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Effect of a tailored home-based exercise program in patients with systemic sclerosis: A randomized controlled trial

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Objective: The aim was to evaluate the effect of a home-based exercise program on functional capacity, health-related quality of life (HRQoL), and disability, in patients with systemic sclerosis (SSc).

Methods: A 6-month randomized controlled trial was conducted on SSc patients by comparing a home-based minimally supervised exercise program (exercise on a stationary cycle and strengthening of upper limbs; stretching of the hands) with usual care. At baseline and after 3 and 6 months, the patients underwent: 6 minutes walking test; hand mobility in scleroderma test; maximal exercise test on an ergo-cycle; strength measures (handgrip, quadriceps, and biceps). HRQoL (short-form 36 [SF-36]) and disability (health assessment questionnaire disability index [HAQ-DI]) were measured at the same time.

Results: Forty-four patients participated in the study. Twenty-two were randomly assigned to the intervention group (IG, mean age 63.60 ± 10.40 years) and 22 to the control group (CG, 61.80 ± 14.40 years). At 6 months, the distance walked in 6 minutes increased by 46 m (baseline 486, 95% CI 458-513 m; 6 months 532, 95% CI 504-561 m) in IG, whereas it decreased by 5 m (baseline 464, 95% CI 431-497 m; 6 months 459, 95% CI 427-490 m) in CG with a significantly different temporal trend at the between-groups comparison ($P < .001$). An improvement was also observed for strength measures (handgrip, $P = .003$; quadriceps, $P < .001$; biceps, $P < .001$), for the SF-36 physical component score ($P < .001$) and for the HAQ-DI ($P = .011$).

Conclusions: This study indicates that in SSc patients, a minimally supervised home-based exercise program improves physical performance, quality of life, and disability in comparison with usual care.

KEYWORDS

disability, exercise therapy, muscles, quality of life, resistance training, scleroderma

1 | INTRODUCTION

Systemic sclerosis (SSc) is an uncommon chronic rheumatic disease with an unknown cause and unpredictable course, characterized by immune activation that leads to a collagen deposition by activated fibroblasts.[1] This activation causes generalized microangiopathy, fibrosis of the skin, and internal organs. SSc is classified into two subtypes: limited systemic sclerosis and diffuse systemic sclerosis. In the former, we can observe a gradual skin thickening limited to the distal extremities and face, but later viscera may be also involved. In addition to skin fibrosis, Raynaud's phenomenon and gastrointestinal involvement are the most common manifestations. In the latter, which is the most severe subtype of the disease given its early internal organ and lung involvement, skin thickening involves the overall body surface and occurs more rapidly and symmetrically.[2] Other than multi-organ involvement, SSc patients may present muscular alterations. Musculoskeletal damage in SSc occurs frequently, with a prevalence of 24%-97%, and is associated with significant disability and economic burden.[3] Weakness and atrophy, which have an inflammatory origin, are frequent musculoskeletal symptoms.[4] In addition, some drugs such as D-penicillamine and glucocorticoids, sometimes used in patients with SSc, can alter muscle fiber.[5] The reduction of functional capacity and easy fatigability are common problems of this disease, which starts a vicious circle that leads to a fast deterioration of physical conditions that causes a reduction in physical functioning (in terms of function, activity, and participation) and health-related quality of life (HRQoL).[6] Noteworthy, Liem et al[7] demonstrated that the total minutes of physical activity per week is significantly lower in SSc patients compared to the general population.

Although extensive efforts have been made to develop therapeutic agents for SSc, satisfactory results have yet to be achieved. Rehabilitation for SSc needs to be regularly and constantly performed at home, as well as in hospitals,[8] but to date, rehabilitation therapy for SSc patients is not widespread.[9] Previous studies have suggested that aerobic exercise or aerobic exercise combined with resistance exercise may improve exercise tolerance, aerobic capacity, walking distance, muscle strength and function, and HRQoL.[10] However, the strength of evidence on the effectiveness of the non-pharmacological intervention in SSc is limited,[10,11] and none of the previous studies estimated the effect of a rehabilitation program performed at home with minimal supervision. On these premises, a simple aerobic and minimally supervised home exercise program was developed, focusing on the feasibility and on its low economic burden, which also promotes an active lifestyle in SSc patients.[10,11] The primary aim of the present study was to evaluate the effect of a multidimensional individualized exercise program performed at home on functional exercise capacity measured by 6 minutes walking test (6MWT) in patients with SSc.[12] Secondary aims were to assess the effect of the same program on VO2peak using a cardiopulmonary test on an ergo cycle,[13] muscular strength of upper and lower limbs, and on finger joint motion. Finally, we aimed to ascertain whether a comprehensive exercise program may affect HRQoL and disability.

