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Investigation of the effects of upper extremity home exercises on grip strength, range of motion, activity performance, and functionality in individuals with systemic sclerosis: a randomized controlled trial

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SUMMARY

OBJECTIVE: This study aimed to investigate the effects of upper extremity home exercises on grip strength, range of motion, activity performance, and functionality in individuals with systemic sclerosis and to compare with patient education.

METHODS: A total of 46 individuals with systemic sclerosis (55.52±11.54 years) were included. Individuals were randomly assigned into intervention (n=23) and control (n=23) groups. Dynamometer, goniometer, Canadian Occupational Performance Measurement, Disabilities of the Arm, Shoulder, and Hand, Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands, and Duruoz Hand Index were used for evaluation.

RESULTS: Post-treatment, in terms of delta (Δ) values, hand grip and pinch strengths (p: 0.000-0.016), active (p: 0.000-0.032) and passive (p: 0.000-0.043) total range of motions, Canadian Occupational Performance Measurement performance and satisfaction, Disabilities of the Arm, Shoulder, Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands, and Duruoz Hand Index (p: 0.000) were in favor of the intervention group.

CONCLUSION: Upper extremity home exercises increase grip strength, range of motion, activity performance, and functionality in patients with systemic sclerosis. We recommend that rehabilitation programs include not only hand exercises but also upper extremity exercises.

KEYWORDS: Systemic sclerosis. Upper extremity. Exercises.

INTRODUCTION

Systemic sclerosis (SSc) is an autoimmune disease characterized by fibrosis, causing musculoskeletal-related disorders. Fibrosis and edema of the skin affect hand function by decreasing grip strength and range of motion (ROM). Therefore, patients with SSc have difficulties in using their upper extremities in a useful manner[1].

Exercises play a key role in the initial stages of rehabilitation of SSc. Literature has focused on hand rehabilitation. To prevent hand disorders due to SSc, hand exercises should be started in the early period and should be a part of daily life[2]. In this case, it is important to emphasize the role of home exercises to improve patients' capacity to manage the disease[1]. Stretching, mobility exercises, and isometric and isotonic strengthening exercises were used[3-5].

Moreover, hand and upper extremity is one of the areas where individuals have more problems that affect their work ability[6]. However, studies on upper extremity rehabilitation were limited. More randomized controlled studies were needed to standardize protocols[1]. In addition, previous studies did not investigate the effects of a detailed upper extremity exercise program on shoulder ROM, activity performance, and functionality in SSc. To the best of our knowledge, this was the first randomized controlled trial investigating the effects of upper extremity home exercises on shoulder ROM and activity performance in SSc. This research was conducted to investigate the effects of upper extremity home exercises on grip strength, ROM, activity performance, and functionality in individuals with SSc, to compare with patient education, and to contribute to the standardization of upper extremity exercise protocols in SSc. We hypothesized that home exercises might show more improvement than patient education in terms of grip strenghts, ROM, activity performance, and functionality in individuals with SSc.

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METHODS

Procedures and study design

The design of the study was a randomized controlled trial. Clinical Research Ethics Committee of Health Sciences University Antalya Training and Research Hospital Ethics Committee approved the study (Protocol no: 2021-085). The clinical trial registration number is NCT050080738.

Participants

Individuals diagnosed with SSc followed by a rheumatologist in the Rheumatology Outpatient Clinic of Antalya Training and Research Hospital were included in the study. Informed consent according to the Declaration of Helsinki was obtained. Individuals with SSc who were included in the study were randomized into intervention (n=28) and control (n=27) groups after initial evaluation with the statistical program according to age and gender.

The inclusion criteria were as follows: being diagnosed with SSc according to 2013 ACR/EULAR criteria[7], over 18 years old, having upper extremity/hand involvement, and agreeing to participate. Exclusion criteria were as follows: being diagnosed with an additional rheumatic or any non-rheumatic disease, having a deformity preventing exercises, presence of an active digital ulcer, being involved in another rehabilitation program, and cognitive impairment.

