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The Effects of Home-Based Exercises on Muscle Strength in Ankylosing Spondylitis Patients Treated with or without Anti-TNF Alpha

Anti-TNF Alfa Tedavisi Alan ve Almayan Ankilozan Spondilit Hastalarında Ev Egzersizlerinin Kas Gücü Üzerine Etkileri

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ABSTRACT Objective: The present study aims to examine the effects of 6-week home-based exercise program on disease activity, spinal pain, functional status, muscle strength and endurance among ankylosing spondylitis (AS) patients under medical therapy with/without tumor necrosis factor (TNF) inhibitor agents. **Material and Methods:** A total of 44 AS patients were included, 23 patients receiving at least three months of anti-TNF agents formed anti-TNF alpha group and 21 patients formed non-anti-TNF alpha group. Home-based exercise program was demonstrated by a physiotherapist to the patients in both groups and done every day for 6 weeks. Patients were evaluated at the beginning and the end of the 6th week. Visual analog scale (VAS)-spinal pain, International Physical Activity Questionnaire-Short Form (IPAQ-SF), Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), Bath Ankylosing Spondylitis Functional Index (BASFI), and modified Schober test were performed. Isokinetic muscle strength was measured by an isokinetic dynamometer. Isokinetic parameters comprised peak torque (PT), peak torque/body weight (PT/BW) and work fatigue (WF) values. **Results:** At the end of the 6th week, in anti-TNF alpha group, a significant improvement was observed in BASDAI, BASFI, modified Schober, chest expansion, PT, PT/BW and WF values ($p<0.05$). In non-anti-TNF alpha group, although an improvement was achieved in BASDAI, BASFI, VAS-spinal pain and chest expansion parameters ($p<0.05$), there was no improvement in modified Schober and isokinetic parameters ($p>0.05$). **Conclusion:** Home-based exercises provide improvement in disease activity, physical functioning, pain and spinal mobility, regardless of the medical treatment. Exercise has been determined to improve muscle strength in patients using anti-TNF alpha. Further studies are required to clarify the possible mechanisms.

Keywords: Ankylosing spondylitis; exercise therapy; tumor necrosis factor-alpha

ÖZET Amaç: Bu çalışma, tümör nekroz faktörü (TNF) inhibitör ajan tedavisi alan/almayan ankilozan spondilit (AS) hastalarında 6 haftalık evde egzersiz programının hastalık aktivitesi, omurga ağrısı, fonksiyonel durum, kas gücü ve dayanıklılık üzerindeki etkilerini incelemeyi amaçlamaktadır. **Gereç ve Yöntemler:** Çalışmaya toplam 44 AS hastası dâhil edildi. En az 3 ay anti-TNF ajan tedavisi alan 23 hasta anti-TNF alfa grubunu oluşturdu. Yirmi bir hasta ise non-anti-TNF alfa grubunu oluşturdu. Evde egzersiz programı, her iki gruptaki hastalara bir fizyoterapist tarafından gösterildi ve 6 hafta boyunca her gün uygulandı. Hastalar 6. haftanın başında ve sonunda değerlendirildi. Vizüel analog skala (VAS)-spinal ağrı, Uluslararası Fiziksel Aktivite Anketi-Kısa Form [International Physical Activity Questionnaire-Short Form (IPAQ-SF)], Bath Ankilozan Spondilit Hastalığı Aktivite İndeksi [Bath Ankylosing Spondylitis Disease Activity Index (BASDAI)], Bath Ankilozan Spondilit Fonksiyonel İndeksi [Bath Ankylosing Spondylitis Functional Index (BASFI)] ve modifiye Schober testi uygulandı. İzokinetik kas kuvveti, izokinetik dinamometre ile ölçüldü. İzokinetik parametreler, pik tork [peak torque (PT)], pik tork/vücut ağırlığı [peak torque/body weight (PK/BW)] ve iş yorgunluğu [work fatigue (WF)] değerlerini içermekteydi. **Bulgular:** Altıncı hafta sonunda anti-TNF alfa grubunda BASDAI, BASFI, modifiye Schober, göğüs ekspansiyonu, PT, PT/BW ve WF değerlerinde anlamlı düzelme gözlendi ($p<0,05$). Non-anti-TNF alfa grubunda BASDAI, BASFI, VAS-spinal ağrı ve göğüs ekspansiyonu parametrelerinde iyileşme sağlanmasına rağmen ($p<0,05$), modifiye Schober ve izokinetik parametrelerde düzelme olmadı ($p>0,05$). **Sonuç:** Evde yapılan egzersizler, medikal tedaviden bağımsız olarak hastalık aktivitesi, fiziksel işlev, ağrı ve omurga hareketliliğinde iyileşme sağlar. Egzersizin anti-TNF alfa kullanan hastalarda kas gücünü artırdığı belirlenmiştir. Olası mekanizmaları netleştirmek için daha fazla çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: Ankilozan spondilit; egzersiz terapisi; tümör nekrozis faktör-alfa