2 | MATERIALS AND METHODS

This was a 6-month, randomized and controlled, parallel-group trial. All the participants were outpatients and gave their informed written consent to participate in the study, which was carried out according to the tenets of the Declaration of Helsinki and approved by the local Ethics Committee (Comitato Etico per la Sperimentazione Clinica delle Province di Verona e Rovigo—approval number: 16060).

Randomization was performed by means a four-block randomization list generated using STATA software by an operator not involved in the selection of the patients.

The patients with a diagnosis of SSc, according to the American College of Rheumatology (ACR) criteria,[14] who attended the Rheumatologic outpatient clinic of our institution were evaluated to participate in the study. The inclusion criteria were a diagnosis of SSc according to the ACR criteria[14]; age 18-85 years; no hospitalizations and changes in anti-rheumatic treatment in the previous three months. The exclusion criteria were as follow: heart failure staging in classes III or IV of New York Heart Association (NYHA)[15]; pulmonary hypertension, defined by echocardiogram as a right ventricular systolic pressure ≥35 mm Hg; vital capacity (VC) ≤50% or diffusion lung capacity of carbon monoxide (DLco) ≤30% of predicted values; renal failure (glomerular filtration rate <30 mL/min)[16]; muscle-skeletal impairments that prevent the participation in the rehabilitation program; pregnancy or planned pregnancy in the next 6 months; psychiatric disorders that prevent collaboration and adherence to the rehabilitation program; and involvement in other exercise programs.

Patients who met the selection criteria underwent two days of screening and testing. During the first visit, the patients underwent clinical assessment (demographic and anthropometric data; medical history; skin thickness, using the modified Rodnan skin score, mRSS[17]), pulmonary function testing (VC, and diffusion lung capacity for carbon monoxide, DLco, measured in accordance with the American Thoracic Society, ATS)[18] (spirometer Sensor Medics 2100, Jorba Linda, Ca, USA), and measurement of body composition by bioimpedentiometry (Bio 101, Akern, Florence, Italy). They performed a maximal exercise test on a cycloergometer, completed the questionnaires to assess HRQoL (short-form 36, SF-36[19]) and functional abilities (health assessment

questionnaire disability index, HAQ-DI[20]), on the same day. During the second visit, the participants carried out the hand mobility in scleroderma test (HAMIS),[21] 6MWT,[22] and measurements of quadriceps, biceps, and handgrip strength. The Italian versions were used for all the questionnaires.[23–25]

After the completion of testing and screening, the patients were randomly assigned to one of two groups: the intervention group (IG) and the control group (CG). The first began a 6-month program of exercise training. In an interview that lasted from 30 to 40 minutes, the patients in the second group were given generic recommendations to increase their physical activity.

The patients in the IG were instructed, in a session of about one hour, how to perform the physical exercise program at home by a physiotherapist. They learned how to use the stationary bike and how to perform the exercises for the upper limbs. Furthermore, they were instructed how to record the exercises performed daily on a checklist sheet. Throughout the first 3 months of the training period, the patients received a phone call from a physiotherapist once monthly, during which the participation in the exercise program was reinforced. Moreover, they were asked about their side effects and adherence to the exercise program. The CG received a phone call with the same schedule, but only to evaluate their health status. Neither group received the monthly phone call from the third to the sixth month. Three and 6 months after the beginning of the program, the subjects underwent 2 days of testing, using the same schedule described at baseline. All the tests were conducted by PF and FZ who did not know which group the patient was assigned to.

2.1 | 6MWT

The 6MWT was conducted on a straight 30 m rout. The start and endpoints were indicated by two skittles, and the subjects were instructed to walk as far as possible for six minutes. The protocol used followed the guidelines of the American Thoracic Society (ATS).[22] The distance walked (meters) was recorded.