Outcome measures

Demographic and health-related information was recorded.

Hand grip strength and pinch strengths (i.e., lateral, triple, and fingertip) were measured with Jamar hydraulic hand dynamometer (Sammons Preston, USA) and pinch meter (Pinchmeter-Sammons Preston, USA) for both hands and were recorded in kilograms[8].

Active and passive ROMs for both upper extremities at appropriate positions were measured using a universal and finger goniometer. Total active and passive ROMs were calculated for right and left shoulders, elbow and forearm, wrist, and fingers[9].

Activity performance and satisfaction were assessed using Canadian Occupational Performance Measurement (COPM). Individuals rate their performance (COPM-P) and satisfaction (COPM-S) on a scale of 1-10. Then, the average scores are taken for each category[10]. Increasing scores of COPM indicate an individual's own perception of activity performance and more satisfaction with this performance.

Functionality was evaluated using Disabilities of the Arm, Shoulder, and Hand (DASH), Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands (SACRAH), and Duruoz Hand Index (DHI). Lower scores indicate better status.

DASH is a questionnaire evaluating disability, activity limitations, leisure time activities, and limitation of participation owing to upper extremity injury[11]. All questions are scored with a 5-point Likert system (1: no difficulty, 5: not able to do at all) (0: no disability, 100: maximum disability).

SACRAH contains 23 visual analog scales of 100 mm determining the status of individuals with rheumatic diseases of hand[12]. The average score is calculated for each category. The overall average for the three category scores is then taken. The overall score ranges from 0 to 100.

DHI is a functional assessment scale specifically for rheumatoid hand[13]. Difficulty of individuals in trying to perform activities without any assistive devices is scored with a 6-point Likert scale (0: perform without any difficulty; 5: completely impossible). The total score ranges from 0 to 90.

All assessments were made at baseline and at the end of 8 weeks.

Protocols

Intervention group: upper extremity home exercises

Individuals performed upper extremity home exercises including stretching and strengthening for 5 days a week for 8 weeks[1,3,4,14]. Exercises were performed from distal to proximal (from fingers to shoulders), first stretching (10 s×10 repetitions), and then strengthening (2 sets×10 repetitions) for each part. Individuals could take rests during exercises. Adherence was checked regularly by phone. An exercise diary and brochure were given to increase adherence.

Control group: patient education

Patient education includes information in the following areas: principles of joint protection, energy conservation techniques, pain and pain control, maintaining body function, organizing activity and rest periods, and posture[15].

Statistical analysis

The G-Power version 3.1.7 (University of Kiel, Kiel, Germany) power analysis was performed to determine sample size. Based on reference study[4] with a medium effect size (d=0.74), with a confidence interval of 95% and a power analysis of 80%, at least 46 (23 for each group) patients applied to the rheumatology outpatient clinic.

Statistical analyses were performed using the SPSS version 22 (IBM SPSS Statistics; IBM Corporation, Armonk, NY, USA) software. Kolmogorov-Smirnov test was used to evaluate normality. In-group comparisons were evaluated

with paired-samples T-test or Wilcoxon signed-rank test. Independent-samples T-test or Mann-Whitney U test was used to compare the groups. The statistical significance level was assumed as $p<0.05$.

RESULTS

A total of 46 individuals completed the study with an 83.6% response rate (Figure 1). The rate of exercise compliance was 87.1% for the intervention group. Wrist pain during the first week of exercise was reported (n=1). There was no statistically significant difference between groups in terms of demographic and health-related variables ($p>0.05$) (Table 1). Individuals mostly reported activities in the field of self-care by COPM. Most frequently reported activities were cooking (45.7%), up-down stairs (30.4%), bathing (28.3%), and dusting (28.3%), respectively.

