be important to know which muscle group is mostly affected during the rehabilitation of AS patient. When weakness is suspected in a muscle group, it is useful to evaluate the isokinetic performance in increasing speed in every angle of that muscle[7]. Although isokinetic testing was used to different

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joints in rheumatoid arthritis, fibromyalgia syndrome and in some other rheumatologic based diseases as well, there is few knowledge about peripheral weakness in patients with AS[8-10]. A study detected muscle weakness and fatigue in ankle plantarflexor muscle groups in AS patients compared to the control group[11].

The objective of this study was to measure the strength and fatigue of the knee extensor/flexor muscle group using by isokinetic in AS patients, who do not have postural disorders or peripheral joint involvement; to compare with healthy controls, and to determine the relation of these values with the functional situation.

Material and Methods

Twenty-six male patients between 18-54 years of age diagnosed with AS and referred to Physical Medicine and Rehabilitation division AS unit, and a control group consisting of 26 healthy males between 20-56 ages were enrolled for this study. The patient group was chosen according to Modified New York diagnosing criteria, diagnosed with AS but not in active period. Patients having serious knee injury, having serious lumbar pain, hip pain or knee pain, having some other systemic diseases, limitations in hip and knee joints, and having surgery in lower extremities were not included in this study group. The control group was selected from the hospital staff with similar age and gender. The control group with serious knee trauma, hip, knee and hip osteoarthritis demonstrated by X--rays, other comorbidities and ligament injury were excluded from the study. Informed consent of the subjects was sought and the ethical committee approval was obtained prior to the initiation of the study.

Evaluation parameters

Knee extensor/flexor muscle group isokinetic muscle strength (peak torque) of both groups was evaluated by Biodex System 3PRO Multijoint System isokinetic dynamometer. Before testing AS patients the following evaluations were performed: Body weight-height, visual analog scale (VAS), modified lumbar Schober (MLS), lower extremity range of motion (ROM) as measured by goniometry, presence of enthesitis as determined by Berlin Enthesitis Index (BEI), the activity of the disease as measured by C-reactive protein (CRP), Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) score and functional status as determined by Bath Ankyolosing Spondylitis Functional Index (BASFI)[12].

Pain

Pain was evaluated by VAS score between 0-10. No pain corresponded to (0), whereas intolerable pain was expressed with (10) points. The severity of the pain was investigated separately if it occurred at night and during resting. The higher points show the severity of the pain[13].

Enthesitis

According to BEI, the patient is asked to evaluate presence of pain during palpation to 12 enthesis areas in the lower extremities. The patient replies with "yes" or "no" and score is determined between 0-12. The score gives an idea about the activity of the disease[12].

Activity of the Disease

BASDAI gives information about the activity of the disease. The evaluated activity is mostly about the presence of inflammation in peripheral joints. Fatigue, axial pain, peripheral pain, morning stiffness and the presence of enthesopathy is evaluated by VAS between 0-10 points. It is accepted as the activity period of the disease, when BASDAI is >4[12,14].

Functional Status

In BASFI scale, 10 daily activities are evaluated. The patient is asked to evaluate each activity by VAS between 0 and 10 according to the difficulty experienced during each activity. The scores show 0= no difficulty, 5= moderate difficulty, 10= maximum difficulty, the total maximum score is determined as 10[15].

Muscle Testing

Isokinetic tests with Biodex System 3PRO Multijoint System isokinetic dynamometer were applied to both groups The reliability of the dynamometer was determined both in healthy group and the AS patient group[16-18]. The tests were performed according to standardizations developed by Wilk *et al*[10]. Warm-up was accomplished on ergonomic bicycle for 10 min. at 60 rpm.

For knee extension/flexion pattern measurement the arms of the dynamometer were held parallel to the leg of the patient having pads fixed dis-

tally. Distal resistance pad was fixed. The stability of the patient on the dynamometer chair was achieved by putting a belt covering the thorax, hip and thigh regions, and the procedure was explained to the patient to ensure good cooperation[10].

Muscle strength is measured better with tests performed with low angular velocities, while high angular velocities are useful for the detection of functional status and endurance of the muscle[7,18,19]. For this reason, slow, moderate and high angular velocities such as 60º/s,180º/s, 240º/s were preferred for the knee extension/flexion pattern[19,21]. The test was performed bilaterally, starting with the dominant side first. Four repetitions were performed at the first two angular velocities in extension/flexion and at the third angular velocity, 20 repetitions were performed. Peak torque (Newtonmetre-Nm) (PT), peak torque/body weight (%) (PT/BW), maximal repetition total work (Joule-J) (MRTW), work/body weight (%) (W/BW), agonist/antagonist ratio (%) (Ag/An) and work fatigue (%) (WF) isokinetic parameters were evaluated at all angular velocities. In order to decrease the occurrence of strain in the muscles, 60 sec. resting period was maintained between each angular velocity[22]. In order to motivate the patients during the test maximal, strength was maintained by verbal instructions. The test was carried out in a quiet and appropriate physical environment with air conditioner.

