The Comparison of the Effects of Electrical Stimulation and Exercise in the Treatment of Knee Osteoarthritis

Diz Osteoartriti Tedavisinde Egzersiz ve Elektriksel Stimülasyonun Etkilerinin Karşılaştırılması

Ömer KOCAMAN, Halil KOYUNCU*, Ahmet DİNÇ*, Halime TOROS*, Şafak S. KARAMEHMETOĞLU*

Abant İzzet Baysal Üniversitesi, Tıp Fakültesi, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, Düzce

**İstanbul Üniversitesi, Cerrahpaşa Tıp Fakültesi, Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, İstanbul, Turkey*

Summary

Objective: Pain is the the main symptom of knee osteoarthritis. Pain causes immobilisation, limitation in the range of motion (ROM) and periarticular muscle spasm through reflex inhibition. Consequently, patients develop weakness and atrophy in the quadriceps muscle. In this study, the effect of isometric exercises and electrical stimulation was compared on patients with knee osteoarthritis.
Materials and Methods: Thirty-eight patients were separated into two groups randomly. In the first group; the combination of paracetamol + infrared + electrical stimulation (20 times, once a day) treatment was applied. In the second group; the combination of paracetamol + infrared + active resistive isometric exercises (20 times, once a day) treatment was applied. The evaluations performed include pre and post-treatment pain, active ROM, thigh circumference measurements, activity time and WOMAC and Lequesne indices. Cross-sections of rectus femoris muscle were measured quantitatively by computerized tomography before and after the treatment. Clinical and radiological findings were evaluated for both groups.
Results: Statistically a significant improvement was observed in all of the parameters for both of the groups ($p<0.05$). The improvement in ROM was found larger in the exercise group in comparative group analysis ($p<0.05$). The diameter of the rectus femoris muscle increased in both of the groups ($p<0.05$). The increase in the diameter of the rectus femoris was higher in the electrical stimulation group ($p<0.05$).
Conclusion: The treatment of electrical stimulation was found to be as efficient as the exercise treatment in cases such as knee osteoarthritis, quadriceps muscle weakness and atrophy prevention. Electrical stimulation treatment could be used alone or in combination with exercise treatment in clinical setting. And, isometric exercises could be undertaken as a home program. *Turk J Phys Med Rehab 2008;54:54-8*
Key Words: Knee osteoarthritis, exercise, electrical stimulation

Özet

Amaç: Diz osteoartritinin ana semptomu ağrıdır. Ağrı, refleks yolla, eklem çevresi kas spazmı, eklem hareket kısıtlığı ve immobilizasyona sebep olur. Sonuçta, kuadriseps kasında zayıflık ve atrofi gelişir. Bu çalışmada, diz osteoartritli hastalarda, izometrik egzersizler ve elektriksel stimülasyon karşılaştırıldı.
Gereç ve Yöntem: Yirmisekiz hasta randomize tek kör olarak iki gruba ayrıldı. Birinci grupta; parasetamol + infraruj + elektrik stimülasyonu (günde bir kez, 20 seans) uygulandı. İkinci grupta; parasetamol + infraruj + aktif rezistif izometrik egzersizler (günde bir kez, 20 seans) uygulandı. Tedavi öncesi ve sonrası ağrı, aktif eklem hareket açıklığı, uyluk çevresi ölçümleri, aktivite zamanı, WOMAC ve Lequesne indeksleri değerlendirildi. Rektus femoris kasının çapı, tedavi öncesi ve sonrası kantitatif olarak bilgisayarlı tomografi ile ölçüldü. Klinik ve radyolojik bulgular, her iki grupta değerlendirildi.
Bulgular: Her iki grupta, parametrelerin tümünde istatistiksel olarak anlamlı düzelme gözlendi ($p<0.05$). Egzersiz grubunda, eklem hareket açıklığı diğer gruptan daha fazla bulundu ($p<0.05$). Rektus femoris kasının çapı, grupların her ikisinde de arttı ($p<0.05$). Bu artış, elektriksel stimülasyon grubunda daha yüksekti ($p<0.05$).
Sonuç: Elektriksel stimülasyon, diz osteoartritinde, kuadriseps kas zayıflığını ve atrofisini önlemede, egzersiz kadar etkin bulundu. Elektriksel stimülasyon, klinik uygulamada, tek başına veya kombinasyonla kullanılabilir. İzometrik egzersizler ev programı olarak devam ettirilebilir. *Türk Fiz Tıp Rehab Derg 2008;54:54-8*
Anahtar Kelimeler: Diz osteoartriti, egzersiz, elektriksel stimülasyon