2.2 | Cardiopulmonary test

All the subjects underwent a maximal cycle ergometric test, following the criteria of ATS.[26] The subjects cycled on an electrically braked cycle ergometer (Corival 400, Lode, Groningen, The Netherlands). The workload was increased every minute following a ramp protocol of 15 Watts/min, until exhaustion. Exercise parameters and VO2 (L/min) were collected breath-by-breath and averaged over 10-second intervals, using the ZAN600 cardiopulmonary measuring device (ZAN600 Ferraris, Germany).

2.3 | Maximum isometric muscle strength

Handgrip strength was measured using a hydraulic handheld dynamometer (Saehan Corp., Masan, Korea). Quadriceps strength was measured by an isometric leg extension. The subject was seated on an adjustable straight-backed chair with the lower leg unsupported and the hip and knee flexed in a 90° angle, with an adjustable belt around the hips. Isometric leg extension strength was measured by a dynamometer (Kern CH50K50, Kern & Sohn, Balingen, Germany) applied with a strap around the ankle just proximal to the malleoli. Biceps strength was measured by an isometric forearm flexion using the same dynamometer fixed on the floor. The subject, sitting on a chair with the adducted arm to the thorax and forearm flexed at 90° to the arm, held the handle of the dynamometer. The isometric forearms flexion strength was performed in this position. After one attempt, three measurements were recorded for the handgrip, quadriceps and biceps strength, and the average was calculated for each side. The average of both sides was used in the analysis. Biceps strength was also assessed by an indirect measurement of 1-RM (1-repetition maximum),[27] which was calculated using Brzycki formula.[28] The 1-RM obtained was used to determine the load for the biceps exercises.

2.4 | Exercise program

A simple, aerobic, and minimally supervised home rehabilitation program was developed. The exercise program consists of an aerobic exercise on a stationary bike, muscular endurance training of the upper limb, and stretching exercises for the hands. The exercise on the stationary bike and muscular endurance training were performed on alternate days, three times a week. Each patient was provided with a stationary cycle (Energetics ct220p, Neomark Sarl, Luxembourg) for lower limb training. Each session consisted of three phases. In the first one, the patient pedaled for five minutes without a load. In the second phase, the patient was instructed to set the brake at a load of approximately 60% of the watts achieved at the peak of the maximal ergocycle exercise test. This phase consists of two periods of fifteen minutes divided by a recovery of three minutes. It was followed by five minutes of cooldown without a load. The frequency of pedaling was higher than 60 rotation/min during the second phase and about 50 during the other phases.

For the upper limbs training, the patients performed two series of 10 repetitions separated by 2 minutes of rest consisting in repeatedly lifting and lowering a weight from the waist to the shoulders. The load was about 60% of the 1-RM.[27,28]

Stretching of the upper limbs, shoulders, and neck was performed after each exercise session. The load for the strength and aerobic exercise was decreased by 20% to allow a gradual

muscular adaptation, in the first 2 weeks. After 3 months, the loads were adjusted on the basis of the results of the maximal cardiopulmonary test and of 1-RM.

The patients were given written and illustrated instructions for hand stretching, which had to be performed twice daily. The patients were invited to report each type of exercise whether the tasks were partially completed, completed, or not carried out (which corresponded to a score of 1-0.5-0, respectively) on a diary card. The attendance rate at the training session was calculated as the ratio between the scores registered on the diary card within 3 months (1-3, 4-6 months) and the number of scheduled sessions in the same period.

2.5 | Statistical analysis

Pre-study power calculation estimated a total of 44 subjects[29] (20 subjects per group + 2 subjects per group, considering 10% of dropout) would provide an 85% power to detect a difference of 54 m (standard deviation of 55 m)[22] on the 6MWT between the groups.[30] All the randomized participants were included in the statistical analysis (intention to treat analysis). Our data were summarized as means with standard deviations or medians with interquartile ranges for continuous variables and as percentages for categorical variables. Comparison of variables across groups (IG, CG) was performed by using the chi-squared test for categorical variables and the t test or the Wilcoxon rank-sum test for continuous variables, as appropriate. The conventional 5% level of statistical significance was used. We used random-intercept multiple linear regression models, to predict the trajectories of performance and quality of life outcomes measures over a period of six months as a function of time. All the models had the individual as the clustering factor (to account for repeated measurements, that is, the values of the outcomes at baseline, three months, and six months), and robust standard errors. The independent variables used in the models were the group (IG, CG), time (baseline, 3 months, and 6 months), age at baseline, and group × time interaction. The statistical analyses were carried out using STATA 15 (StataCorp, College Station, TX).