There was no significant difference ($p>0.05$) between groups except for passive total ROM of the right fingers and COPM scores in the pre-treatment values (Table 2).

When pre-treatment and post-treatment intra-group evaluation results were examined, there was a statistically significant difference in all parameters in the intervention group except for right-hand lateral grip strength ($p<0.05$); in the control group, there was a significant difference in pinch strengths for both hands, active total ROM of left shoulder, right and left wrist and fingers, passive total ROM of left shoulder and wrist, right and left fingers, DASH, SACRAH, and DHI scores ($p<0.05$) (Table 3).

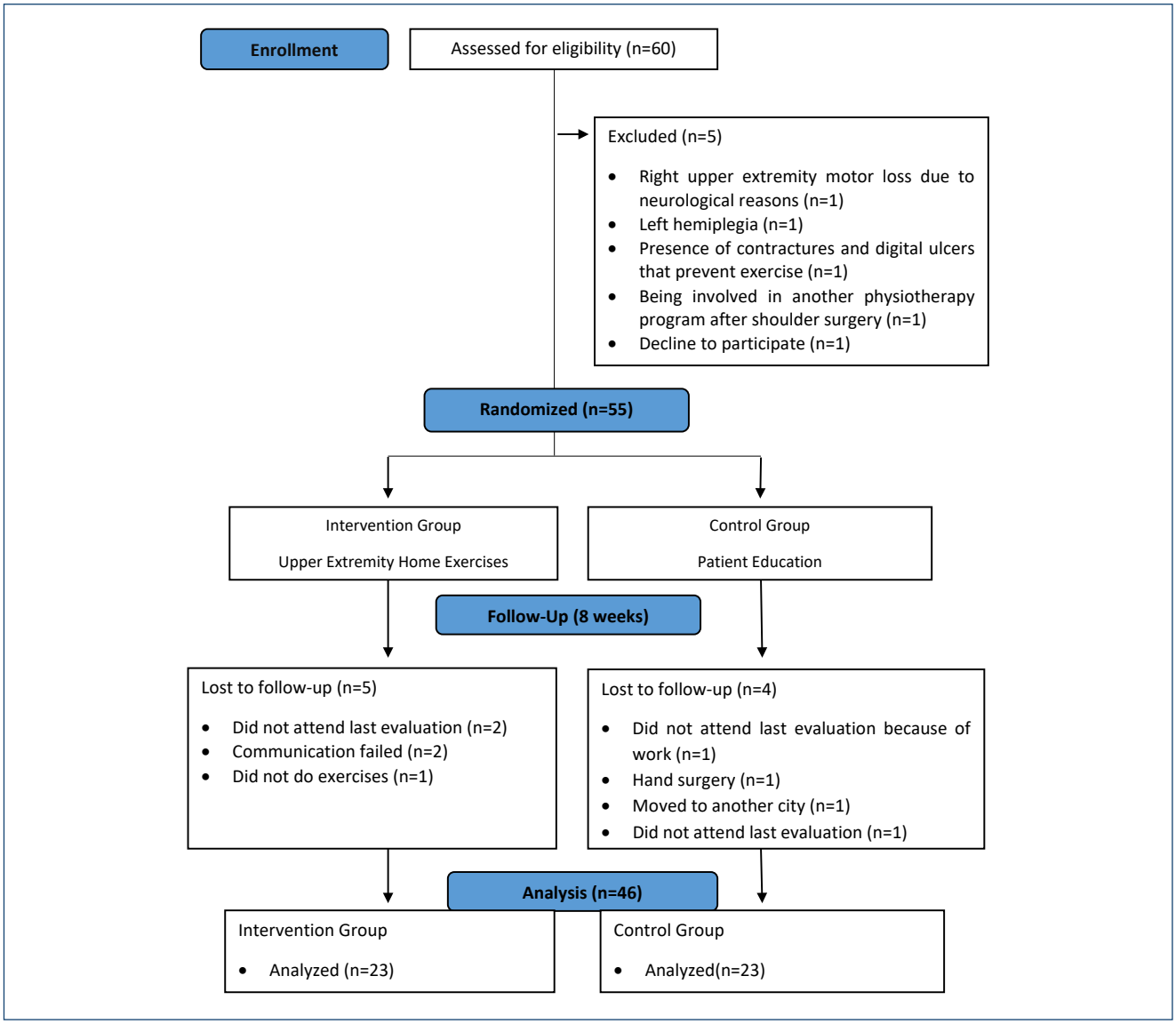

Figure 1. CONSORT flow diagram.

Table 1. Comparison of groups in terms of demographic and health-related variables at baseline.

	Intervention Mean±SD	Control Mean±SD	Intervention n (%)	Control n (%)	Z[b] t[a]	p*
Gender					0.000[b]	1.000
Female			21 (91.3)	21 (91.3)		
Male			2 (8.7)	2 (8.7)		
Age (years)	53.43±11.95	57.60±10.97	-	-	0.583[a]	0.224
BMI (kg/m^2)	27.72±2.98	27.04±3.53	-	-	0.494[a]	0.488
Smoking (years)	3.26±10.83	2.47±8.37			-1.380[b]	0.167
Yes			2 (8.7)	6 (26.9)		
No			21 (91.3)	17 (73.1)		
Alcohol (years)	2.17±10.42	0.00±0.00			-1.000[b]	0.317
Yes			1 (4.3)	0 (0)		
No			22 (95.7)	23 (100)		
Disease duration (years)	6.04±3.19	7.60±5.20	-	-	-1.202[b]	0.229
Dominant hand	-	-			-0.591[b]	0.555
R			22 (95.7)	21 (91.3)		
L			1 (4.3)	2 (8.7)		
Morning stiffness	-	-			-0.933[b]	0.351
Yes			14 (60.9)	17 (73.1)		
No			9 (39.1)	6 (26.9)		
Stiffness duration (min)	20.76±15.39	42.52±69.88	-	-	-0.550[b]	0.582