Address for Correspondence/Yazışma Adresi: Dr. Halil Koyuncu, İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, İstanbul, Turkey
Tel: 0212 414 30 00 E-mail: halil_koyuncu@yahoo.com **Accepted:** Ekim 2007

Introduction

Osteoarthritis (OA) is the most common rheumatological disease which causes physical disability (1). The main pathologies are as follows; damage of the joint cartilage and reactive hypertrophy in the subchondral bone. There may be synovitis in the flare-ups of the disease (1,2). Pain, local sensitivity, limitation of the joint motion, muscle atrophy due to inactivity, crepitation and local inflammation with different degrees can be seen during the course of this disease (2,3). OA is seen mostly in middle and advanced age groups and its frequency increases with age. Although its frequency is similar in both sex below the age of 55, there is an increase in women after the age of 55 (1-4). Knee OA is common in the elderly population and manifestation of the OA is seen in these patients. A positive correlation between knee OA and obesity has been demonstrated (5-7). Mechanical loading and weakness of the peripheral muscles accerelate joint degeneration. In time, the symptoms get aggravated and the activities of daily living (ADL) become restricted (8,9). Knee pain can cause spasm of the adjacent muscles. Muscle spasm increases joint loading and can cause limitation in the movement. Pain causes progressive loss of function and muscle atrophy through reflex mechanisms (8-10). The treatment aims to relieve pain, maintain range of motion, prevent contractures and preserve knee functions increase muscle strength and absorb compressive loadings. Minor analgesics, non-steroidal anti-inflammatory drugs, physical modalities like superficial and deep heating and low frequency currents and quadriceps muscle strengthening exercises can be used. Isometric exercises and neuromuscular electrical stimulation are just some of the specific methods of muscle strengthening (11,12).

In this study, we aimed to evaluate the effects of the isometric exercises and neuromuscular electrical stimulation on the clinical and functional outcomes of the knee osteoarthritis and to determine the quantitative changes of the rectus femoris muscle with computerized tomography.

Meterials and Method

Thirty eight patients were over the age of 45. They were admitted to the out-patient department of our clinic. They had chronic knee pain and were diagnosed primary knee OA according to the modified the American College of Rheumatology (ACR) criteria (12) and evaluated radiologically according to the stages Kellgreen-Lawrence I, II, and III were included (13). Patients with cardiovascular, inflammatory, infectious, endocrinological and tumoral diseases, fractures, ruptured ligaments, active synovitis and meniscopathy were excluded.

Physical examination of the patients was performed after a thorough medical history. Limitations of movements, accompanying diseases, operation and trauma history were inquired. Pain while moving and resting was measured by visual analogue scale (VAS). Deformity, swelling and joint collection were investigated by physical examination. Joint range of motion (ROM) was evaluated with goniometer and muscle strength was evaluated with manual muscle testing. Thigh and knee circumferences were measured by a measuring tape. Time of climbing up and going down of twenty-five steps was recorded in seconds. Pain before and after the motion was evaluated with VAS.

Body mass index (BMI) was calculated according to the formula BMI= weigth (kg)/height (m^2).

Diameter of the rectus femoris were measured milimetrically by computerized tomography before and after treatment.

The study was designed single-blindly. Patients were randomised into two groups. In the first group; the combination of infrared, neuromuscular electrical stimulation (NMES) and analgesic (paracetamol; 1500 mg/day) treatment were applied. The combination of infrared, resistive isometric exercise and analgesic (paracetamol; 1500 mg/day) treatment were applied to the second group.