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Ankylosing spondylitis (AS) is potentially disabling chronic inflammatory arthritis of the axial skeleton that can manifest with chronic back pain.[1] This back pain is typically inflammatory and mostly due to sacroiliitis, spondylitis, and development of syndesmophytes inducing ankylosis of the spine and resulting in physical limitation and decreased quality of life in patients with AS.[2,3] Since there is not any treatment that can eradicate the disease, the treatment goals comprise diminishing pain and morning stiffness, and keeping proper posture and good physical functions. Assessment of SpondyloArthritis (ASAS)/European League Against Rheumatism (EULAR) guidelines recommend combining pharmacologic and non-pharmacologic therapy in the treatment of patients with AS to have better control of the disease.[4]

While conventional disease-modifying antirheumatic drugs such as sulfasalazine and methotrexate have limited efficacy in AS, tumor necrosis factor (TNF) inhibitor agents like infliximab, etanercept, adalimumab, golimumab, and certolizumab have shown their efficacy in improving physical functioning, spinal mobility, and peripheral manifestations.[5]

Physical exercise has been recommended as the cornerstone of the treatment plan in patients with AS by ASAS/EULAR guidelines.[4] The number of studies focusing on the effects of regular exercise programs on AS has increased with the use of TNF inhibitor agents.[6] To the best of our knowledge, there is no study in the literature to compare the efficacies of regular exercise in AS patients treated with different pharmacologic agents. Additionally, this is the first study to assess the effects of physical exercise on muscle strength and endurance in AS patients. The purpose of the current study is to examine the efficacy of a 6-week home-based exercise program on disease activity, spinal pain, functional status, muscle strength and endurance among AS patients under medical therapy with or without TNF inhibitor agents.

MATERIAL AND METHODS

A total of 44 patients with AS, between 18 and 65 years, fulfilling the modified New York Criteria followed-up at the department of physical medicine and rehabilitation of a medical school were included in the study.[7] None of the patients with AS had knee involvement. Those who had undergone surgical intervention for the knee joint in the last 6 months, those with high disease activity [the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) >4], those with neurological deficits, mental disability, and cardio-pulmonary insufficiency were excluded.[8]

Participants were divided into two groups according to their use of anti-TNF agents. Patients receiving at least three months of anti-TNF treatment were included in the anti-TNF alpha group. Patients who have never used any anti-TNF agents formed the non-anti-TNF alpha group.

A home-based exercise program was demonstrated by a physiotherapist to all of the patients in both groups. Also, a home exercise booklet was given to all of the patients.

This program included spinal flexibility exercises, upper and lower extremity range of motion and stretching exercises, isotonic quadriceps strengthening (10 seconds maximal contraction-90 repetitions), and respiratory exercises.

Patients were telephoned weekly by a physician to remind them to do their exercises regularly. Exercises were required to be done every day for 6 weeks, at least once a day in 2 sets. All the patients were evaluated at the beginning and the end of the 6th week of the exercise program.

EVALUATION PARAMETERS

The severity of spinal pain was determined by using 10 cm visual analog scale (VAS)-spinal pain.[9] The International Physical Activity Questionnaire-Short Form (IPAQ-SF) was used for evaluating physical activity status.[10] Disease activity was monitored by the BASDAI, and functional status by the Bath Ankylosing Spondylitis Functional Index (BASFI).[8,11]

Modified Schober test was used to assess spinal mobility.[12] There are several types of measurement. In this study, measurements were made as suggested by the ASAS group. While the patient was standing upright, a line was drawn between both posterior superior iliac spines. Then a mark was set 10 cm above this line. The patient was asked to lean forward as

much as he can. The interval between two signs was measured and recorded.

Chest expansion was used to measure the rib cage mobility.[12] The difference between maximum expiration and inspiration was measured from the 4th intercostal space (about nipple level in men) with the patient's hands on the back or above the head. After a deep expiration, inspiration was done as much as possible. The distance between maximum inspiration and expiration was calculated. The better of the two attempts was recorded.

