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Original Article / Özgün Araştırma

The effectiveness of galvanic electrotherapy and a conservative hand exercise program in a rheumatoid hand: a randomized controlled trial

Romatizmal elde galvani elektroterapisinin ve konservatif el egzersiz programının etkinliği: Randomize kontrollü çalışma

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ABSTRACT

Objectives: This study aims to evaluate whether the galvanic electrotherapy can relieve rheumatic hand pain and whether conservative hand exercises increase the hand strength.

Patients and methods: Between March 2012 and November 2012, 30 female patients with rheumatoid arthritis (mean age 54.0±11.2 years; range 50 to 75 years) who were followed in our outpatient clinic were randomized into two groups. The study group (n=16) was administered the galvanic electrotherapy combined with a conservative exercise program. The patients in the control group (n=14) were administered the conservative exercise program alone. The pain level of the hand was evaluated using the Visual Analog Scale (VAS). Hand grip and pinch strength were measured by dynamometry. The level of disability was examined using the Health Assessment Questionnaire (HAQ). The functional disability of the hand was assessed using the Duruöz Hand Index (DHI). All measurements were performed on both hands before and immediately and at five weeks after therapy.

Results: The VAS scores did not significantly differ between the groups. In the study group, a significant increase was noted in the grip strength of the right and left hand between the first and second measurement (p=0.011 and p=0.025). In the control group, there was no significant difference between the measurements in terms of the grip strength of the right hand. In the study group, significant differences in the HAQ scores were recorded between first and subsequent measurements (p=0.001 and p=0.007).

Conclusion: Our study results show that the galvanic electrotherapy and conservative hand exercises are effective in the treatment of rheumatic hands.

Keywords: Hand exercise; galvanic electrotherapy; rheumatic hand.

ÖZ

Amaç: Bu çalışmada galvani elektroterapisinin romatizmal el ağrısını azaltıp azaltmadığı ve konservatif el egzersizlerinin el gücünde artış sağlayıp sağlamadığı değerlendirildi.

Hastalar ve yöntemler: Mart 2012 - Kasım 2012 tarihleri arasında polikliniğimizde takip edilen romatoid artritli 30 kadın hasta (ort. yaş 54.0±11.2 yıl; dağılım 50-75 yıl) rastgele iki gruba ayrıldı. Çalışma grubuna (n=16) konservatif el egzersizi programına ek olarak galvani elektroterapisi uygulandı. Kontrol grubundaki hastalara (n=14) ise, yalnızca konservatif el egzersiz programı uygulandı. Elin ağrı düzeyi Görsel Analog Ölçeği (GAÖ) ile değerlendirildi. El kavrama ve çimdik gücü, dinamometre ile ölçüldü. Özürlülük düzeyi, Sağlık Değerlendirme Anketi (SDA) ile incelendi. Elin fonksiyonel özürlülüğü, Duruöz El İndeksi (DEİ) ile değerlendirildi. Bütün ölçümler her iki el için tedavi öncesi, tedaviden hemen sonra ve beşinci haftada yapıldı.

Bulgular: Gruplar arasında GAÖ skoru anlamlı düzeyde farklı değildi. Çalışma grubunda, birinci ve ikinci ölçümler arasında sağ ve sol elin kavrama gücünde anlamlı artış saptandı (p=0.011 ve p=0.025). Kontrol grubunda sağ elin kavrama gücü açısından ölçümler arasında anlamlı bir fark yoktu. Çalışma grubunda, SDA skorlarında ilk ve müteakip ölçümler arasında anlamlı farklılıklar kaydedildi (p=0.001 ve p=0.007).

Sonuç: Çalışma bulgularımız, galvani elektroterapisi ve konservatif el egzersizlerinin romatizmal ellerin tedavisinde etkili olduğunu göstermektedir.

Anahtar sözcükler: El egzersizi; galvani elektroterapi; romatizmal el.

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Rheumatoid arthritis (RA) is a chronic disease that can lead to loss of joint range of motion (ROM) in the joints of the hands and wrists, decreased muscle strength, joint damage, and deformity. The hands are symmetrically affected in the first two years of the disease, which is considered the early phase.[1] Disease progression leads to the loss of hand function, decreased joint ROM, and decreased grip strength caused by the decrease in muscle strength.[2] The main focus of therapy is to prevent joint deformity, maintain joint functions, control inflammation and provide pain relief.[3]

In the management of RA, electrotherapy and hand exercises appear as additional therapy options where non-steroidal anti-inflammatory drugs (NSAIDs), disease modifying anti-rheumatic drugs (DMARDs), and biological agents are insufficient.[4,5] In clinical practice, the effectiveness of electrotherapy is limited in the management of RA. Although there are studies in the literature that utilized transcutaneous electrical nerve stimulation (TENS) to relieve joint pain in RA, no studies were found that employed galvanic electrotherapy.[6-8]

Some studies of RA report an improvement in hand grip and joint stiffness with hand exercises,[3,4,9] whereas other studies do not show the efficacy of hand exercises.[10] It is generally accepted that resting in the acute phase and hand exercises in the chronic phase improve grip strength and the extension capacity of the wrists and fingers leading to better hand function.[11]

The aim of this study was to improve joint ROM, hand grip strength, and dexterity with hand exercises, and to provide pain relief with galvanic electrotherapy. This study aimed to evaluate and compare the effectiveness of electrotherapy and conservative hand exercises program (CEP).