PT is the highest torque value measured with all velocities in one angular velocity and is expressed in terms of newtonmeter. PT is the most convenient and the most used parameter in isometric test parameters[20]. PT/BW ratio is used to personalize, standardize and interpret isokinetic scores[23]. MRTW is one of the parameters where the relationship between flexion and extension is interpreted and is expressed as Joules[21,24,25]. W/BW is the maximum work (force x distance) produced in a single repetition. This could be a better representation of the functional ability (over PT), because the muscle must maintain the force throughout the range of motion, as opposed to the force at one instant[24]. Ag/An ratio evaluates the balance between the knee extensor/flexor muscles. With this ratio, the weakest muscle in the muscle group can be determined. The ag/an ratio is calculated as the ratio between the peak values of the concentric torque of the flexor muscles, and the concentric peak torque of the extensor of the knee. The hamstring action as antagonist is directly proportional to its ability to generate concentric strength[26-28]. WF test measures the weariness of the muscle after an excess number of repetitions. This is calculated as the percentage of the difference between the production of work between the first 1/3 and the last 1/3 repetitions at the 240º/sec. velocity. There is no standardized test to evaluate fatigue. The number of trials to evaluate fatigue is between 20-100. In this study, we used 20 trials. This parameter acts as a dependent variable used to evaluate the strength of the muscle and shows the endurance capacity of the muscle[29,30].

Statistical Analysis

The comparison demographic data of both groups were assessed using Mann–Whitney U tests. Two way ANOVA was used in the group evaluations for comparisons between the groups for PT, PT/BW, MRTW, W/BW, AG/AN and dominant versus non-dominant leg isokinetic parameters. The comparison WF of both groups was assessed using Mann–Whitney U tests. The correlation between PT parameter and BASFI, VAS and ROM was assessed by Pearson correlation test. $p<0.05$ values were accepted as statistically significant.

Results

Age, gender, height, weight, MLS, VAS, CRP, BASFI, BASDAI, and BEI values are presented in Table I. There was no statistically significant difference between the two groups for age, gender, height and weight. The test group was not in the active stage; BASDAI values were <4, BEI 0-2 and CRP was <5[11]. Resting and night VAS values were below 5. Hip flexion and knee extension and flexion ROM measurements for isokinetic tests performed with the goniometer's dynamometer revealed no statistically significant difference between the two groups. In both groups, the right side was the dominant side.

Significantly lower values than the healthy control group were observed in AS patients for the knee PT, PT/BW, MRTW and W/BW parameters evaluated with bilateral extension and flexion performed at the angular velocities of 60º/s, 180º/s and 240º/s ($p<0.001$) (Tables II, III). There was no significant difference between the groups in dominant versus non-dominant leg for bilateral knee movement tested at 60º/s, 180º/s and 240º/s. Statistical eva-

Table I. Characteristics of patients with ankyolosing spondylitis (AS) and the control group (CG)

	AS (n:26)	CG (n:26)	p
Age/mean	37.04±8.85	38.46±10.35	0.464
Height	172	174.31	0.139
Weight	75.19	73.42	0.288
Modified lumbar Schober	18.72±2.62		
BASFI	3.12±2.20		
BASDAI	2.28±1.41		

luation for the Ag/An parameter revealed a significant difference in AS patients compared to the healthy controls for bilateral knee movements tested at 60º/s ($p<0.05$). There was no statistically significant difference in Ag/An scores for bilateral knee movement tested at 180º/s and 240º/s. There was no significant difference for Ag/An values between the dominant and non-dominant side in AS patients (Table IV).

A significant decrease of work fatigue in AS patients was determined for knee extensors at 240º/s after 20 repetitions ($P<0.05$) (Table V).

There was no statistical correlation between muscle strength measurements and BASFI, VAS and ROM ($p>0.05$).