NMES application was performed in sitting position and knee flexed to 60 degrees. The leg was tied to the application table by a Velcro tape passing from the ankle in order to inhibit the joint movement that would result from quadriceps muscle contraction. In each session, warm-up, training and massage phases were applied by the chosen program of the NMES. Each session lasted 23 minutes and was applied 5 times a week for 4 weeks.

Exercises were applied in sitting position and knee flexed to 60 degrees. Patient was forced to push one's leg with maximum contraction against a fixed barrier in front of the ankle. Exercise program lasted 9.5 minutes and was applied as a three sets of 10 repetitions. Both knees were included for 4 weeks, 5 times a week.

The following parameters were evaluated in the study:

- Pain occurred while moving and at rest measured with visual analogue scale (VAS).
- Duration of climbing up and down of 25 steps was recorded in seconds. Pain before and after this activity was evaluated with VAS.
- Active flexion and extension of each knee were measured with a goniometer.
- Thigh circumference was measured by a measuring tape, 10, 15 and 20 cm above the superior margin of the patella. Patella was sustained at the anatomical position during measurement.
- Severity of osteoarthritis according to Lequesne index (14) , and functional status according to Western Ontario and Mc Master (WOMAC) Universities osteoarthritis index (15) were defined.
- The diameter of the rectus femoris muscle was measured at 10 and 15 cm above the superior margin of the patella with computerized tomography and recorded in millimeters. Measurements were performed in supine lying position with knee extended and hip in neutral position.

Clinical and radiological evaluations were performed before and after treatment. All parameters, obtained before and after treatment, were compared statistically. During the comparison of the values of the two groups before and after treatment, student's t test and Mann-Whitney U test were used. In the evaluation of the effectiveness of the applications paired t test and Wilcoxon test were also used. The level of the significance was accepted as 0.05.

Results

Thirty-eight patients were enrolled in the study. There were 4 men (21.1%) and 15 women (78.9%) in NMES group (first), and 5 men (26.3%) and 14 women (73.7%) in the exercise group (second). There were no statistically significant differences between groups according to age, weight, height and body mass index (Table 1). There was no difference between two groups in radiological grading. The mean radiological grade was 2.32±0.67 in NMES group and 2.26±0.73 in exercise group (P=0.885).

Table 1. Demographic features of the subjects.

GROUP	NMES*	EXERCISE	P value
Age	61.63±10.16	60.42±7.64	0.708
Weight (kg)	74.03±11.30	78.68±13.04	0.297
Height (cm)	158.79±11.24	159.42±9.09	0.583
BMI** (kg/m^2)	29.42±3.90	31.16±6.06	0.370

* Neuromuscular Electrical Stimulation
** Body Mass Index

Table 2. Comparison of the parameters of functional evaluation in NMES and exercise groups before and after treatment.

	NMES	EXERCISE	p-value
Activity time (second)	41.42±19.02	40.11±18.41	0.751
WOMAC (Total score)	27.42±14.59	25.37±10.82	0.686
Lequesne (Total score)	9.74±8.34	7.16±2.77	0.354

* Western Ontario and Mc Master Universities Osteoarthritis Index

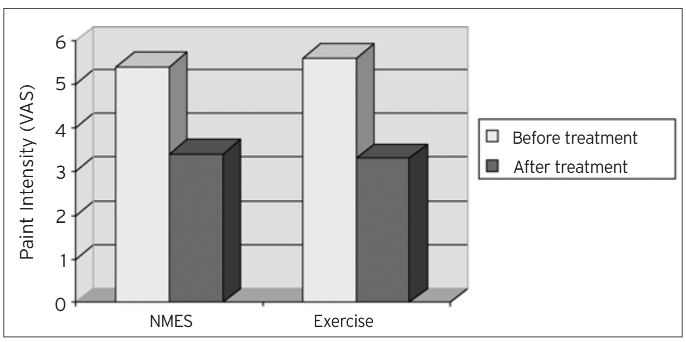

Figure 1. Pain values of two groups before and after treatment.