PATIENTS AND METHODS

Patients who had been diagnosed with RA according to the criteria of the American Rheumatism Association (ACR) and who attended outpatient clinics for follow-up visits between March 2012 and November 2012 were included in the study.[12] The present study was designed as a prospective randomized controlled study. The study was approved by the Ethics Committee of the Hospital with assessment number 01/02 dated 27.02.2012. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

A total of 33 female patients, who had chronic RA, a moderate Disease Activity Score 28 (DAS28: 3.2-5.1), disease duration of at least one year, right hand dominance, and who had been on the same medical therapy for the last six months, were assigned to two groups. The patients were randomly allocated by restricted randomization, and a table of random numbers was prepared by the first author in the beginning. One patient in the study group did not tolerate the therapy due to increased pain in the first session of electrotherapy. Two patients in the control group did not return for second visit. These patients were excluded. The study was completed with 30 patients (mean age 54.0±11.2 years; range 50 to 75 years) (Figure 1).

Patient data including disease duration, DMARDs and NSAIDs used, rheumatoid factor (RF), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) was recorded.

Clinical evaluation

During the physical examination, the joints of the hands were evaluated for tenderness (TJ), swelling (SJ) and for the presence of hand deformities. The pain level of the patients was evaluated using 0-100 mm visual analog scale (VAS), and a patient global assessment (PGA) questionnaire was administered. The disease activity was determined with DAS28. The level of disability was investigated using the Health Assessment Questionnaire (HAQ).[13] The functional disability of the hand was evaluated using the Duruöz Hand Index (DHI), which was developed by Duruöz et al.[14] in 1996, and consists of 18 questions related to hand and wrist function. The answers are scored on a scale from 0-90.

Joint mobility was measured as: *(i)* flexion deficit of digits 2-5 as the distance in millimeters from palmar crease to the distal point of digits; *(ii)* extension deficits

Figure 1. Galvanic current treatment.

of digits 2-5 as the distance in millimeters from the distal point of the nail bed of the extended fingers to a table where the patients rested their hand in a supinated position; *(iii)* opposition deficit of digit 1 as the distance between the tip of the thumb and the base of digit 5; and *(iv)* wrist mobility as palmar and dorsal flexion of the wrist measured with a goniometer.[15]

Grip strength (GS) was measured using a Jamar dynamometer (Fabrication Enterprises Inc., Irvington, NY, USA). Pinch strength (PS) (tip-to-lateral) was measured using a Baseline hydraulic pinch gauge (Fabrication Enterprises, Inc., Elmsford, NY, USA).[16] Grip strength was measured while the patient was seated with the elbow flexed at a 90° angle. The palm was turned inward toward the body, and the total inner hand surface grasped the dynamometer handle. Lateral pinch strength measurements were performed with the palm facing medially while force was exerted between the pad of the thumb and the opposing lateral side of the middle phalanx of the index finger through the opposing surfaces. Grip strength and PS measurements were repeated three times in each session, and the average of the three measurements was recorded in kilograms.

Dexterity was evaluated using the Nine Hole Peg Test (NHPT). Patients were asked to take nine pegs from a container, and place them in the holes, as quickly as possible, and then remove the pegs from the holes, and place them back in the container. A trial was performed for each hand before the test was performed, and a stopwatch was used to measure time. Dexterity was considered when the test time was above 20 seconds.[17]

The assessments and measurements (M) of the patients were arranged as if each patient had been evaluated by a single author. A total of 30 patients were evaluated by three authors. Each measurement was repeated three times for each hand at baseline (M1), at the end of two weeks when the therapy was completed (M2), and during the control visit at five weeks (M3).

Interventions

In the study group (n=17), a 1.5 mA galvanic electrotherapy (Electra, Chirana Progress) was applied to both hands in a water tank for 20 minutes a day for a duration of 10 days in the physical therapy clinic (Electra, Chirana Progress) (Figure 1). In addition, the patients were administered CEP twice a day for a duration of 10 days and each exercise was repeated three times[18] (Appendix). The control group only performed CEP at home.

Statistical analysis

The analysis of the data was performed using PASW for Windows version 17.0 software package (SPSS Inc., Chicago, IL, USA). The continuous variables were evaluated using the Shapiro-Wilk test to determine whether or not they exhibited normal distribution. In the descriptive statistics, the data was expressed as mean ± standard deviation for continuous variables, and as frequencies and percentages (%) for nominal variables using the chi-square test. Statistically significant differences in repeated measurements within the groups were evaluated using the Friedman test and Wilcoxon signed rank test. The Bonferroni correction was used to control possible type I errors in intra-group comparisons ($p<0.05$). Statistically significant differences between the groups in terms of normal undistorted continuous variables were analyzed with the Mann-Whitney U test. On the other hand, the significance of difference for nominal variables was analyzed using Fisher's exact test. Values of $p<0.05$ were considered statistically significant.

RESULTS

Demographic and clinical features of the groups and the medications administered are shown in Table 1. The mean disease duration was 11.31±8.32 years in the study group, and 12.35±6.24 years in the control group; the mean DAS28 score was 3.94±0.87 in the study group and 3.65±0.79 in the control group. There were no differences between the groups in terms of the clinical features and the measurements at baseline. The number of NSAIDs used in the control group was significantly higher ($p=0.017$), and pain score was significantly lower ($p=0.005$).