3 | RESULTS

Seventy-one patients were contacted from May 2017 to March 2018. The 44 patients who satisfied the inclusion and exclusion criteria where equally divided into the IG and CG groups. The study was completed by 16 patients in the IG and 17 in the CG (Figure 1). Family reasons were given for the discontinuation of the program. Of a total of three patients in the IG, one abandoned before and two after the evaluation at 3 months. For the same reason, of a total of 5 in the CG, one abandoned before and four after the evaluation at 3 months. Three patients in the IG all abandoned before the evaluation at three months due to pain in the joints or other parts of the body, whereas no patients abandoned the CG. Among the patients in IG who discontinued the program, one experienced elbow pain, another one lower back pain, and the last one had

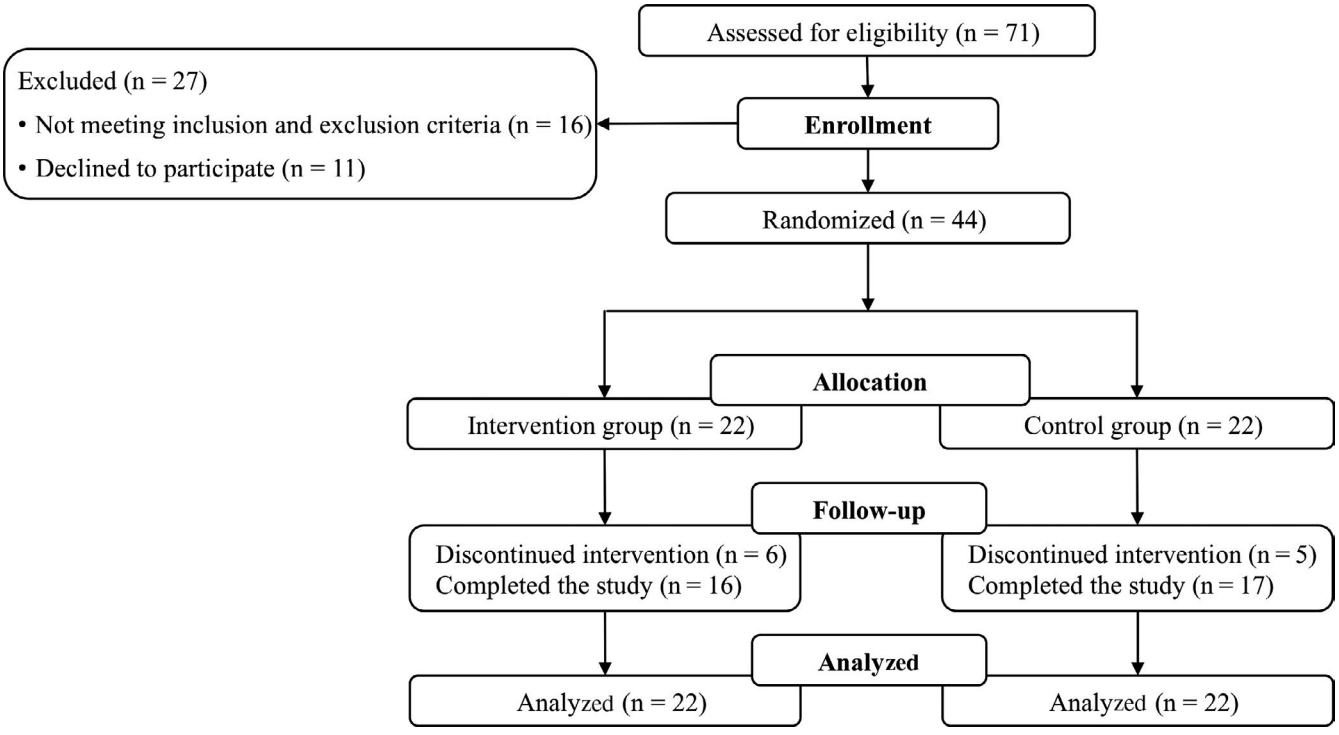

FIGURE 1 Flow diagram

TABLE 1 Baseline characteristics of the randomized patients

	Control group (n = 22)	Intervention group (n = 22)
Age (years)	61.80 ± 14.40	63.60 ± 10.40
Female sex (%)	79.20	80.00
BMI (kg/m^2)	24.70 (23.50;28.20)	26.20 (24.00;28.30)
lcSSC (%)	75.00	56.00
Disease duration (years)	11.50 (7.00;17.50)	10.00 (6.00;16.00)
Modified Rodnan skin score	6.50 ± 3.90	8.60 ± 5.50
FEV1% predicted	99.0 (91.50;104.50)*	90.00 (81.00;90.00)*
VC % predicted	110.50 (98.00;115.00)	101.00 (87.00;113.00)
DLCO % predicted	73.80 ± 17.90	64.20 ± 21.40
PAPs (mm Hg)	29.50 (22.00;30.50)	28.00 (23.00;31.00)
Current treatment		
Iloprost (%)	91.70	96.00
Calcium channel blockers (%)	25.00	32.00
Corticosteroids (%)	16.70	12.00
Mycofenolate mofetil (%)	12.50	12.00
Azathioprine (%)	4.00	8.00
D-Penicillamine (%)	0.00	4.00
Hydroxychloroquine (%)	16.70	24.00

Note: Measures are expressed as mean ± SD or median (Q1;Q3) using parametric and no parametric tests, respectively, or as percentages where appropriate.

Abbreviations: BMI, body mass index; DLCO, diffusion lung CO; FEV1, forced expiratory volume; lcSSC, limited cutaneous systemic sclerosis; PAPs, pulmonary artery pressure systolic; VC, vital capacity.

*$P \leq .05$.

perineum pain during cycling due to a pre-existent urethral caruncle.