ESR (mm/s)	7.80±4.99	11.66±12.27	-	-	-0.354[b]	0.723
CRP (mg/L)	2.55±2.89	3.05±2.91	-	-	-0.975[b]	0.330
RF (IU/mL)	13.91±9.93	11.40±6.59	-	-	-0.933[b]	0.351
Employment status					-0.014[b]	0.989
Not working			17 (73.9)	16 (69.6)		
Employee			6 (26.1)	7 (30.4)		

SD: standard deviation; R: right; L: left; BMI: body mass index; ESR: erythrocyte sedimentation rate; CRP: C-reactive protein; RF: rheumatoid factor. [a]Independent-samples T-test. [b]Mann-Whitney U test. *p<0.05.

Delta (Δ) values were calculated to examine the difference between the groups after treatment. In terms of D values, hand grip and pinch strengths (p: 0.000-0.016), active (p: 0.000-0.032) and passive (p: 0.000-0.043) total ROMs, COPM performance and satisfaction, DASH, SACRAH, and DHI (p: 0.000) were in favor of the intervention group (Table 2).

DISCUSSION

In this study, it was concluded that upper extremity stretching and strengthening exercises applied at home were effective in improving hand grip and pinch strengths, upper extremity active and passive total ROM, activity performance, and functionality of individuals with SSc.

Rehabilitation approaches for the hand/upper extremity in scleroderma primarily aim to improve grip strength, mobility, and function[3,4]. To manage the disease and reduce the financial burden on health sources, rehabilitation interventions in SSc are arranged in a way that individuals can apply on his/her own and become a part of their lives[2]. In this context, our home exercise program consisted of stretching and strengthening exercises involving the entire upper extremity. Exercise duration, frequency, intensity, and repetitions were similar to the literature[1,3-5,14,16].