Discussion

Isokinetic dynamometer is an instrument which helps us to measure the joint movements in all angles, in constant angle speed, allowing maximal muscle contraction along with the measurement of the contraction and muscle capacity objectively[8]. In isokinetic measurements for painful chronic diseases like osteoarthritis, rheumatoid arthritis, fibromyalgia syndrome and chronic low back pain angular velocities such as 60º/s 180º/s, 240º/s and 300º/s angular velocities were used and many repetitions were employed[8,9,18-22,25,31]. There is no standardized model for isokinetic measurement in AS patients, so we have used 60º/s 180º/s, 240º/s angular velocities in our study. The most valid parameter in isokinetic evaluation is the PT which may be affected by body mass index and the PT/BW value is important in this issue as well as the MRTW value that reflects the balance between flexor and extensor muscle groups. The W/BW as one of the best indicator of PT values is also important[20,21,23-25]. The parameters above at all angular velocities showed significant lower scores for knee extensor and flexor muscles on both sides in AS patients as compared to the controls in this study. Although 60º/s Ag/An ratio was significantly decreased on both sides in the AS group, there was no significant difference between the Ag/An ratio for bilateral knee obtained at the angular velocities of 180º/s and 240º/s in the AS and the healthy control groups. Also, higher velocities reflect the Ag/An ratio better than lower velocities[8]. Since the extension and flexion losses for the knee joint are seen together in AS patients, there was no statistically significant difference in Ag/An scores. The low level of the work fatigue showed that the work of knee extensor is decreased in the first third and the last third period of the work thus indicating a decrease in endurance capacity of the muscles. The main finding of this study indicates that in AS patients the tested knee muscles were significantly weaker and the muscle endurance capacity decreases compared to apparently healthy controls. Interestingly, the results of this study show that the forces at different angles and endurance of the tested muscles related to non-involvement joints in patients with AS are lower than those of control subjects.

The reason of the decrease in muscle strength in AS patients is complicated[32]. The decreased muscle strength in inflammatory diseases is related to inflammation, pain, stiffness, inactivity, degeneration at the joints, fatigue and the primary symptoms of AS patients are also pain, enthesis and stiffness[1,33,34]. Inactivity that is related to pain, inflammation and stiffness has a great role in the weakness of muscles in AS patients. Muscle weakness develops in the first week of inactivation. After that, weakness increases rapidly. Decreased physical activity or inactivation results with atrophy in the muscles, which further leads to weakness in the muscles, causes a decrease in neuromuscular performance and thus a decrease in the functional capacity ensues. But, this process does not have to be similar for all muscle groups[1,32,35]. In a study on inflammatory disease, the decrease in dynamic and isometric muscle strength was shown in early stages[36]. Inflammation raises catabolic stimulations including IL-6, IL-1 and TNF alpha cytokine, each case causes muscle protein catabolism. Consequently, inflammatory conditions

Table II. Means of parameters evaluated by the isokinetic test for the knee

Group	AS				CG			
M	Extensors		Flexors		Extensors		Flexors	
S	R	L	R	L	R	L	R	L
PT (Nm)								
60°/s	139.56±28.21	139.67±24.99	61.63±13.52	60.20±10.74	174.29±36.09	171.82±33.97	83.92±22.78	83.27±18.18
180°/s	105.43±21.64	104.90±16.91	58.19±12.72	63.00±14.87	122.78±25.37	125.29±27.36	75.55±19.59	79.16±16.06
240°/s	96.61±16.52	95.52±12.40	67.25±13.11	74.79±15.46	110.62±23.21	111.62±25.31	82.21±18.68	89.35±17.73
PT/BW (%)								
60°/s	187.48±42.10	187.96±38.37	82.50±18.27	81.05±16.97	235.89±36.53	233.25±36.07	114.30±29.67	113.55±24.33
180°/s	141.29±29.45	141.06±25.38	78.33±19.08	85.00±22.34	166.09±24.19	170.13±29.12	103.32±27.44	108.43±23.23
240°/s	129.58±23.97	127.96±17.16	90.70±19.97	101.08±25.27	147.80±22.45	149.88±30.49	110.54±24.98	120.35±23.56
MRTW (J)								
60°/s	147.21±30.92	147.34±25.53	65.29±18.09	64.79±15.48	187.88±40.05	183.04±38.45	98.94±29.30	97.61±24.44
180°/s	117.61±27.48	117.19±17.70	49.42±18.42	47.22±15.21	141.06±30.09	141.47±32.17	73.95±23.29	70.15±19.99
240°/s	100.84±21.67	100.61±15.39	40.20±15.90	38.78±14.09	119.89±24.68	121.56±28.13	59.78±18.78	56.88±19.76
W/BW(%)								
60°/s	191.60±57.17	198.19±38.32	91.77±30.08	94.00±43.17	254.58±43.06	248.01±37.12	134.72±38.06	132.98±31.10
180°/s	157.56±36.71	157.45±26.62	66.22±24.23	63.75±21.74	190.51±26.60	191.65±30.90	100.63±29.83	95.69±25.01
240°/s	135.28±30.17	135.90±22.30	54.27±21.31	52.43±20.09	162.02±21.66	164.65±28.71	81.02±22.51	78.15±23.49

R: right, L: left. AS: ankyolsing spondylitis, CG: control group. M: muscle, S: side.