MEASUREMENT OF ISOKINETIC MUSCLE STRENGTH

Isokinetic muscle strength was calculated by using Biodex System 3 Pro Multijoint System isokinetic dynamometer (New York, USA). The device was calibrated before each test procedure after insertion of the appropriate attachments for the knee joint flexion and extension pattern. The patients were informed about all steps of the isokinetic testing. They were seated back and the seat back was set to 90 degrees from the horizontal plane and they were instructed to hold the handles on the side of the seat throughout the test. Thigh, pelvis, and trunk were fixed by belts. With the help of an adjustable lever arm, the patient's ankle was stabilized at the lateral malleolus level with the help of a padded cuff. Axis of the dynamometer was accepted as the transverse line passing through lateral femoral condyles and dynamometer was adjusted according to this axis. Verification of the torque at 45º according to gravity was carried out by the software of the computer.

Low angular velocity is useful for the measurement of muscle strength; while high angular velocity is appropriate for determining the endurance of the muscle. Accordingly, low and high angular velocities were chosen for the knee extension/flexion pattern. The knee exercise protocol was as follows: 5 repetitions at 60 °/sec angular velocity; 10 sec rest period; 30 repetitions at 180 °/sec angular velocity. Isokinetic parameters including peak torque (PT), peak torque/body weight (PT/BW), and work fatigue (WF) values were evaluated.

Peak torque is the highest torque value on the force-velocity curve. It indicates the maximum strength capability of muscles. The unit of PT is Nm. PT/BW ratio is used to systematize and explicate isokinetic scores. WF is a ratio of difference between the first 1/3 and last 1/3 of work during the test.[13] It is calculated automatically by an isokinetic dynamometer and gives information about muscle endurance.

At the first admission of the patients, age, sex, height, weight, extremity dominance, delays in diagnosis were recorded. All questionnaires and measurements were applied to the patient at the beginning and the end of the 6th week.

The study protocol was was approved by the Hacettepe University Non-interventional Clinical Researches Ethics Committee (date: 15/10/2014/number: 16969557/1036). The study was conducted in compliance with the decrees of the World Medical Association's Declaration of Helsinki. All of the participants gave their written informed consent prior to inclusion.

STATISTICAL ANALYSIS

Statistical analysis was accomplished using SPSS (Statistical Package for Social Sciences) for Windows 22. Shapiro-Wilk W test was used to examine if the numerical data were normally distributed. Differences among groups were assessed by using independent samples t-test and Mann-Whitney U tests. Paired t-test and Wilcoxon sign test were used for within-group comparisons and Chi-square test for categorical parameters. The results were evaluated at the 95% confidence interval and a value of $p<0.05$ was regarded as statistically significant.

RESULTS

DEMOGRAPHIC CHARACTERISTICS

Of all the patients, 59.1% (26 patients) were male, and 40.9% (18 patients) were female. While 23 patients (15 male, 8 female) were included in the anti-TNF alpha group, 21 patients (11 male, 10 female) were included in the non-anti-TNF alpha group. The male to female ratio was 1.44. Age, weight, height, delay in diagnosis, and IPAQ-SF scores did not significantly differ among the groups ($p>0.05$). Demographic and clinical characteristics of the patients were given in Table 1.

The most commonly used TNF inhibitor agent was infliximab in anti-TNF alpha group followed by

TABLE 1: Demographic and clinical data of the patients.

	Anti-TNF alpha group (n=23) mean±standard deviation	Non-anti-TNF alpha group (n=21) mean±standard deviation	p value
Male/female ratio	15/8	11/10	0.387
Age (years)	40.08±8.43	38.90±11.05	0.756
Weight	78.52±15.67	74.80±13.07	0.143
Height	168.43±9.46	167.33±9.14	0.434
Delay in diagnosis (years)	6.47±5.15	6.38±5.95	0.350
IPAQ-SF	1.65	1.62	0.863

TNF: Tumor necrosis factor; IPAQ-SF: International Physical Activity Questionnaire-Short Form.

etanercept, adalimumab, and golimumab, respectively. Current medication of patients is summarized in Table 2.

There was no significant difference in the baseline mean values among the groups in the parameters except BASDAI and VAS-spinal pain ($p>0.05$). At the end of the 6th week of the treatment, there was no significant difference in BASFI, modified Schober, chest expansion, PT, PT/BW and WF parameters among the groups except BASDAI and VAS-spinal pain ($p>0.05$). BASDAI and VAS-spinal pain were lower in anti-TNF alpha group than in the non-anti-TNF alpha group at both baseline and the end of the 6th week (Table 3).