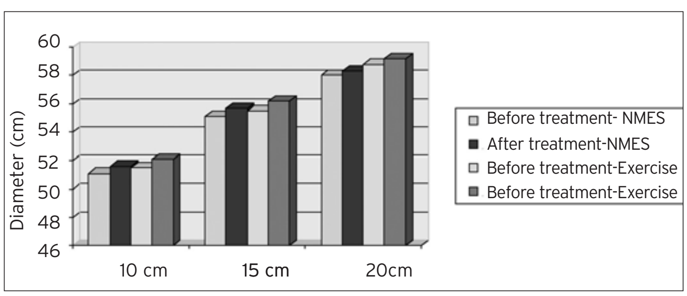

Figure 2. Change in thigh circumference of two groups.

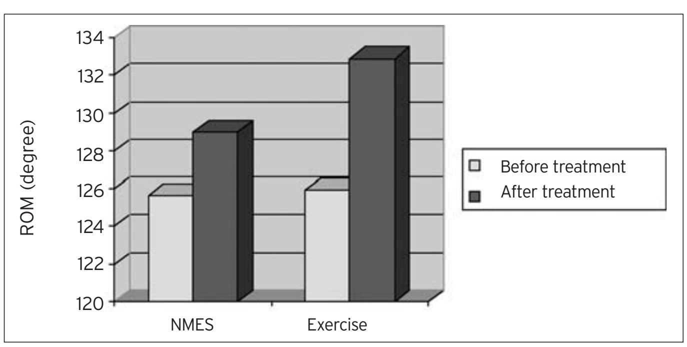

Figure 3. Change in active ROM (Range of Motion) of the joint.

The values of pain, thigh circumference and active ROM were similar in both of the groups before the treatment. Activity time, Lequesne and WOMAC indices and rectus femoris diameters were also similar before the treatment.

After treatment there was a significant improvement in knee pain in each group, but in terms of results no difference was found between the two groups (P>0.05) (Fig. 1). Circumferences of thigh were increased significantly in each group after treatment, but in terms of increase in the circumference of the thigh the difference between the two groups was not significant (P>0.05) (Fig. 2). Active knee motion was improved significantly in each group, and the improvement in the exercise group was more prominent than the NMES group (P<0.05) (Fig. 3).

After treatment, there were significant improvements in activity time, Lequesne and WOMAC indices in each group. But in terms of the improvement in the activity time, there was no significant difference between the two groups (P>0.05) (Table 2).

The diameter of the rectus femoris was improved significantly in each of the group after treatment. In terms of the improvement in the diameter of the rectus femoris there was no difference between the two groups (P>0.05) (Fig. 4).

Discussion

OA is the most common musculoskeletal system disease. Secondary OA has multifactorial etiology. Primary OA which is seen among the elderly affects mostly hands and load-bearing large joints. Knee OA is one of the most common OA type together with spinal and hip OA. The main cause of knee OA is the increase of the mechanical stress per area on joint surface (4).

Knee OA may cause physical disability such as ambulatory disfunction and transferral difficulties in particular. Functional limitations become prominent according to the severity of the disease (8,9).

Treatment of knee OA aims to control pain, preserve and increase range of joint motion and muscle strength, and gain independence in daily (living) activities ADL. Resting, walking with stick or cane, cold application and TENS can be used in acute phase. Analgesics and NSAID's can also be administered. In chronic phase, superficial and deep heating can be applied to decrease pain and muscle spasm, in addition to medication. Isometric exercises can be used for preserving muscle strength in acute phase. Isometric, isotonic and isokinetic exercises are used to increase muscle strength and endurance. Exercises increase the compliance with therapy and decrease pain and spasm and can be used in combination with physical therapy agents (14-17).

