Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 21s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Low-Level Laser Therapy versus Resisted Exercise in Hand Function of Patients with Systemic Sclerosis

Ahmed Samir Abdel-Moneim[1], Zakaria Mowafy Emam Mowafy[2], Hamed Abd Allah Hamed[3], Khadra Mohmed Ali[4]

[1] B.Sc. Physical therapy Department for Surgery, Faculty of Physical Therapy, Cairo University, Egypt,
[2] Professor of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Egypt,
[3] Professor of Dermatology, Faculty of Medicine, Cairo University, Egypt,
[4] Assistant Professor of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Egypt.

***Corresponding author: Ahmed Ahmed Samir**

Email ID: ahmedsamir@pt.cu.edu.eg

Cite this paper as: Ahmed Samir Abdel-Moneim, Zakaria Mowafy Emam Mowafy, Hamed Abd Allah Hamed, Khadra Mohmed Ali (2025). Low-Level Laser Therapy versus Resisted Exercise in Hand Function of Patients with Systemic Sclerosis. *Journal of Neonatal Surgery*, 14 (21s), 1210-1219.

ABSTRACT

Introduction: Systematic sclerosis is connective tissue autoimmune lesion, where nearby 90% suffers` have an apparent hand` functional restrictions. This research designed to estimate the value of low-level laser versus resisted exercise on systemic sclerosis suffers` hand function in line to state the proper management approach for hand function restrictions among systematic sclerosis individuals.

Material and methods: Forty participants suffering from systematic sclerosis affecting their hands` function with scleroderma allocated randomly into equal groups; A received 3 sessions per week of low-level laser, also conventional physical program involved stretch, and active mobility training, where B received resisted exercises, also conventional physical program comprising stretching, as well active range of motion exercises. Skin thickness, serum cortisol level, and Hand Grip strength were evaluated pre-, then post- intervention using a Modified Rodnan skin scoring, Serum cortisol laboratory analysis, and hand-held dynamometer (HHD), also pinch gauge, respectively.

Results: The groups revealed equivalent remarkable modified Rondon skin thickness, and serum cortisol level reduction, plus highly significant increase in hand grip strength ($p < 0.001$).

Conclusion: Both low-level laser and resisted exercises are equivalent effectively enhance hand grip strength, as well functional capabilities throughout systematic sclerosis management.

Keywords: *Hand grip dynamometer, Low-level laser, Modified rodnan skin score, Resisted exercise, Serum cortisol level, Systemic sclerosis.*

1. INTRODUCTION

Systemic sclerosis is connective tissues autoimmune that manifested clinically by obvious hand functional limitations, and rank as a multisystem involvement. Systemic sclerosis sufferers often experience chronic scleroderma 'marked dermal thickness', Raynaud's phenomenon, and restricted functional capabilities [1,2]. In addition to enumerated clinical features, numerous multisystem manifestations e.g., visceral, musculoskeletal, cardiac and lungs, gastrointestinal, peripheral and central nervous system [3,4].

Clinical systemic sclerosis unique spectrum that varied from Raynaud's phenomena, plus debilitating fatigue up to more serious manifestations unless widespread torso, proximal extremities` microvascular injuries, distal extremities` collagen excessive deposition almost resulted in dermal fibrosis, as well within visceral organs [2,4,5].

Overall systemic sclerosis reported worldwide prevalence massively differs geographically unless it is over 3.1-144.5 sufferers per 100.000 individuals, with pooled rate of incidence reaches 1.4 per 100.000 individuals yearly, as well raised reported female by five times mainly in working-age. Systemic sclerosis is coupled with elevated morbidity burden [6.7].

Broad systemic sclerosis manifestations can restrict physical and functional capacities based on sufferers` dermal restrictions, arthralgia, friction tendon rubs that regressed up to musculoskeletal contractures, plus reduced hand grip strength. In addition, bilateral developed erythematous, also symmetrical distributed along extremities, and torso, as well moderate distributed regarding face [8,9].