In the anti-TNF alpha group, a statistically significant improvement was observed in BASDAI, BASFI, modified Schober, chest expansion, PT, PT/BW, and WF values at the end of the 6th-week home-based exercise treatment compared to the baseline measurements ($p<0.05$). Although VAS-spinal pain reduced, this difference was not statistically significant ($p>0.05$) (Table 4).

In the non-anti-TNF alpha group, at the end of the 6th week, a statistically significant improvement was achieved in BASDAI, BASFI, and VAS-spinal pain and chest expansion parameters compared to the baseline ($p<0.05$). Although there was an increase in the modified Schober compared to the baseline, this difference was not found to be statistically significant ($p>0.05$). An increase was found in PT, PT/BW, and WF parameters compared to the baseline, but these were not statistically significant ($p>0.05$) (Table 5).

DISCUSSION

The present study aimed to compare the effectiveness of a 6-week-home exercise program on disease activity, functional status, spinal pain, spinal mobility, muscle strength, and endurance between the patients

TABLE 2: Distribution of medication among groups.

Anti-TNF alpha group (n=23) n (%)		Non-anti-TNF alpha group (n=21) n (%)	
Infliximab	17 (73.9)	Sulphasalazine	13 (61.9)
Etanercept	2 (8.7)	Indometacin	3 (14.3)
Adalimumab	3 (13)	Acemetacin	3 (14.3)
Golimumab	1(4.3)	Hydroxychloroquine	1 (4.8)
		Diclofenac	1 (4.8)
Methotrexate	1 (50)	Indometacin	2 (28.6)
Diclofenac	1 (50)	Acemetacin	2 (28.6)
		Flurbiprophen	1 (14.3)
		Diclofenac	1 (14.3)
		Naproxen	1 (14.3)

TNF: Tumor necrosis factor.

TABLE 3: Comparison of mean values at the beginning and at the end of 6 weeks of home exercise therapy among the groups.

	Anti-TNF alpha group (n=23) mean±standard deviation	Non-anti-TNF alpha group (n=21) mean±standard deviation	p value
VAS-spinal pain-1	19.60±18.00	31.90±14.87	0.010*
VAS-spinal pain-2	15.91±12.22	25.76±14.84	0.016*
BASDAI-1	1.70±1.16	2.58±0.88	0.008*
BASDAI-2	1.30±0.83	2.02±1.00	0.012*
BASFI-1	1.90±1.59	1.90±1.25	0.707
BASFI-2	1.37±1.28	1.46±1.02	0.444
Modified Schober-1	14.16±1.73	14.31±1.30	0.743
Modified Schober-2	14.50±1.80	14.63±3.29	0.769
Chest expansion-1	3.02±1.38	3.47±1.40	0.292
Chest expansion-2	4.16±1.47	5.67±6.84	0.979
PT-1	142.92±44.87	137.34±37.20	0.769
PT-2	158.44±48.16	141.87±32.71	0.193
PT/BW-1	181.84±38.84	189.44±43.59	0.542
PT/BW-2	200.73±42.20	197.78±47.00	0.827
WF-1	33.36±10.10	32.86±13.20	0.888
WF-1	39.79±10.09	37.51±11.01	0.478

TNF: Tumor necrosis factor; VAS-spinal pain: Visual Analog Scale-spinal pain; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; PT: Peak torque; PT/BW: Peak torque/body weight; WF: Work fatigue; 1: At the beginning of the exercise therapy; 2: At the end of the exercise therapy; *: p<0.05 (significant).

TABLE 4: Comparison of mean values at the beginning and at the end of the treatment in the anti-TNF alpha group.

	Mean±standard deviation	p value
BASDAI 1-BASDAI 2	0.40±0.75	0.017*
BASFI 1-BASFI 2	0.53±1.03	0.003*
VAS-spinal pain 1-VAS-spinal pain 2	3.69±12.70	0.341
Modified Schober 1-Modified Schober 2	-0.33±0.36	0.000*
Chest expansion 1-Chest expansion 2	-1.14±0.80	0.000*
PT 1-PT 2	-15.52±17.53	0.001*
PT/BW 1-PT/BW 2	-18.89±23.09	0.001*
WF 1-WF 2	-6.43±11.19	0.012*

TNF: Tumor necrosis factor; VAS-spinal pain: Visual Analog Scale-spinal pain; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; PT: Peak torque; PT/BW: Peak torque/body weight; WF: Work fatigue; 1: At the beginning of the exercise therapy; 2: At the end of the exercise therapy; *: p<0.05 (significant).

treated with/without anti-TNF alpha. To the best of our knowledge, this is the first study to compare the efficacy of home exercises in different AS treatment groups. Also, this study is the first to measure post-exercise muscle strength in AS patients.