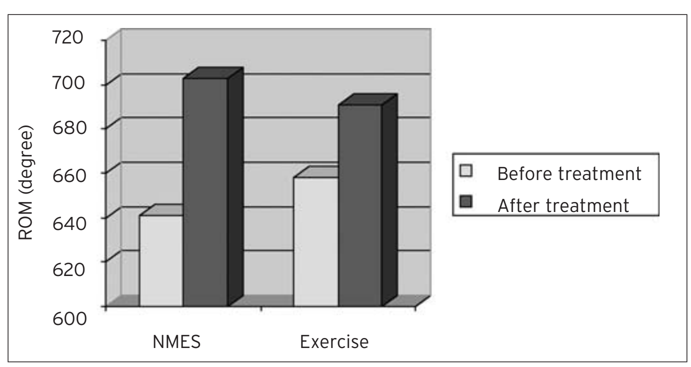

Figure 4. Change in rectus femoris diameter in two groups.

Electrical stimulation is used for both diagnosis and therapy in clinical practice. Its analgesic and muscle contracting effects are clinically important. It is preferred for pain control and muscle education with these specifications. Also, NMES is used for muscle strengthening in atrophies relating to immobilisation and inactivity (18-23).

Quadriceps muscle strengthening and inhibition of atrophy are important in knee OA therapy (17). In several studies, it was shown that weakness in affected leg up to 40 % is correlated with radiological findings (24). Quadriceps muscle atrophy and weakness are important factors that restrict the efficacy of the treatment (25). It has been reported that OA risk was decreased by 20 % to 30 % with quadriceps strengthening (4).

Quittan et al. (20) showed that knee extensor muscle strength was increased with NMES in patients with chronic heart disease and no respiratory distress occured. In the study of Neder et al. (21) similar results were obtained with NMES in patients with chronic obstructive pulmonary disease. Muscle strength, endurance and exercise tolerance were increased while respiratory distresses were decreased. Man et al. (22) showed that NMES increased the venous return and lymphatic drainage and decreased the venous stasis in patients with musculo-venous pumping deficiency in lower extremities.

In physiological studies, it has been shown that muscle strengthening stimulation pattern is closely associated with muscle tension (26). We applied both NMES and isometric exercises on knees fixed at 60 degrees of flexion. Thus, similarity was obtained between the two different types of treatment methods. Isometric exercises increase muscle strength depending on the angle of the joint. This increase in quadriceps muscle strength is maximum at knees flexed at 30-60 degrees. Also, in the activities like rapid walking and running which need more than 30 degree of knee flexion; compressive effect of patella on femur is increased (17). We aimed to facilitate the ADL in our patients with strengthening exercises above 60 degrees of flexion. Pain was significantly decreased with treatment in both groups but there was no difference between the groups. A 35 % decrease in knee pain with quadriceps exercises in Fisher et al.'s study (27) and 22.5 % decrease in another study has been shown (28). It was also reported that pain was decreased with coordination, balance, strenghtening and stretching exercices in one year (29). In our study, the decrease of pain was found to be 36.6 % in the NMES group and 40.1 % in the exercise group. These results were in accordance with literature.

Active knee flexion was increased significantly with treatment in both groups. ROM was increased after treatment in exercise group while there was no difference before treatment. This difference might have arisen from the ADL according to Lequesne Index of patients. However, the difference between two groups was below 3 %. In our opinion superficial heat and medical treatment (paracetamol) used in both groups may have additive effects on pain control. Medications, physical therapy and quadriceps muscle exercises seemed to be useful to be applied in combination in the treatment of knee OA.

We found no difference between the two groups in thigh circumference measured before and after treatment. Thigh circumferences were increased with treatment and differences were significant in both groups. No significant difference was found between the groups. The mean increase was 0.5 cm (1 %) for both groups. Similar increase in thigh circumference was reported with NMES and exercise in Sahin et al.'s study (10).

There was no difference between the two groups in rectus femoris muscle diameter measurements before and after treatment. But, significant increase was found in both groups after treatment compared to previous values. The increase was significantly higher in the NMES group in comparison with the exercise group.