Table 1 reports the clinical demographic characteristics of patients participating in the study. There were no differences between the groups for the variables measured at baseline, except for the predicted FEV1%. The adherence to the exercise program did not show significant variations during the study period. At three and six months, the average of the self-reported adherence was greater for hand-stretching exercises (87.0%-87.9%, respectively), relatively lower for weight sessions (86.4%-86.0%, respectively), and stationary cycling sessions (84.2%-84.5%, respectively).

Table 2 shows the mean predicted outcome measures adjusted by age at baseline, highlighting differences in the temporal trend between subjects in the IG and the CG. There is evidence of a significantly different temporal trend in the two groups for 6MWD ($P < .0001$), quadriceps ($P = .0001$), biceps ($P < .0001$), and grip strength ($P = .0030$). These outcomes increased for subjects in the IG, whereas they were nearly steady for subjects in the CG (Figure 2, Table 2). A similar trend was highlighted for the weight ($P = .0001$) and fat mass ($P = .0149$).

The quality of life, as measured by the SF-36 physical score, improved in the IG group as compared to the CG ($P < .0001$). Moreover, at six months, 11 subjects in the IG (50.0%), but only four in the CG (18.2%), recorded an increase of PCS above the minimal important difference (MID).[31] The two groups did not show any evidence of temporal change in the SF-36 mental score during the six months ($P = .1494$). The temporal variation of HAQ-DI was different in the IG with respect to the CG ($P = .0106$): the exercise program produced a reduction (ie, an improvement) in the HAQ-DI score, while no change was evident for subjects in the CG (Figure 3).

The HAMIS score ($P = .3926$) and VO2peak ($P = .8531$) showed no differences in the temporal trend between the IG and the CG.

4 | DISCUSSION

This is one of the few RCTs showing that a minimally supervised, tailored, and home-based physical exercise program for 6 months increases the distance walked in 6 minutes and muscular strength of upper and lower arms.