Hand deformities, flexion, extension, opposition deficit measurements of the hands, and ROM measurements are shown in Table 2. There was no statistically significant difference between the two groups ($p>0.05$).

In the comparison of measurements before and after therapy and control measurements in the study group, changes in the number of TJ were significantly different between M1 and M2 and M3 ($p=0.007$, $p=0.009$, respectively), and there was no significant difference between M2 and M3 ($p=0.414$). In terms of SJ, only the difference between M1 and M3 was significant ($p=0.029$). In terms of HGD, there was a significant difference between M1 and M2 ($p=0.004$), but M2 and M3 were equal ($p=0.996$). In terms of VAS, the differences between M1 and the other M were

Table 1. Distribution and comparison of demographic data, disease, and functional characteristics of patients according to group

	Study group (n=16)				Control group (n=14)				
	n	%	Median	Min.-Max.	n	%	Median	Min.-Max.	*p*
Age (years)			55.00	50.00-75.00			51.5	51.00-68.00	0.560
Disease duration (years)			11.00	1.00-25.00			11.00	5.00-30.00	0.677
NSAIDs	8	50			13	92.9			**0.017**
Methotrexate	6	37.5			6	42.9			1.000
Sulfasalazine	6	37.5			8	57.1			0.464
Leflunomide	5	31.3			4	28.6			1.000
Hydroxychloroquine	10	62.5			5	35.7			0.272
Colchicine	0	0			1	7.1			0.467
Disease Activity Score 28			4.10	2.10-5.60			3.53	2.38-5.20	0.244
Hand pain (VAS=0-100 mm)			50.00	0.00-70.00			22.50	0.00-90.00	**0.005**
Health assessment questionnaire			1.50	0.12-2.30			1.05	0.15-2.50	0.559
Duruöz hand index			17.50	2.00-62.00			17.50	0.00-57.00	0.739

Min.: Minimum; Max.: Maximum; NSAIDs: Non-steroidal anti-inflammatory drugs; VAS: Visual analog scale.

significant (p=0.001, p=0.013, respectively), but there was no significant difference between M2 and M3 (p=0.157). In terms of HAQ, the differences between M1 and other measurements were significant (p=0.001, p=0.007, respectively), but there was no significant difference between M2 and M3 (p=0.763).

In terms of DHI, the differences between M1 and the other measurements were significant (p=0.006, p=0.001, respectively), but there was no significant difference between M2 and M3 (p=0.366).

A significant increase was found in the right hand GS between M1 and M2 (p=0.011). There was a

Table 2. Distribution and comparison of hand deformities, range of motion, grip strength, hand dexterity and hand functional status of patients according to group at baseline

	Study group (n=16)				Control group (n=14)				
	n	%	Median	Min.-Max.	n	%	Median	Min.-Max.	*p*
Patients with hand deformity									
Swan neck deformity (RH)	2	12.5			0	0			0.233
Swan neck deformity (LH)	2	12.5			0	0			0.233
Ulnar deviation (RH)	2	12.5			1	7.1			0.507
Ulnar deviation (LH)	2	12.5			1	7.1			0.507
Boutonniere deformity (RH)	4	25.0			3	21.4			0.584
Boutonniere deformity (LH)	3	18.8			1	7.1			0.384
Z deformity (RH)	3	18.8			2	14.3			0.538
Z deformity (LH)	3	18.8			2	14.3			0.538
Interosseous atrophy (RH)	4	25.0			3	21.4			0.584
Interosseous atrophy (LH)	3	18.8			3	21.4			0.532
Deficit (cm)									
Flexion (RH)			0.65	0.0-23.50			1.00	0.00-3.00	0.768
Flexion (LH)			0.50	0.0-2.60			0.50	0.00-2.50	0.579
Extension (RH)			0.00	0.0-3.00			0.00	0.00-3.00	0.470
Extension (LH)			0.00	0.0-3.00			0.00	0.00-3.00	0.557
Opposition (RH)			0.00	0.0-1.70			0.00	0.00-0.00	0.094
Opposition (LH)			0.00	0.0-1.70			0.00	0.00-0.00	0.094
Range of motion									
Wrist palmar flexion (degree) (RH)			50.00	10.00-70.00			50.00	32.00-80.00	0.967
Wrist palmar flexion (LH)			52.50	20.00-80.00			55.00	21.00-90.00	0.530
Wrist dorsal flexion (RH)			45.00	30.00-65.00			42.50	27.00-70.00	0.882
Wrist dorsal flexion (LH)			40.00	25.00-80.00			42.50	20.00-80.00	0.631
Grip strength (kg) (RH)			17.00	10.20-25.83			18.00	5.10-23.60	0.950
Grip strength (kg) (LH)			14.83	3.33-23.33			16.49	4.60-25.00	0.603
Pinch strength (kg) (RH)			5.41	2.33-9.16			5.83	2.50-8.16	0.723
Pinch strength (kg) (LH)			4.73	2.16-8.33			5.30	2.20-7.83	0.429
Nine hole peg test (second) (RH)			23.27	18.00-28.63			22.63	17.59-28.30	0.145
Nine hole peg test (LH)			24.45	17.64-32.80			22.43	18.85-25.83	0.058

Min.: Minimum; Max.: Maximum; RH: Right hand; LH: Left hand; p<0.05 statistically significant.

significant increase in the left hand GS between M1 and M2 (p=0.003). A significant increase was found in the right hand PS between M1 and M2 (p=0.025). A significant increase was found in the left hand PS between M1 and M3 (p=0.043).