In this study, pre-treatment, patient education group was superior in terms of some values. This could be explained by the presence of clinical subtypes of SSc affecting individuals at different levels and the use of self-reported assessment tools.

Table 2. Comparison of the groups pre-treatment and comparison of Δ values between groups in terms of grip strength, total range of motion, Canadian Occupational Performance Measure, Disabilities of the Arm, Shoulder and Hand, Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands, and Duruoz Hand Index post-treatment.

		Pre-treatment				Post-treatment (Δ values)			
		Intervention Mean±SD	Control Mean±SD	Z[b] F[a]	p	Intervention Δ (Mean±SD)	Control Δ (Mean±SD)	Z[b] t[a]	p
Hand grip strength	R	22.11±7.93	24.38±9.01	1.488[a]	0.369	-2.31±4.69	0.57±2.95	0.484[a]	0.016*
	L	20.77±8.35	23.66±11.03	1.048[a]	0.323	-2.78±4.60	0.36±2.94	2.458[a]	0.008*
Lateral pinch strength	R	6.57±1.73	7.14±2.27	1.391[a]	0.344	-0.49±1.33	0.76±0.85	1.980[a]	0.000*
	L	6.49±1.83	6.75±2.15	0.282[a]	0.663	-0.63±1.08	0.65±0.74	2.283[a]	0.000*
Triple pinch strength	R	5.17±1.74	6.07±2.21	1.787[a]	0.129	-0.97±1.12	0.82±1.01	0.089[a]	0.000*
	L	5.05±1.80	5.80±2.25	1.278[a]	0.220	-0.89±1.17	0.80±1.11	0.078[a]	0.000*
Fingertip pinch strength	R	4.54±1.48	5.07±1.50	0.039[a]	0.231	-0.97±1.32	0.61±0.97	4.956[a]	0.000*
	L	4.33±1.42	4.96±1.63	1.323[a]	0.171	-0.68±1.09	1.01±1.02	0.546[a]	0.000*
Shoulder active total ROM	R	549.78±44.55	576.30±38.76	-2.146[b]	0.032	-34.34±31.99	3.69±12.35	-4.933[b]	0.000*
	L	554.78±47.42	576.52±36.25	-1.496[b]	0.135	-35.65±31.16	12.17±14.68	-5.456[b]	0.000*
Elbow-forearm active total ROM	R	309.56±16.91	317.73±9.45	-1.108[b]	0.268	-7.17±10.09	-0.08±2.37	-2.717[b]	0.007*
	L	309.56±15.66	317.39±9.87	-1.480[b]	0.139	-6.95±11.84	0.43±4.74	-2.151[b]	0.032*
Wrist active total ROM	R	165.00±37.92	171.43±25.54	-0.341[b]	0.733	-24.13±23.04	8.60±15.01	-4.906[b]	0.000*
	L	172.39±38.34	175.86±27.66	-1.165[b]	0.869	-18.69±21.70	17.82±16.22	-5.470[b]	0.000*
Fingers active total ROM	R	1234.08±131.79	1295.65±107.71	1.065[a]	0.090	-142.43±100.50	46.56±39.58	14.549[a]	0.000*
	L	1255.47±137.75	1299.26±104.65	0.677[a]	0.231	-120.39±78.81	43.08±53.72	1.735[a]	0.000*
Shoulder passive total ROM	R	567.82±37.68	584.26±33.11	-1.081[b]	0.280	-25.21±28.46	0.34±6.25	-4.527[b]	0.000*
	L	571.52±38.91	584.95±29.57	2.649[a]	0.194	-28.69±26.50	4.30±8.13	21.984[a]	0.000*
Elbow-forearm passive total ROM	R	314.91±11.40	320.65±7.27	-1.567[b]	0.117	-4.47±6.45	-1.00±2.74	-2.021[b]	0.043*
	L	314.95±10.81	321.30±7.10	-1.935[b]	0.053	-4.39±7.35	0.43±2.57	-2.971[b]	0.003*
Wrist passive total ROM	R	182.00±32.95	185.95±21.73	-0.176[b]	0.860	-19.52±19.38	2.34±9.46	-4.579[b]	0.000*
	L	187.52±32.28	188.69±23.94	-0.121[b]	0.903	-16.82±15.61	6.47±9.18	-5.554[b]	0.000*
Fingers passive total ROM	R	1317.69±114.10	1387.78±97.34	0.702[a]	0.030*	-117.30±81.97	17.82±33.68	10.614[a]	0.000*
	L	1332.60±123.34	1390.17±86.20	0.943[a]	0.073	-105.43±72.29	16.30±34.52	5.937[a]	0.000*
COPM-performance		7.21±1.64	8.29±1.63	0.261[a]	0.031*	-1.09±1.25	0.31±0.85	1.123[a]	0.000*
COPM-satisfaction		7.13±1.69	8.30±1.65	0.095[a]	0.022*	-1.24±1.34	0.32±0.85	1.991[a]	0.000*
DASH		32.57±18.49	22.23±18.23	0.028[a]	0.063	15.47±12.93	-6.14±8.35	4.522[a]	0.000*
SACRAH		22.05±18.36	17.78±17.59	-0.802[b]	0.422	9.71±10.21	-8.05±10.46	-5.218[b]	0.000*
DHI		10.00±10.84	7.82±11.07	-1.528[b]	0.126	5.04±5.91	-3.60±5.07	-5.090[b]	0.000*