Laughman et al. (26), have found in healthy adults that the quadriceps muscle strength was increased 18 % in exercise group and 22 % in NMES group. In another study, it was reported that NMES had a strengthening effect on the quadriceps muscle without any flare-ups in knee pain (30). Primary knee OA is a common disease in the elderly. Deep sensation in the lower extremities and balance may be affected in these patients. We applied exercise treatment under the supervision of a physiotherapist. But, patients might not be able to perform maximal isometric contractions due to decreased proprioception and old age. The difference in the NMES group might depend on these factors. Mohr has shown that electrical stimulation can induce more contraction (10-30 %) than exercises in both healthy and weakened muscles (31).

We assessed the changes in the functional capacity and ADL by using activity time, WOMAC and Lequesne indices. In both groups, activity time was shortened with treatment and WOMAC and Lequesne indices were significantly improved. No significant difference was found between the two groups. Pain intensity was found to be positively correlated with Lequesne and WOMAC indices in a study investigating the association between clinical findings and health quality in patients with knee OA (32).

As a result, it could be suggested that, NMES was found to be as effective as isometric exercises in quadriceps strengthening, improving knee OA symptoms and quality of life. Thus, NMES could be used in addition to isometric exercises and alone in patients with cardiovascular disease, motivation and concentration difficulties.

References

1. Altman RD, Lozada CJ. Clinical features. In: Rheumatology. 3rd Ed. Vol. 2. Eds: Hochberg, Silman AJ, Smolen JS, Weinblatt ME, Weismann MH: Mosby, 2003, pp. 1793-800.
2. ACR subcommittee: Recommendations for the medical management of osteoarthritis of the hip and knee. 2000 update, Arthritis Rheum 2000;43: 1905-15.
3. Dennison E, Cooper C. Osteoarthritis: Epidemiology and classification. In: Rheumatology. 3rd Ed. Vol. 2. Eds: Hochberg MC, Silman AJ, Smolen JS, Weinblatt ME, Weismann MH: Mosby, 2003, pp. 1781-91.
4. Nuki G. Role of mechanical factors in the etiology, pathogenesis and progression of osteoarthritis. Reginster YJ, Pelletier PJ, Pelletier JM, Henrotin Y, Eds. Osteoarthritis. Springer Verlag, Berlin Heidelberg 1999, pp. 101-14.
5. Manek NJ, Hart D, Spector TD, MacGregor AJ. The association of body mass index and osteoarthritis of the knee joint: an examination of genetic and environmental influences. Arthritis Rheum 2003;48:1024-9.
6. Focht BC, Ewing V, Gauvin L, Rejeski WJ. The unique and transient impact of acute exercise on pain perception in older, overweight, or obese adults with knee osteoarthritis. Ann Behav Med 2002;24:201-10.
7. Jadelis K, Miller ME, Ettinger WH Jr, Messier SP. Strength, balance, and the modifying effects of obesity and knee pain: results from the Observational Arthritis Study in Seniors (oasis). J Am Geriatr Soc 2001;49:884-91.