In terms of NHPT in the right hand, only the difference between M1 and M2 was significant (p=0.016). In terms of NHPT in the left hand, the differences between M1 and other measurements were significant (p=0.001, p=0.005, respectively), but there was no significant difference between M2 and M3 (p=0.796).

There was no significant difference between M1, M2 and M3, as well as between M2 and M3 in terms of right hand flexion deficit. In terms of flexion deficit in the left hand, the differences between M1 and other measurements were significant (p=0.001, p=0.021, respectively), but there was no significant difference between M2 and M3 (p=0.414). In terms of extension deficit in the right hand, the differences between M1 and other measurements were significant (p=0.045, p=0.034, respectively), but there was no significant difference between M2 and M3 (p=0.317). There was no significant difference between all measurements in terms of extension deficit in the left hand. There was no significant difference between all measurements in terms of opposition deficit in both hands. In the goniometric evaluation of the wrist dorsal flexion (WDF) and palmar flexion (WPF), no significant difference was observed between the three measurements (Table 3).

In the comparison of measurements before and after therapy and control measurements at five weeks in the control group, there was no significant difference in terms of changes in the number of TJ and SJ. In terms of HGD, there was a significant difference between M1 and M2 (p=0.009), but there was no significant difference between M2 and M3. In terms of VAS score, the difference between M1 and M2 was significant (p=0.047), but there was no significant difference between M2 and M3. In terms of HAQ, the differences between M1 and other measurements were significant (p=0.002, p=0.004, respectively), but there was no significant difference between M2 and M3 (p=0.705). In terms of DHI, the differences between M1 and other measurements were significant (p=0.002, p=0.009, respectively), but there was no significant difference between M2 and M3 (p=1.000).

Table 3. Comparison of results from baseline (M1) and after therapy (M2) and control (M3) in the study groups

	Measurement 1		Measurement 2		Measurement 3	
	Median	Min.-Max.	Median	Min.-Max.	Median	Min.-Max.
Tender joint (n)	4.00	0.00-9.00‡¶	0.0	0.00-9.00	1.50	0.00-9.00
Swollen joint (n)	1.00	0.00-4.00¶	0.0	0.00-7.00	0.0	0.00-3.00
Patient global assessment (VAS=0-100 mm)	50.00	0.00-75.00‡	35.00	0.00-60.00	30.00	0.00-70.00
Hand of pain (VAS=0-100 mm)	50.00	0.00-70.00‡¶	35.00	0.00-70.00	30.00	0.00-70.00
Health assessment questionnaire	1.50	0.12-2.30‡¶	1.10	0.00-2.30)	1.00	0.00-2.10
Duruöz hand index	17.50	2.00-62.00‡¶	7.00	0.00-49.00	8.50	0.00-54.00
Deficit (cm)						
Flexion (RH)	0.65	0.00-23.50	0.50	0.00-2.70	0.40	0.00-2.10
Flexion (LH)	0.50	0.00-2.60‡¶	0.27	0.00-2.30	0.27	0.00-2.00
Extension (RH)	0.00	0.00-3.00‡¶	0.0	0.00-1.00	0.0	0.00-1.00
Extension (LH)	0.00	0.00-3.00	0.0	0.00-1.50	0.0	0.00-1.50
Opposition (RH)	0.00	0.00-1.70	0.0	0.00-1.00	0.0	0.00-0.30
Opposition (LH)	0.00	0.00-1.70	0.0	0.00-0.50	0.0	0.00-0.50
Range of motion (degree)						
Wrist palmar flexion (RH)	50.00	10.00-70.00	65.00	10.00-90.00	70.00	10.00-80.00
Wrist palmar flexion (LH)	52.50	20.00-80.00	70.00	30.00-85.00	70.00	30.00-85.00
Wrist dorsal flexion (RH)	45.00	30.00-65.00	55.00	30.00-85.00	57.50	30.00-70.00
Wrist dorsal flexion (LH)	40.00	25.00-80.00	55.00	30.00-80.00	55.00	30.00-80.00
Grip strength (kg) (RH)	17.00	10.20-25.83‡	19.15	10.30-26.00	18.33	11.00-27.00
Grip strength (LH)	14.83	3.33-23.33‡	16.30	10.30-26.00	17.83	8.50-23.33
Pinch strength (RH)	5.41	2.33-9.16‡	6.58	3.80-9.60	6.00	4.00-8.50
Pinch strength (LH)	4.73	2.16-8.33¶	6.00	3.00-8.50	5.63	3.00-8.10
Nine hole peg test (second) (RH)	23.27	18.00-23.63	21.30	2.00-25.50	21.90	16.00-27.00
Nine hole peg test (LH)	24.45	17.64-32.80‡¶	21.14	18.00-25.50	22.76	17.00-28.00

Min.: Minimum; Max.: Maximum; VAS: Visual analog scale, RH: Right hand; LH: Left hand; ‡ There is a statistically significant difference between Measurement 1 and Measurements 3 (p<0.05); ¶ There is statistically significant difference between Measurement 1 and Measurements 2 (p<0.005).

There was no significant difference between the measurements in term of GS in the right hand. In terms of GS in the left hand, only the difference between M1 and M3 was significant (p=0.003).