In the present study, no difference was observed in gender, age, height, weight, delay in diagnosis, and IPAQ scores between anti-TNF alpha and non-anti-TNF alpha groups at the beginning of the exercise therapy. This indicates that both groups were homogeneously distributed. Of the patients, 60% were men and 40% were women. The male/female ratio was consistent with the recent studies.[14] Diagnostic delay emerges as an important problem in AS. Mean diagnostic delay was reported as 7.9 years in previous research.[15] We found it to be 6.5 years in our study, similar to another study from Turkey where it was reported to be 5.6 years.[16]

TABLE 5: Comparison of mean values at the beginning and at the end of the treatment in the non-anti-TNF alpha group.

	Mean±standard deviation	p value
BASDAI 1-BASDAI 2	0.55±0.90	0.011*
BASFI 1-BASFI 2	0.44±0.90	0.038*
VAS-spinal pain 1-VAS-spinal pain 2	6.14±12.67	0.033*
Modified Schober 1-Modified Schober 2	0.49±3.69	0.055
Chest expansion 1-Chest expansion 2	-2.20±6.95	0.000*
PT 1-PT 2	-4.53±18.87	0.140
PT/BW 1-PT/BW 2	-8.33±27.24	0.176
WF 1-WF 2	-4.65±12.56	0.105

TNF: Tumor necrosis factor; VAS-spinal pain: Visual Analog Scale-spinal pain; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; PT: Peak torque; PT/BW: Peak torque/body weight; WF: Work fatigue; 1: At the beginning of the exercise therapy, 2: At the end of the exercise therapy; *: p<0.05 (significant).

In the literature thus far, there are many papers that have investigated the efficacy of exercises in patients with AS. In the meta-analysis by Liang et al., based on seven studies involving 1,098 AS patients, it was reported that home-based exercise programs had significant beneficial effects in reducing BASDAI and BASFI scores.[17] Also, results indicated that home-based exercise interventions significantly improved health-related quality of life. No clear effect of interventions was obtained on pain scores, since pain evaluation methods differed among the studies. Of six studies that were analyzed, only one study included the patients on anti-TNF alpha therapy, the others mentioned no data of medical treatment. In a meta-analysis by Hu et al. including 10 studies and 534 AS patients, the exercise group had statistically significant improvements in pain, BASDAI, and BASFI scores compared to the non-exercise group.[18] In our study, it was found that 6-week home exercise program improved BASDAI and BASFI scores significantly more in the anti-TNF alpha group than in the non-anti-TNF group. Although there was an improvement in VAS-spinal pain scores in the anti-TNF alpha group, it was not statistically significant. In the non-anti-TNF group, there was a statistically significant improvement in BASDAI, BASFI, and VAS-spinal pain scores. Improvements in BASDAI, BASFI, and VAS-spinal pain scores in both groups were in accordance with these meta-analyses.[17,18] BASDAI and VAS-spinal pain baseline mean values were significantly lower in the anti-TNF alpha group, than in the non-anti-TNF alpha group. At the end of the treatment, the change in BASDAI and VAS-spinal pain mean values was found to be lower in the anti-TNF alpha group, compared to the non-anti-TNF alpha group. This indicates that there was more improvement in BASDAI and VAS-spinal pain in the non-anti-TNF alpha group compared to the anti-TNF alpha group. Although both groups had low disease activity (BASDAI <4), mean values of BASDAI and VAS-spinal pain were higher in the non-anti-TNF alpha group. It is known that TNF alpha inhibitors are more effective than other drugs in the control of disease activity and pain.[19] Since the disease activity and pain may have drawn a plateau in the group receiving anti TNF alpha, it may explain that the difference to be achieved with exercise is lower in this group compared to the non-anti-TNF alpha group.