8. Wolheim FA. Pathogenesis of osteoarthritis. In: Rheumatology. 3rd Ed. Vol. 2. Eds: Hochberg MC, Silman AJ, Smolen JS, Weinblatt ME, Weismann MH: Mosby, 2003, pp. 1801-15.
9. Moskowitz RW. Clinical and laboratory findings in osteoarthritis. In: Artritis and allied conditions. McCarty DJ, Koopman WJ, Eds. Lea Febiger, Philadelphia, 1993, pp. 1735-60.
10. Şahin Ü, Karamehmetoğlu ŞS, Akgün K, Kayserilioğlu A, ve ark.: Comparison of neuromuscular electrical stimulation and isometric exercise in muscle strenghtening. Turk J Phys Med Rehab 1997;21:4:161-7.
11. Hart DJ, Spector TD. Radiographic criteria for epidemiologic studies of osteoartritis. J Rheumatol 1995;22:46-8.
12. Altman R, Alarcon G, Appelrouth D, Bloch D, Borenstein D, Brandt K, et al. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. Arthritis Rheum 1991;34:505-14.
13. Kellgren JH, Lawrence JS. Radiological Assessment of Osteoarthritis. Ann Rheum Dis 1957;16:494-501.
14. Lequesne MG: The algofunctional indices for hip and knee osteoarthritis. The Journal of Rheumatology, 1997:24:779-81.
15. Barr S, Bellamy N, Buchanan WW, Chalmers A, et al. A comparative study of signal versus aggregate methods of outcome measurement based on the WOMAC Osteoarthritis Index, Western Ontario and Mc Master Universities Osteoarthritis Index. J Rheumatol 1994;21:2106-12.
16. Brandt KD. The importance of non-pharmacologic approaches in management of osteoarthritis. Am J Med 1998;105:39-44.
17. Dieppe P. Management of osteoarthritis of the hip and knee joints. Curr Opin Rheumatol 1993;5:487-93.
18. Hainaut K, Duchateau J. Neuromuscular electrical stimulation and voluntary exercise. Sports Med 1992;14:100-13.
19. Ferrari de Castro MC, Cliquet A. Artificial sensorimotor integration in spinal cord injured subjects through neuromuscular and electrotactile stimulation. Artificial Organs 2000;24:710-7.
20. Quittan M, Sochor A, Wiesinger GF, Sturm B, et al. Strength improvement of knee extensor muscles in patients with chronic hearth failure by neuromuscular electrical stimulation. Artificial Organs 1999;23:432-5.
21. Neder JA, Sword D, Ward SA, Mackay E, Cochrane LM, Clark CJ. Home based neuromuscular electrical stimulation as a new rehabilitative strategy for severely disabled patients with chronic obstructive pulmonary disease (COPD). Thorax 2002;57:333-7.
22. W Man IO, Lepar GS, Morrissey MC, Cywinski JK. Effect of Neuromuscular Electrical Stimulation on Foot/Ankle Volume during Standing. Med Sci Sports Exerc 2003;35:630-4.
23. Lieber RL, Kelly MJ. Factors influencing quadriceps femoris muscle torque using transcutaneous neuromuscular electrical stimulation. Physical Ther 1991;71:715-21.
24. Hazneci B, Göktepe AS, Alaca R, Balaban B, Kalyon TA. Effects of on exercise program combined with physical therapy on pain and functional parameters in patients with gonarthrosis. Turk J Phys Med Rehab 2000;3:30-4.
25. Van Baar ME, Assendelft WJJ, Dekker J, Oostendorp RAB, et al. Effectiveness of exercise therapy in patients with osteoarthritis of the hip and knee, a systematic review of randomized clinical trials Arthritis Rheum 1999:42:361-9.
26. Laughman RK, Youdas JW, Garrett TR, Chao EYS. Strength changes in the normal quadriceps femoris muscle as a result of electrical stimulation. Physical Ther 1983;63:494-9.
27. Fisher NM, Pendergast DR, Gresham GE, Calkins E. Muscle rehabilitation ; its effect on muscular and functional performance of patients with knee osteoarthritis. ARC Phys Med Rehab, 1991;72:367-74
28. O'Relly SC, Muir KR, Doherty M. Effectiveness of home exercise on pain and disability from osteoarthritis of knee: a randomized controlled trial. Ann Rheum Dis , 1999;58:15-9.
29. Rogind H, Bibow NB, Jensen B, Moller HJ, Moller HF, Henning B. The effects of a physical training program on patients with osteoarthritis of the knees. Arch Phys Med Rehabil, 1998; 79:1421-27.
30. Talbot LA, Gaines JM, Ling SM, Metter EJ. A home-based protocol of electrical muscle stimulation for quadriceps muscle strength in older adults with osteoarthritis of the knee. J Rheumatol 2003;30:1571-8.
31. Mohr T, Carlson B, Sulentic C, Landry R. Comparison of isometric exercise and high volt galvanic stimulation on questionnairesi femoris muscle strength. Physical Ther 1985;65: 606-9.
32. Hepgüler S, Şahin Y, Barış M, Akşit R. Relationship between clinical findings and various quality of life questionnaires in patients with osteoarthritis of the knee. Turk J Phys Med Rehab 1998;4:49-54.