In terms of PS in the right hand, the differences between M1 and other measurements were significant (p=0.008, p=0.004, respectively), but there was no significant difference between M2 and M3 (p=0.593). There was no significant difference between the measurements in terms of PS in the left hand.

In terms of NHPT in the right hand, the differences between M1 and other measurements were significant (p=0.039, p=0.040, respectively), but there was no significant difference between M2 and M3 (p=0.405). In terms of NHPT in the left hand, only the difference between M1 and M3 was significant (p=0.044).

In terms of flexion deficit in the right hand, the differences between M1 and other measurements were significant (p=0.029, p=0.036, respectively), but there was no significant difference between M2 and M3 (p=0.564). In terms of flexion deficit in the left hand, the difference between M1 and M3 was significant (p=0.027).

There were no significant differences between the measurements in terms of extension and opposition deficits in both hand, as well as WDF and WPF (Table 4).

In comparison of the differences between the groups, no significant differences were observed between M1, M2 and M3, and M2 and M3 in terms of TJ, SJ, PGA, VAS, HAQ, DHI, GS, and PS (Table 5). Figure 1 shows VAS, DHI, GS, PS, and NHPT values of the groups in measurements 1, 2, and 3 (Figure 2).

DISCUSSION

In the present study, we performed galvanic therapy and CEP on patients with rheumatoid hands. The results of the study indicated that both galvanic electrotherapy and CEP are effective in providing pain relief in rheumatoid hands, improving the strength and dexterity of the hands and reducing hand stiffness. In the galvanic electrotherapy group, the number of TJ decreased and a significant decrease in VAS score was noted after the therapy. The number of TJ and VAS scores in the control group did not show any decrease. However, it should not be overlooked that the number of NSAIDs used at baseline was higher, and the VAS score was lower in the control group. Improvements were noted in the flexion of the left

Table 4. Comparison of results from baseline (M1) and after therapy (M2) and control (M3) in the control group

	Measurement 1		Measurement 2		Measurement 3	
	Median	Min.-Max.	Median	Min.-Max.	Median	Min.-Max.
Tender joint (n)	1.50	0.00-9.00	0.0	0.00-8.00	0.0	0.00-8.00
Swollen joint (n)	0.50	0.00-5.00)	0.0	0.00-2.00	0.0	0.00-5.00
Patient global assessment (VAS=0-100 mm)	27.50	0.00-70.00‡	15.00	0.00-50.00	10.00	0.00-60.00
Hand of pain (VAS=0-100 mm)	22.50	0.00-90.00‡	10.00	0.00-90.00	10.00	0.00-50.00
Health assessment questionnaire	1.05	0.15-2.50‡¶	0.73	0.00-2.10	0.83	0.00-2.00
Duruöz hand index	17.50	0.00-57.00‡¶	9.50	0.00-34.00	10.00	0.00-38.00
Deficit (cm)						
Flexion (RH)	1.00	0.00-3.00‡¶	0.15	0.00-2.50	0.30	0.00-2.00
Flexion (LH)	0.50	0.00-2.50¶	0.30	0.00-1.50	0.40	0.00-1.50
Extension (RH)	0.00	0.00-3.00	0.0	0.00-2.50	0.0	0.00-3.00
Extension (LH)	0.00	0.00-3.00	0.0	0.00-2.00	0.0	0.00-1.70
Opposition (RH)	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.50
Opposition (LH)	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.50
Range of motion (degree)						
Wrist palmar flexion (RH)	50.00	32.00-80.00	62.50	32.00-90.00	60.00	38.00-90.00
Wrist palmar flexion (LH)	55.00	21.00-90.00	67.50	40.00-90.00	57.50	30.00-90.00
Wrist dorsal flexion (RH)	42.50	27.00-70.00	54.00	30.00-80.00	55.00	29.00-80.00
Wrist dorsal flexion (LH)	42.50	20.00-80.00	60.00	23.00-85.00	57.50	20.00-80.00
Grip strength (kg) (RH)	18.00	5.10-23.60	17.33	5.66-25.66	20.30	10.60-25.33
Grip strength (LH)	16.49	4.60-25.00¶	18.66	6.30-26.66	18.83	8.30-27.50
Pinch strength (RH)	5.83	2.50-8.16‡¶	6.49	4.00-8.60	6.36	4.33-8.83
Pinch strength (LH)	5.30	2.20-7.83	5.83	4.00-7.50	6.13	3.50-8.20
Nine hole peg test (second)(RH)	22.63	17.59-28.30‡¶	20.32	12.20-25.60	20.35	15.03-29.00
Nine hole peg test (LH)	22.43	18.85-25.83¶	20.02	18.22-25.40	21.21	16.02-24.12

Min.: Minimum; Max.: Maximum; VAS: Visual analog scale, RH: Right hand; LH: Left hand; ‡ There is a statistically significant difference between Measurement 1 and Measurement 3 ($p<0.05$); ¶ There is statistically significant difference between Measurement 1 and Measurement 2 ($p<0.05$).