SD: standard deviation; R: right; L: left; ROM: range of motion; COPM: Canadian Occupational Performance Measure; DASH: Disabilities of the Arm, Shoulder and Hand; SACRAH: Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands; DHI: Duruoz Hand Index. [a]Independent-samples T-test. [b]Mann-Whitney U test. *p<0.05.

In the literature, no change or decrease in grip strength was observed when no exercise was applied or when exercise duration and/or frequency were lower[1,2,3,9]. Some studies showed that grip strengths increased[3,5,16], while in the study of Murphy et al., grip strength decreased after 8 weeks; lateral grip strength did not change[9]. In this study, grip strengths increased after exercise, similar to other studies[3,5,16]. We thought that exercises are necessary to protect and maintain hand grip and pinch strengths in SSc. Stretching and strengthening exercises should be applied at appropriate frequency and time for the upper extremity.

Table 3. Comparison of the groups in terms of grip strength, total range of motion, Canadian Occupational Performance Measure, Disabilities of the Arm, Shoulder and Hand, Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands, and Duruoz Hand Index before and after treatment.

		Intervention group				Control group			
		Pre-treatment Mean±SD	Post-treatment Mean±SD	Z[d] t[c]	p	Pre-treatment Mean±SD	Post-treatment Mean±SD	Z[d] t[c]	p
Hand grip strength	R:	22.11±7.93	24.43±8.77	-2.369[c]	0.027*	24.38±9.01	23.80±9.18	0.939[c]	0.358
	L:	20.77±8.35	23.56±7.55	-2.902[c]	0.008*	23.66±11.03	23.30±9.91	0.589[c]	0.562
Lateral pinch strength	R:	6.57±1.73	7.07±1.82	-1.770[c]	0.091	7.14±2.27	6.38±2.23	4.302[c]	0.000*
	L:	6.49±1.83	7.13±1.64	-2.808[c]	0.010*	6.75±2.15	6.10±1.97	4.168[c]	0.000*
Triple pinch strength	R:	5.17±1.74	6.14±1.82	-4.157[c]	0.000*	6.07±2.21	5.25±1.89	3.871[c]	0.001*
	L:	5.05±1.80	5.94±1.49	-3.625[c]	0.000*	5.80±2.25	4.99±1.81	3.461[c]	0.002*
Fingertip pinch strength	R:	4.54±1.48	5.51±1.73	-3.521[c]	0.002*	5.07±1.50	4.46±1.44	3.009[c]	0.006*
	L:	4.33±1.42	5.01±1.34	-2.986[c]	0.007*	4.96±1.63	3.95±1.31	4.764[c]	0.000*
Shoulder active total ROM	R:	549.78±44.55	584.13±26.57	-3.998[d]	0.000*	576.30±38.76	572.60±37.68	-1.205[d]	0.228