TABLE 2 Outcome measures

	Baseline	3 months[a]	6 months[a]	*P*[b]
6MWD (m)				
IG	486 (458;513)	518 (492;544)	532 (504;561)	<.0001*
CG	464 (431;497)	461 (432;489)	459 (427;490)	
VO2peak (mlO_2/kg/min)				
IG	18.17 (15.64;20.70)	20.27 (17.84;22.70)	20.91 (18.46;23.35)	.8531
CG	16.07 (13.38;18.77)	17.56 (14.72;20.40)	18.13 (15.42;20.84)	
Weight (kg)				
IG	71.00 (65.00;76.80)	70.20 (64.40;76.00)	69.80 (64.20;75.40)	.0001*
CG	65.90 (60.80;71.00)	66.00 (61.00;71.20)	66.30 (61.10;71.40)	
Free fat mass (kg)				
IG	47.80 (44.70;51.00)	48.00 (44.90;51.20)	48.10 (45.00;51.30)	.5938
CG	45.20 (42.30;48.20)	45.30 (43.40;48.20)	45.10 (42.20;48.00)	
Fat mass (kg)				
IG	23.00 (18.90;27.30)	22.20 (18.00;26.40)	21.60 (17.60;25.70)	.0149*
CG	20.70 (16.80;24.60)	20.80 (16.90;24.60)	20.80 (17.10;24.60)	
SF36-PCS				
IG	39.80 (36.30;43.20)	45.30(42.30;48.30)	46.70 (43.70;49.70)	<.0001*
CG	45.10 (41.50;48.80)	43.90 (40.10;47.80)	43.20 (39.70;46.70)	
SF36-MCS				
IG	49.10 (46.00;52.30)	51.60 (48.80;54.50)	50.30 (46.90;53.70)	.1494
CG	45.10 (41.70;48.50)	44.30 (41.20;47.30)	43.60 (40.00;47.20)	
HAQ-DI				
IG	0.39 (0.23;0.55)	0.26 (0.10;0.42)	0.20 (0.06;0.35)	.0106*
CG	0.29 (0.12;0.46)	0.29 (0.12;0.47)	0.30 (0.12;0.47)	
HAMIS (mean right hands)				
IG	1.11 (0.20;2.02)	0.89 (0.14;1.64)	0.83 (0.10;1.56)	.3926
CG	0.97 (0.38;1.55)	0.67 (0.12;1.22)	0.77 (0.24;1.31)	
Handgrip (kg)[a]				
IG	24.60 (20.20;29.00)	26.40 (21.90;30.80)	27.30 (22.70;32.00)	.0030*
CG	23.20 (19.30;27.00)	22.90 (19.00;26.70)	22.50 (18.30;26.60)	
Quadriceps strength (kg)[a]				
IG	22.30 (18.70;25.80)	24.40 (20.70;28.10)	26.00 (22.00;29.80)	.0001*
CG	20.60 (17.20;24.10)	20.00 (16.60;23.40)	20.00 (16.80;23.30)	
Biceps strength (kg)[a]				
IG	11.30 (9.10;13.50)	12.70 (10.50;14.80)	13.60 (11.30;15.90)	<.0001*
CG	11.80 (9.70;13.80)	11.20 (9.40;13.00)	11.00 (9.20;12.90)	

Note: Measures are expressed as mean predicted levels by regression models with 95% CI (see method section).

Abbreviations: 6MWT, 6 minutes walking test; CG: control group; IG: intervention group; HAMIS, hand mobility in scleroderma test; HAQ-DI, health assessment questionnaire disability index; MCS, mental component score; PCS, physical component score; SF-36, short-form 36.

[a]Average of both sides of maximum isometric contraction.

[b]*P* per group interaction.

*$P \leq .05$.

Noteworthy, the gain in physical performance was associated with an improvement of a HRQoL and a disability reduction.

The present study shows that an individualized program of aerobic exercise on the stationary bike can significantly improve the distance walked during the 6MWT with a mean