Many parameters can be used to evaluate spinal mobility.[20] In our study, modified Schober and chest expansion were preferred because they can be performed easily and quickly. In the anti-TNF alpha group, a significant increase was achieved in the mean modified Schober and chest expansion compared to the baseline. These results were in accordance with the study of Masiero et al.[21] They reported improvement in BASMI and chest expansion scores in AS patients after the exercise therapy. In the non-anti-TNF alpha group, mean values of chest expansion increased significantly compared to baseline. Modified Schober mean values were not statistically significant although there was an increase with 6-week home exercise program. However, we are in the opinion that this difference will become meaningful

if the number of patients is increased. These results are similar to the findings of previous studies and demonstrate that home-based exercise is an important part of the treatment that has positive effects on disease activity, physical functioning and spinal mobility parameters, regardless of the medication of the patients.[22-24]

Although there is no accepted exercise protocol in AS patients, there are conventional exercises recommended by experts. The most recommended exercises flexibility exercises of the cervical, thoracic and lumbar spine, strengthening exercises of the erector spinae, shoulder girdle and hamstring muscles, and as well as breathing exercises. Although quadriceps muscle strength is decreased in AS patients compared to the normal population, quadriceps strengthening programs are not included in exercise recommendations.[25] In our study, quadriceps muscle strength measurement with single plane motion was preferred to evaluate the effect of exercise on muscle strength in AS patients since it is not possible to measure the muscle strength of the spine with a single plane movement. Besides, back and low back pain negatively affect muscle strength.[26] As expected in this study, after 6-week home-based exercise in the anti-TNF alpha group, there was a significant increase in the strength parameters such as PT, PT/BW. In addition, there was a significant increase in WF compared to the baseline. Although there was an increase in the parameters of PT, PT/BW, and WF in the non-anti-TNF group, this increase was not significant. To our knowledge, this is the first study in the literature to evaluate strength and muscle fatigue after exercise therapy in AS patients. In studies in which muscle strength was evaluated with the isokinetic system in AS patients, it was shown that muscle strength was lower than in healthy population.[27,28] Marcora et al. found a decrease in upper and lower extremity muscle mass in long-term AS patients.[29] In addition to this decrease in muscle mass, it was stated that there was a decrease in grip strength and knee extensor strength. The effect of TNF alpha on muscle strength is not exactly known. However, there are studies reporting that suppression of TNF alpha may have positive effects on muscle strength. In the study of Ermolova et al., an increase in muscle strength was found after 3 mg/kg infliximab treatment in the mice with Duchenne muscular dystrophy.[30] In a placebo-controlled study with healthy volunteers, a significant increase in muscle strength was observed in the group given etanercept before heavy exercise.[31] In addition, there are studies supporting that TNF alpha is involved in the repair and regulation of damaged muscle cells.[32] As in our study, in AS patients, the positive effects of exercises were observed on pain, inflammation, fatigue, functionality, and mobility, regardless of the medication of the patients.[17,33] Data of our study demonstrate that exercise-induced strengthening may be greater in the patients receiving anti-TNF alpha. Also an increase in muscle strength may increase the motivation of the patients and encourage them to exercise for longer.

In our study, a significant increase was found in the WF parameter in the anti-TNF alpha group after 6-week exercise compared to the baseline. Although there was an increase in the WF compared to the baseline in the non-anti-TNF alpha group, this was not statistically significant. The work done would be expected to increase with the development in muscle strength after the exercises. Fatigue would be expected to decrease, since it is a dependent variable of the work done.[34] When the validity and reliability measurements of Biodex 3 isokinetic device were examined, it was found that repeated fatigue measurements were lower, although repeated strength measurements were higher.[34,35]

The first limitation of the present study was the lack of supervision of the exercises. The mean age of the patients participating in the study was 40 and most of them were actively working. This was the main obstacle to the supervised exercise program. The second limitation of the study was that the muscle strength parameters of the patients were evaluated at the end of the 6th week. Considering the response of muscles to exercises, this period is sufficient, but may not be optimal.

CONCLUSION

In conclusion, our study is the first study investigating the comparative effectiveness of home-based exercises in AS patients who received and did not

receive TNF alpha inhibitors. According to our findings, home-based exercises are an effective, inexpensive, and accessible form of treatment in AS patients with low disease activity. Home-based exercises provide improvement in disease activity, physical functioning, pain, and spinal mobility, regardless of the medical treatment. Exercise has been determined to improve muscle strength in patients receiving anti-TNF alpha. Further studies with a higher number of participants are needed to elucidate the mechanisms that TNF alpha inhibitors provide exercise-induced muscle strength increase in AS patients.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

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