	L:	554.78±47.42	590.43±25.71	-4.112[d]	0.000*	576.52±36.25	564.34±38.91	-3.149[d]	0.002*
Elbow-forearm active total ROM	R:	309.56±16.91	316.73±10.51	-2.810[d]	0.005*	317.73±9.45	317.82±8.63	-0.378[d]	0.705
	L:	309.56±15.66	316.52±9.70	-2.689[d]	0.007*	317.39±9.87	316.95±9.50	-0.465[d]	0.642
Wrist active total ROM	R:	165.00±37.92	189.13±26.31	-4.071[d]	0.000*	171.43±25.54	162.82±22.40	-2.421[d]	0.015*
	L:	172.39±38.34	191.08±29.50	-3.687[d]	0.000*	175.86±27.66	158.04±25.61	-4.001[d]	0.000*
Fingers active total ROM	R:	1234.08±131.79	1376.52±99.76	-6.79[c]	0.000*	1295.65±107.71	1249.08±93.98	5.64[c]	0.000*
	L:	1255.47±137.75	1375.86±106.66	-7.32[c]	0.000*	1299.26±104.65	1256.17±84.65	3.84[c]	0.001*
Shoulder passive total ROM	R:	567.82±37.68	593.04±23.14	-3.920[d]	0.000*	584.26±33.11	583.91±32.08	-0.122[d]	0.903
	L:	571.52±38.91	600.21±21.76	-5.191[c]	0.000*	584.95±29.57	580.65±29.43	2.538[c]	0.019*
Elbow-forearm passive total ROM	R:	314.91±11.40	319.39±8.31	-2.814[d]	0.005*	320.65±7.27	321.65±5.88	-1.667[d]	0.096
	L:	314.95±10.81	319.34±8.16	-2.677[d]	0.007*	321.30±7.10	320.86±7.33	-0.816[d]	0.414
Wrist passive total ROM	R:	182.00±32.95	201.52±23.37	-3.976[d]	0.000*	185.95±21.73	183.60±19.10	-1.143[d]	0.253
	L:	187.52±32.28	204.34±24.55	-4.028[d]	0.000*	188.69±23.94	182.21±22.69	-2.968[d]	0.003*
Fingers passive total ROM	R:	1317.69±114.10	1435.00±88.62	-6.86[c]	0.000*	1387.78±97.34	1369.95±91.60	2.53[c]	0.019*
	L:	1332.60±123.34	1438.04±97.17	-6.99[c]	0.000*	1390.17±86.20	1373.86±76.55	2.26[c]	0.012*
COPM-performance		7.21±1.64	8.30±1.23	-4.170[c]	0.000*	8.29±1.63	7.98±1.55	1.753[c]	0.094
COPM-satisfaction		7.13±1.69	8.38±1.26	-4.463[c]	0.000*	8.30±1.65	7.98±1.57	1.802[c]	0.085
DASH		32.57±18.49	17.10±15.89	5.734[c]	0.000*	22.23±18.23	28.37±22.94	-3.528[c]	0.002*
SACRAH		22.05±18.36	12.34±15.19	-4.107[d]	0.000*	17.78±17.59	25.83±20.76	-3.319[d]	0.001*
DHI		10.00±10.84	4.95±8.13	-3.627[d]	0.000*	7.82±11.07	11.43±12.38	-3.051[d]	0.002*

SD: standard deviation; R: right; L: left; ROM: range of motion; COPM: Canadian Occupational Performance Measure; DASH: Disabilities of the Arm, Shoulder and Hand; SACRAH: Score for Assessment and Quantification of Chronic Rheumatic Affections of the Hands; DHI: Duruoz Hand Index. [c]Paired samples T-test. [d]Wilcoxon signed-rank test. *p<0.05.