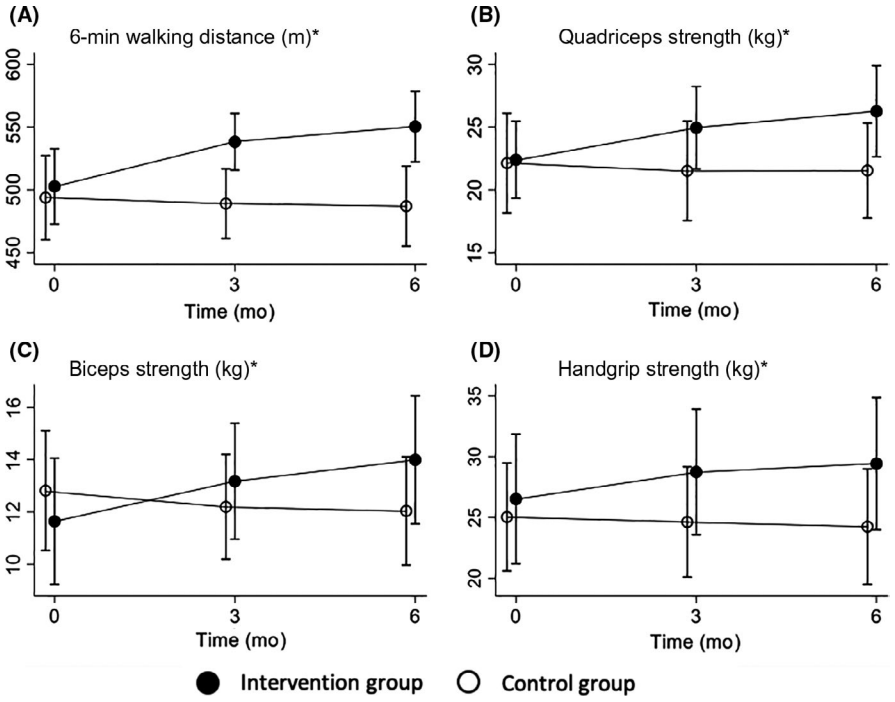

FIGURE 2 Temporal trend of performance outcome measures of patients in IG and CG. Legend: The error bars represent the 95% confidence interval of the outcome estimates. *$P \leq .05$ of time per group interaction. ● Intervention group (IG); ○ control group (CG)

difference between groups of 51 m at 6 months. To our knowledge, the minimal important difference in the 6MWD in rheumatologic disease is not well known. However, the difference between the two groups of 51 m is similar to the MID reported for other diseases.[22] To date, few studies have evaluated the effects of exercise programs in the SSc. Oliveira et al[32] reported a significant improvement in physical performance in a group of seven patients after an 8-week intensive aerobic exercise program of 40 minutes per session, twice per week. Similar results were obtained by Pinto et al[33] in 12 patients and by Antonioli et al[34] in 16. Schouffoer et al[35] also demonstrated that individual exercise provided by a physical therapist once a week, and a home-based exercise program at least 6 days per week, was more effective than usual outpatient care with respect to 6 minutes walking distance.[31] The results of previous studies should be interpreted with caution given that only a few of them were RCTs.[9,10]

Our exercise program did not significantly change the VO2peak. This result is not surprising since the exercise program was not formulated to improve the maximum aerobic capacity.

The increase in the strength of biceps and quadriceps in the IG indicates the effectiveness of our program. Our data are in

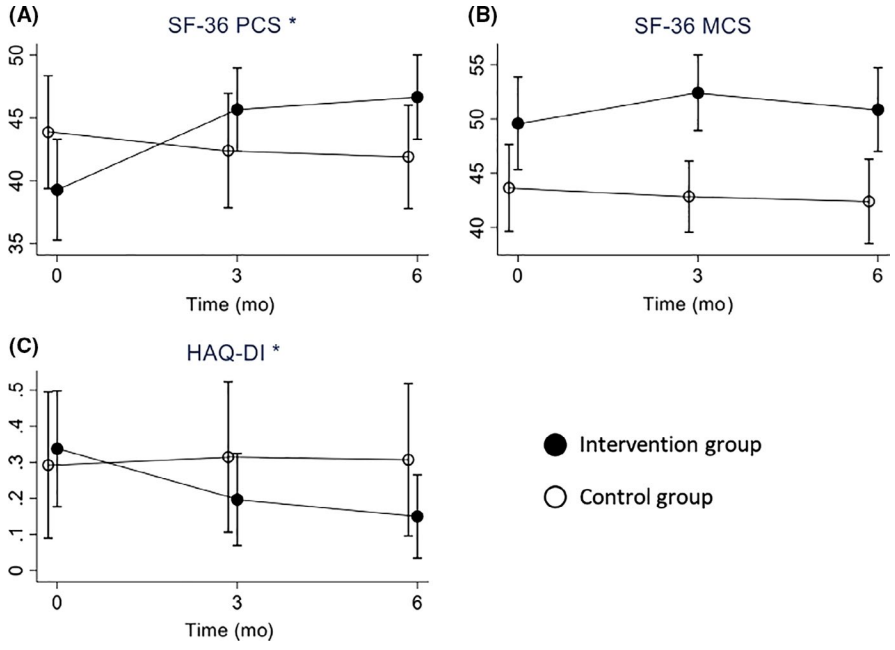

FIGURE 3 Temporal trend in quality of life and disability outcome measures of patients in the IG and CG. Legend: SF-36: short-form 36; PCS: physical component score; MCS: mental component score; HAQ-DI: health assessment questionnaire disability index. The error bars represent the 95% confidence interval of the outcome estimates. *$P \leq .05$ of time per group interaction. ● Intervention group (IG); ○ control group (CG)

agreement with Pinto et al,[33] who showed an improvement in muscle power after following a supervised resistance-training program. Strength improvement may be important in subjects with SSc because muscle weakness is a frequent symptom.[36] The increase in muscle strength could have positive effects on the ability to perform some actions of daily life. It is interesting to note that previous studies demonstrated an association between the strength of the quadriceps with quality of life[37] and physical disability.[38]

The stretching exercise did not produce significant variations in the mobility of the hands. However, it should be considered that the impairment of the hand mobility in our patients was very low, as indicated by the value of the HAMIS score. This fact probably made it difficult to demonstrate an improvement.