may affect muscle mass and cause loss of strength[37,38]. The chronic inflammatory response is likely to be a major cause of muscle wasting in AS patients. Marcoro *et al.*, showed that patients with long-standing AS have significant losses of lean mass in arms and legs. This muscle wasting is significantly associated with reduced knee extensor muscle strength and grip strength of the dominant hand[5]. The other reason of the decrease in muscle strength is fatigue in AS patients. There are a lot of mechanisms responsible for the development of muscle fatigue[19]. An exceeding fatigue in AS patients is acquainted with activity of the disease, functional disability, and global wellness[34]. The fatigue in muscles is responsible in motor control deficit and in posture and balance changes[1,12,24,34]. Considering the relationship between the postural changes and fatigue, fatigue may play an important role in postural changes in AS patients. In this study, we determined that the muscle endurance capacity decreases in the patient group, even though we used the least number of trials recommended in the literature. According to this result, the muscle weakness can be the cause of fatigue in AS patients, or fatigue seen in most of the AS patients can be one of the causes of muscle weakness.

The other possible reasons for muscle strength decrease mechanism are local inflammation (enthesitis) and proprioception deterioration, which is related to it. Enthesitis, which is the basic mechanism of pathogenesis in AS patients, is an inflammation of enthesis, the location where the point at which a tendon or ligament or muscle inserts into bone. Enthesitis leads to instable joint structure and these changes apparently cause muscle weakness in AS patients. Furthermore, the attachment sites of the ligamentous formations harbor the afferent nerve endings, which regulate the information about posture and are responsible for joint motion; therefore, a pathology at this site results with changes in proprioception in AS patients. Insufficiency of proprioception may a cause to decrease in muscle strength[32,35,39-41]. Consequently, the muscle weakness detected in our study may have correlation with the disorders in proprioceptors that is related to enthesitis.

Table III. p values of isokinetic testing in AS versus CG

	Knee			
	AS-CG		ND-D leg	
	Extensor	Flexor	Extensor	Flexor
PT (Nm)				
60°/s	<0.001	<0.001	0.603	0.755
180°/s	<0.001	<0.001	0.829	0.183
240°/s	<0.001	<0.001	0.990	0.055
PT/BW (%)				
60°/s	<0.001	<0.001	0.635	0.803
180°/s	<0.001	<0.001	0.723	0.215
240°/s	<0.001	<0.001	0.954	0.071
MRTW (J)				
60°/s	<0.001	<0.001	0.727	0.836
180°/s	<0.001	<0.001	0.723	0.215
240°/s	<0.001	<0.001	0.873	0.525
W/BW (%)				
60°/s	<0.001	<0.001	0.724	0.867
180°/s	<0.001	<0.001	0.930	0.484
240°/s	<0.001	<0.001	0.830	0.563

AS: ankylosing spondylitis, CG: control group.
ND: nondominant, D: dominant.

Conclusions

In this study, we detected fatigue and muscle weakness in knee extensor and flexor muscle groups in AS patients compared to the control group. Rehabilitation of the muscle weakness and fatigue is important to delay the development of the posture disorder and thus prevent the development of balance problems in AS patients. More studies are needed to be done on this subject, in order to detect the effect of exercises especially on the lower extremities, on the activity of the disease, on the posture of the patient and on the functional status in early stages of the disease before any postural change occurs in AS patients. The results of this study showed us how important the effect of muscle weakness in maintaining posture in AS patients is. As a conclusion, functional disability in patients with AS is not only developed by axial deformities, but may also by muscular weakness and fatigue affect. Based on this knowledge, it should be reminded that

Table IV. Means of agonist/antagonist parameters evaluated by isokinetic test (%)

	AS		CG		
Group	R (F/E)	L (F/E)	R (F/E)	L (F/E)	p
Knee-AV 60°/s	45.30±12.32	43.50± 6.56	48.28±8.77	48.68± 7.43	0.001
180°/s	56.55±14.32	61.00±16.84	61.84±11.35	80.40±16.22	0.116
240°/s	72.37±18.91	80.05±17.49	75.31±14.65	82.01±17.28	0.312

R: right, L: left. AS: ankyolsing spondylitis, CG: control group. E:extensor, F: flexor.

Table V. Means of work fatique parameters evaluated by the isokinetic test (%)

	Group		AS	CG	p
Knee 240°/s	Extensor	R	35.35 (2.7-64.0)	27.50 (-9.0-47.8)	0.034
		L	35.90 (3.2-65.2)	23.50 (-7.6-45.3)	0.030
	Flexor	R	38.75 (10.2-69.4)	24.30 (-8.3-79.7)	0.253
		L	41.10 (16.6-68.8)	30.70 (-6.0-71.0)	0.249

R: right, L: left. AS: ankyolsing spondylitis, CG: control group. p<0.05

isokinetic evaluation is also important in the follow up of the efficacy of the scheduled effective rehabilitation in patients with AS.

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