Table 5. The comparison between the groups before and after therapy and at the control visit

	Measurement 1-Measurement 2					Measurement 1-Measurement 3					Measurement 2-Measurement 3				
	Study group		Control group			Study group		Control group			Study group		Control group		
	Median	Min.-Max.	Median	Min.-Max.	*p*	Median	Min.-Max.	Median	Min.-Max.	*p*	Median	Min.-Max.	Median	Min.-Max.	*p*
TJ (n)	1.50	-2.0-9.0	0.0	-3.0-5.0	0.140	1.00	-2.0-4.0	0.0	-3.0-5.0	0.328	0.0	-4.0-9.0	0.0	-1.0-2.0	0.569
SJ (n)	0.0	-7.0-4.0	0.0	-1.0-5.0	0.823	0.0	-7.0-4.0	0.0	-1.0-2.0	1.000	0.0	-2.0-7.0	0.0	-5.0-0.0	0.737
PGA (VAS)	5.0	-20.0-70.0	2.50	-20.0-40.0	0.966	10.0	0.0-40.0	10.0	-10.0-40.0	0.593	5.0	-20.0-70.0	0.0	-10.0-50.0	0.515
HP (VAS)	12.50	-20.0-60.0	0.0	-20.0-25.0	0.190	22.50	-10.0-50.0	0.25	-20.0-90.0	0.092	0.0	-50.0-50.0	0.0	-70.0-40.0	0.631
HAQ	0.20	-0.13-1.50	0.17	-0.0-1.30	0.601	0.30	-0.18-0.80	0.25	-0.20-0.90	0.786	0.0	-0.90-0.50	0.0	-0.70-0.40	1.00
DHI	7.0	-2.0-19.0	9.0	-16.0-26.0	0.692	4.0	-4.0-29.0	8.50	-3.0-27.0	0.588	0.0	-9.0-11.0	0.0	-10.0-13.0	0.539
Deficit (cm)															
F (RH)	0.0	0.0-2.50	0.0	-0.50-1.60	0.874	0.10	-0.20-2.50	0.0	0.0-1.60	0.982	0.0	-0.60-0.50	0.0	-1.0-0.50	0.715
F (LH)	0.0	0.0-1.50	0.0	0.0-1.00	0.906	0.22	0.0-0.60	0.0	0.0-1.00	0.204	0.0	-1.0-0.50	0.0	-1.0-0.0	0.173
E (RH)	0.0	0.0-3.00	0.0	0.0-3.10	0.487	0.0	0.0-3.00	0.0	0.0-3.20	0.620	0.0	-0.50-0.0	0.0	0.0-1.00	0.079
E (LH)	0.0	0.0-3.00	0.0	0.0-2.30	0.457	0.0	0.0-3.00	0.0	0.0-1.00	0.457	0.0	-0.50-0.0	0.0	0.0-3.00	0.163
O (RH)	0.0	0.0-1.70	0.0	0.0-0.0	0.094	0.0	0.0-1.70	0.0	-0.50-0.0	0.053	0.0	-1.0-0.0	0.0	-0.50-0.0	0.632
O (LH)	0.0	0.0-1.20	0.0	0.0-0.0	0.094	0.0	0.0-1.20	0.0	-0.50-0.0	0.053	0.0	-0.50-0.10	0.0	-0.50-0.0	0.549
ROM (degree)															
WPF (RH)	-10.0	-52.0-10.0	-10.0	-34.0-11.0	0.982	-6.50	-42.0-10.0	-6.0	-35.0-15.0	0.476	0.0	-10.0-10.0	0.0	-35.0-15.0	0.636
WPF (LH)	-10.0	-50.0-10.0	-10.0	-30.0-20.0	0.287	-10.0	-40.0-15.0	-5.0	-30.0-30.0	0.187	2.0	-15.0-20.0	2.0	-20.0-30.0	0.287
WDF (RH)	-7.50	-30.0-10.0	-6.50	-33.0-5.0	0.502	-10.0	-40.0-10.0	-6.50	-45.0-25.0	0.599	-2.50	-25.0-25.0	-2.50	-25.0-25.0	1.000
WDF (LH)	-10.0	-45.0-10.0	-11.0	-49.0-15.0	0.966	-6.0	-45.0-20.0	-7.50	-35.0-25.0	0.161	-5.0	-30.0-30.0	1.0	-20.0-45.0	0.165
GS (kg) (RH)	-0.42	-5.64-5.0	0.0	-5.90-6.34	0.307	-1.25	-6.34-1.0	-0.99	-3.66-5.0	0.371	-0.25	-4.90-4.0	-0.18	-5.94-5.0	0.532
GS (LH)	-1.0	-7.97-3.66	-1.82	-5.30-2.67	0.505	-1.33	-7.67-0.0	-0.83	-4.66-1.0	0.124	0.0	-9.00-3.0	-1.48	-3.97-5.64	0.236
PS (RH)	-0.20	-3.00-1.33	-0.58	-2.30-0.36	0.429	-0.83	7.27-0.53	-0.67	-3.40-0.66)	0.632	-0.50	-5.60-2.20	-0.24	-1.77-1.67	0.145
PS (LH)	-0.48	-4.50-1.16	-0.30	-2.16-0.83	0.917	-0.52	-5.84-1.56	-0.51	-4.50-1.16	0.917	-0.50	-4.20-1.20	-0.33	-2.04-1.60	0.708
NHPT (RH)	0.90	-1.00-5.50	1.30	-2.70-5.39	0.308	0.67	-1.76-4.76	0.88	-1.52-3.30	1.000	0.33	-1.50-2.0	0.27	-3.40-3.00	0.724
NHPT (LH)	1.30	-1.00-5.50	0.91	-1.80-4.41	0.422	2.33	-2.76-5.0	1.23	-3.60-4.13	0.803	0.15	-5.50-5.0	0.20	-2.32-2.48	0.755

Min.: Minimum; Max.: Maximum; TJ: Tender joint; SJ: Swollen joint; HP: Hand pain; PGA: Patient global assessment; HP: Hand pain; VAS: Visual analog scale; HAQ: Health assessment questionnaire; DHI: Duruoz Hand Index; RH: Right hand; LH: Left hand; F: Flexion; E: Extension; O: Opposition; ROM: Range of motion; WPF: Wrist palmar flexion; WDF: Wrist dorsal flexion; GS: Grip strength; PS: Pinch strength; NHPT: Nine hole peg test; $p<0.05$ statistically significant.