There was no study evaluating shoulder ROM. In a study, total active ROM for fingers increased for both hands, but the difference was found only for the left hand; wrist and elbow flexion did not change[9]. In the study of Mancuso and Poole, the total ROM of fingers improved clinically[14]. In the study of Piga et al., finger ROM increased in the dominant hand for both groups[4]. In this study, ROM of the shoulders, elbows, forearms, wrists, and fingers increased in total in the whole upper extremity after exercise.

COPM has been used as an assessment tool in various rheumatic disorders and conditions with upper extremity

involvement[15]. In the study of Sandqvist et al., performance and satisfaction scores were found to be 4 and 3, according to COPM, and individuals had most difficulties in the area of household chores and work[2]. In another study, activities related to nutrition and personal care were reported as the most difficult activities, while indoor mobility and transfers were the easiest[17]. In this study, compared with others, individuals' activity performance and satisfaction were higher before and after treatment[15,18,19]. This may be due to psychological and sociocultural factors, and advances in treatment that affected performance and satisfaction scores[18]. Stefanantoni et al. reported that COPM scores increased after hand exercises besides occupational therapy[19]. In this study, individuals reported activities in the field of self-care frequently: in general, cooking (45.7%), up-down stairs (30.4%), bathing (28.3%), and dusting (28.3%). In this respect, our results were similar to others evaluating difficulties in ADL in SSc[17,18]. Besides, activity performance and satisfaction improved after upper extremity home exercises.

It was reported that the most important factor restricting functionality in SSc is hand impairment[6]. In the study by Murphy et al., upper extremity function increased after 8 weeks[9]. In the study by Waszczykowski et al., upper extremity and hand function decreased after the first month but increased in the 6-month period compared with the beginning. The group doing home exercises for only 30 min showed improvement after 1 month, but no difference was found[16]. In this study, similar to other studies showing positive effects of upper extremity/hand exercises on functionality in SSc, functionality improved after upper extremity home exercises according to DASH, SACRAH, and DHI.

The strength of our study is that it also included upper extremity exercises, unlike others that included only hand exercises and were not comprehensive[4,16,19]. Another importance of the study is that, because this study was conducted during the COVID-19 pandemic period and due to the chronic nature of SSc, the long-term rehabilitation needs of individuals were met with confidence due to home exercises. One of the strengths of the study was the use of objective assessment tools such as dynamometer. In addition, individuals were able to stay in touch with the physiotherapist. Thus, coping strategies were supported in every sense, and they were better adapted to the exercises.

The study has several limitations. First, it did not have a follow-up period to determine the persistence of effects of exercises. Second, measurement evaluating edema, vascular function, or skin condition was not performed. Therefore, we cannot make a definite conclusion about the effect of exercise on the mechanism. Finally, cardiopulmonary parameters were not monitored during exercise. However, for individuals at risk of cardiopulmonary disease, monitoring them during upper extremity exercises is recommended[20].

CONCLUSION

Grip strength, active and passive total ROM, activity performance, and functionality improved after upper extremity home exercises. We recommend that rehabilitation programs include not only hand exercises but also routine upper extremity exercises. More well-designed randomized controlled studies are needed to standardize protocols for total upper extremity in SSc.

AUTHORS' CONTRIBUTIONS

EIS: Data curation, Investigation, Software, Writing – original draft. **SYC:** Conceptualization, Formal Analysis, Methodology, Project administration, Supervision, Validation, Writing – review & editing. **AA:** Funding acquisition, Resources, Visualization, Supervision.

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