The grip strength was significantly improved after 6 months in treated subjects, even though a specific exercise program to reinforce the hands was not utilized in our intervention. Due to the fact that the grip strength is the expression of both the intrinsic and extrinsic muscles of the hand, this result could be explained as an indirect effect of the training of the upper limb.

The exercise program produced a weight reduction of about 1 kg in the IG. The decrease was mainly attributable to the loss of fat mass, whereas no concomitant variation was detected in the lean mass.

The exercise program was associated with a significant increase in the physical score of the SF-36 questionnaire in IG. Moreover, it should be noted that 67% of the subjects in the IG recorded an increase of PCS above the MID (2.18 points).[30] The mental component score of SF-36 also tended to increase in the IG, even though no difference emerged from the comparison with the CG. This result may be attributed to the fact that the leading cause of mental health impairment in SSc is due to changes in patients' appearance, a characteristic that cannot be influenced by the exercise program.[39,40]

An important result was the decrease in the index of disability induced by the exercise program. In particular, 59% of the patients in the IG showed an improvement of HAQ-DI that was higher than the estimated MID for patients with SSc (−0.125 points).[30]

The positive effect on the quality of life and disability can be attributed to an ameliorated physical performance and to the fact that the results were achieved through the execution of a simple program carried out at home. In addition, patients avoided daily visits to a hospital environment to exercise, which emotionally reminded them of the disease. In contrast with our results, in a twelve month controlled trial on the effects of a physical exercise program in SSc, Rannou et al[41] failed to demonstrate a positive effect in reducing disability (expressed using a HAQ-DI). The reason for this result may be attributable to the poor compliance with the exercise program reported by the authors. It is also important to note that there was an unexpected improvement in HAQ-DI in the CG, in the study of Rannou et al,[41] a fact that may justify the failure to detect a difference between treated and untreated patients.

Adherence to the exercise program (albeit self-reported) was as an average more than 80%, and it was only slightly lower for sessions on a stationary bike. This is probably due to the fact that cycling is more demanding from a physical point of view and more time-consuming. It should also be noted that adherence was constant over time. These data suggest that reinforcing the motivation to exercise by phone call is useful during the treatment period.

Our study has some limitations. Even if 71 patients were considered in the initial assessment, only 44 were enrolled. This number seems to be low, even though it is in line with the sample size calculation. A limit is also the fact that the high number of patients contacted refused to participate. This could possibly have led to a selected group that was particularly keen on carrying out the exercise program, which could have made it easier to obtain positive results. Another study limitation is the discontinuation of the study by a high percentage of participants. This could be due to the long duration of the treatment study period. However, the same number of treatment discontinuations occurred in the two groups and only three of those recorded in the IG could be directly linked to the exercise program, indicating that the exercise program is well tolerated.

The enrolled patients presented a low disability impairment and a moderate derangement of the respiratory function. Furthermore, the systolic pulmonary artery pressure mean value was within the normal limits. Therefore, our results are not applicable to scleroderma patients with interstitial lung disease, pulmonary hypertension, or high-grade disability. Further studies are needed.

5 | PERSPECTIVES

Our study may have positive implications since the subjects with SSc have reduced physical functions and a lower quality of life than the general population. The results are even more relevant if we consider that they were obtained with a simple exercise program carried out at home, a characteristic that could extend the intervention to a large number of patients. The economic burden would probably be lower than other programs that are partially or totally supervised in a hospital setting and supported by a complex organization. Moreover, the exercise program performed at home, far from a medical environment, would have the advantage of promoting physical activity by stimulating a healthier way of life. Finally, considering the limited therapeutic possibilities in SSc nowadays, the positive effects of an exercise program could constitute a useful support to pharmacological therapies.

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CONFLICT OF INTEREST

All the authors declare that they have no conflict of interest derived from the outcomes of this study.

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