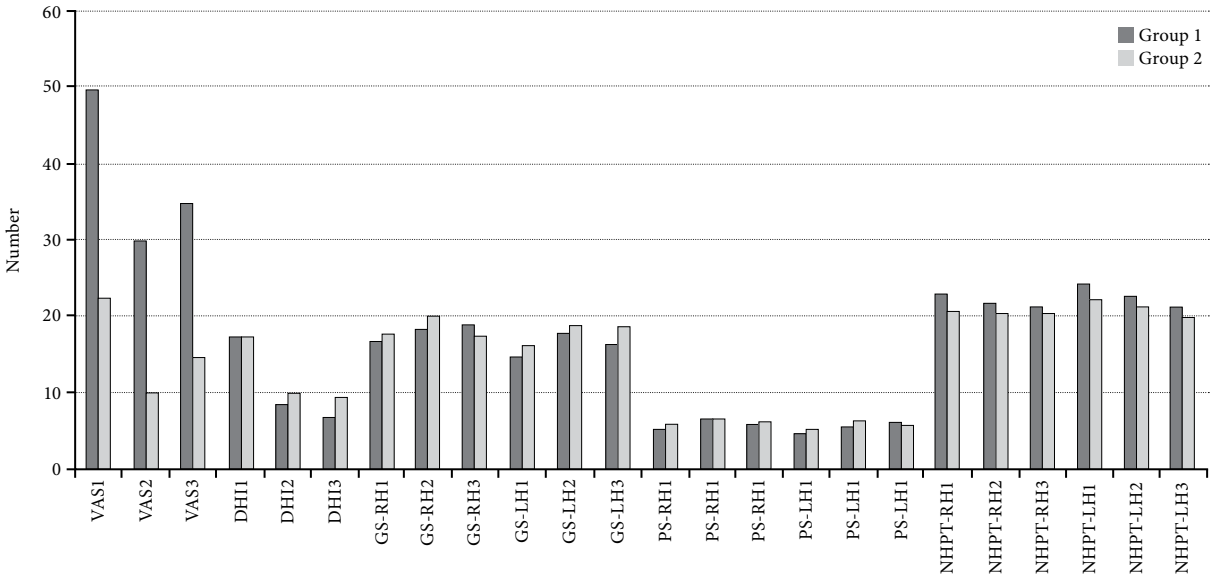

Figure 2. Overall evaluations at follow-up. VAS: Visual analog scale; GS: Grip strength; PS: Pinch strength: NHPT: Nine hole peg test; RH: Right hand; LH: Left hand.

hand in both groups, flexion of the right hand in the control group, and extension and ROM of the right hand in the control group. The exercise resulted in no change in opposition. Improvements in HAQ and DHI values were noted in both groups. Improvements in the flexion deficit of the right hand and extension deficit of the left hand were noted in the study group. In the control group, an improvement in the flexion deficit was observed in both hands. Although goniometric measurements of the ROM of the wrists showed increases in both groups, and improvements in the flexibility of the hand after the therapy, this difference did not reach statistical significance. Grip strength and PS were found to be improved, and this was more prominent in the study group. However, this effect became weaker three weeks after the completion of the 10 day therapy. The NHPT measurements showed improvement in the speed and dexterity of both hands in the control group and in the left hand in the study group.

Research indicates that women with RA have a 21% decline in grip strength compared to healthy patients, and experience restrictions in most activities. Suggested reasons include pain, decreased hand strength and grip function.[18] Exercise is recommended, although there is limited evidence for the effectiveness of hand exercises in patients with RA.[4,9,19] Evidence for an improvement in hand strength has been proposed with forced exercise for a long time.[20] Although there is no clear evidence for the control of hand deformity and joint destruction by physical agents and exercise, these modalities are used to relieve hand pain, stiffness, and weakness.[5,10,21]

Cima et al.[22] randomly assigned women with RA and hand deformity to two groups (n=13), and the study group performed exercises to strengthen the intrinsic and extrinsic muscles of the hands, and no exercise was performed by the control group (n=7). The patients in the study group performed exercises once daily and five days in a week under the supervision of a physiotherapist and performed 20 sessions of home exercises for two months. The study found marked improvements in GS, PS, and HAQ values of the study group compared to the control group. Prolonged duration of physical therapy up to 20 sessions was said to be effective.

In this study, improvements were also noted in HAQ, GS, and PS values although a 10 day exercise program was performed. The reason for the shorter treatment period is that the insurance coverage was limited to 10 days of physiotherapy. Therefore, the duration of the exercise program was reduced together with electrotherapy.

O'Brien et al.[3] randomly assigned 67 patients with RA to three groups, and experienced therapists administered a joint protection program along with strengthening and mobilizing exercises to the patients in group 1 (n=21); joint protection program and mobilizing exercises were administered to patients in group 2 (n=24); and only the joint protection program was administered to the patients in group 3 (n=22).

They performed Arthritis Impact Measurement Scales II (AIMS II; upper limb, and hand and finger function subscales), gross grip, key grip, and right index finger flexion assessments at 1, 3, and 6 months. As a consequence, they reported improvements in hand function and grip strength with strengthening and mobilizing exercises.

Brorsson et al.[11] performed a finger resistance exercise program in 20 patients with RA for 10 minutes a day, five sessions a week for a duration of 12 weeks using therapeutic putty, and compared the results with 20 patients in a control group. They evaluated finger extension force, hand function (grip ability test), and administered the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire every six weeks for the study duration of 18 weeks. At the end of the study, they reported improvement in hand function in both groups, and the DASH score showed marked improvement in the exercise group.

Rønningen et al.[18] randomly assigned 60 patients with RA to two groups; one group was administered CEP, and the other group was administered an intensive hand exercise program five times a week for a duration of 14 weeks. Grip ability test (GAT), self-estimated hand function (SEHF), and the Stanford Health Assessment Questionnaire (MHAQ) were administered to evaluate GS, PS, VAS, and joint mobility assessment at baseline, two weeks and 14 weeks. At the end of 14 weeks, the intensive hand exercise group showed significant improvements in all measurements compared to the other group.

In the study by Dogu et al.[23] one group (n=23) was administered isotonic exercises, and another group (n=24) was administered isometric exercises. The patients performed exercises for two weeks under the supervision of a physiotherapist, and hot paraffin wax was applied for 15 minutes before each exercise session. The patients continued the exercise program at home for four weeks. At the end of the six-week exercise program, improvements were noted in both groups in terms of VAS score, DHI, NHPT, and HS and exercise types were not superior to each other.

Many types of hand exercises are available for rheumatoid hands, including active-assisted and active ROM exercises, forced finger exercise, and dynamic isotonic exercises. In addition, there is no consensus regarding frequency of exercises, such as twice daily, daily, or twice weekly.[21] The researchers of this study preferred CEP due to the fact that the patients easily learned how to perform this exercise and they continued to perform the exercises at home twice daily without need for further supervision. The exercises were gentle and therefore well-tolerated by the patients, and did not cause an increase in inflammation.

Electrotherapeutic modalities are used to relieve pain and stiffness in RA. The main advantage of electrotherapy is reduced side effects compared to DMARD. In three reviews by Brosseau et al. electrical stimulation and TENS were evaluated in the management of RA.[5-7] There is only one randomized and controlled trial (RCT) of 15 cases, in which electrical stimulation was reported to provide clinical benefits to grip strength and fatigue resistance in rheumatoid hands.[7] Three RCT showed that TENS for 15 minutes a day for three weeks reduced the intensity of resting pain in 78 patients with RA. The present study performed galvanic electrotherapy for 15 minutes a day for 10 days.

Electrotherapy provides pain relief and improves muscle strength. TENS and galvanic electrotherapy have a unidirectional electric flow with 0 frequencies. A hydroelectric bath therapy can be performed in the Stanger bath or using small water tanks with electrodes placed in the water. The patient places the upper and lower extremity in the water tank and the therapy continues for 15-20 minutes. Only two cells can be used for the hands. The basic effect of a galvanic electrotherapy is the introduction of ions into tissue to produce chemical reactions. Analgesic effects are related to the stimulation of afferent nerve fibers.[24]

The limitations of the present study include the small sample size, duration of the therapy being limited to 10 days, and a lack of long-term outcomes at six months, although outcomes were also evaluated three weeks after the conclusion of therapy.

The therapy employed two galvanic cells and intragroup analyses showed reductions in pain, hand strength, and flexion and extension deficits of the hand, as well as significant improvement in dexterity. These findings suggest that practitioners should take advantage of different modalities of electrotherapy.

In conclusion, a decrease in hand pain and improvement in functionality and strength were observed, which was more prominent in the study group; however, this effect decreased after three weeks. The comparison of the two groups did not reveal a significant difference. It can be inferred that galvanic electrotherapy and conservative hand exercises are effective in the treatment of rheumatoid hands. However, we are unable to suggest the superiority of galvanic electrotherapy over hand

exercises, with the exception of better pain relief with galvanic electrotherapy. We can recommend CEP in order to improve hand strength and dexterity, and to reduce stiffness in patients with RA. Exercise and electrotherapy favorably affected hand mobility, function and strength.

Appendix

Conservative hand exercise program (CEP)

The program consisted of the following gentle exercises performed against resistance of a soft putty: ulnar deviation of the wrist (with fingers flexed), flexing the fingers into a fist, extending the fingers, touching the tip of each finger with the thumb, rolling a "ball" with palm on the table with extended fingers, radial finger walking with the four ulnar fingers moving towards the thumb, and abduction of the thumb with the IP joint flexed. Additionally, the following exercises were performed without resistance: volar and dorsal flexion of the wrist, pronation and supination of the hand and forearm, opposition of the thumb, and flexion of the IP joint of the thumb. In total, the program contained 11 different exercises. Each exercise in the program was repeated three times.[7]

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