No debut, there is no cure for systemic sclerosis therefore the prime management objective is to minimize hands` functional disabilities, plus to improve health-related life quality [10]. Current systemic sclerosis management guidelines defined the potential role of multimodal physical therapy e.g., low-level laser, electrical stimulation, manual approaches, and therapeutic exercises as a rehabilitation branch with limited evidence [11,12].

Non-pharmacological management strategies progressively substantiated via growing evidence. Various physical therapy approaches for hand functional restrictions management have been approved including therapeutic exercises e.g., resisted exercises [13-17]. The key objectives of resisted exercises include building muscular strength, improving anaerobic endurance, and contour of muscles, as well enhancing overall functional status, hand mobility, and physical performance. Regular resisted exercises enhance mobility, and physical functional capabilities via anti-inflammatory gains in chronic systemic low-grade lesions and inflammatory markers thus alleviate inflammatory process and minimize painful complains, as an effective and safe managing strategy [18-19].

Resisted exercises with addressed intensity range 75-85% of one repetition maximum along 8-12 weeks have been demonstrated to improve the endothelial vascularity in digital areas [20-21]. Recently, Gokcan and his colleagues had ensured that therapeutic intervention permits self-administered hand approach as an effective in term of hand mobility [22], as well Uras and his colleagues ensured the face-to-face therapeutic training in order to gain orofacial therapeutic exercises` benefits [23].

Along with other training protocols, resisted exercise training targets improve microstomia, hand functional capabilities, and overall physical capacity. Accelerating evidence regarding physical activities, also resisted training systemic sclerosis in terms of cardiovascular burden, hand functional restrictions, and sufferers` life quality those agreed with cost-effectiveness aspects [24].

Furthermore, non-pharmacological management for systemic sclerosis involves numerous modalities

e.g., self-management, lifestyle modifications, relaxation technique, hand-feet interventions, as well paraffin wax, shockwave therapy, hydrotherapy, and low-level laser [14-15, 25-28]. Almost earlier systemic sclerosis course represented with digital ulcers within fingertips those known to be ischemic etiology mainly in recurrent forms [29]. Low-level laser as a rapid growing safe, and efficient physical therapy modality for digital refractory ulcerations within systemic sclerosis sufferers was stated beneficial for targeted healing via fibroblast and macrophages stimulation, also improve leucocyte mobility those modulated aimed neovascularization and collagen deposition [30]. Actual lack of published benefits of such modalities seeks conducting this trial under title of low-level laser versus resisted exercise in terms of hand function in systemic sclerosis sufferers` rehabilitation. Thus, the current study designed to estimate the value of low-level laser versus resisted exercise in hand function of patients with systemic sclerosis, to state the proper management approach for systemic sclerosis patients` management.

2. MATERIALS AND METHODS

Trial design

A double-blind, random, control trail was conducted from July 2023 to March 2024 at dermatology departments of Cairo university hospitals and Om El-Misrieen hospital, Giza governate, Egypt. The trial followed Helsinki Declaration, also approval No.: P.T.REC/012/004207 by Physical Therapy College ethical committee, Cairo University, as well held all baseline signed participants` consent.

Participants

Forty suffers` from systemic sclerosis were participated, their age range was 45-60 years-old, both genders, all were conscious, have scleroderma particularly dorsum of the hand.

Patients were excluded if they had: diabetes mellitus, hypertension, those were familiar with low-level laser or resisted exercise training via hand grip strengthener, haemorrhage; particularly within digestive system or bleeding rectum, sever fungal or viral infections, active tuberculosis or tumors, also who have pacemakers, polyneuropathy, or thyroid disorders.

Sample Calculated size

A 76 suffers was estimated via G*POWER statistical software (ver. 3.1.9.2; Franz Faul, Universität Kiel, German) to ensure proper statistical strength. This estimated size was based on modify Rodnan skin score of Khanna and his colleagues. [31], that ensured modified Rodnan skin tool clinical suitability for systemic sclerosis. So, calculated size was assigned at 20 person per group. Those calculations were based on a two-sided 5% significance level, an effect size of 0.8, and a power of 85%.

Randomizing

Each subject has received full objectives of this trial features, aim, gains plus the withdraw rights even declining any time if desire. After Consent was signed, all subjects` demographics were gathered. External assistant performed computer-random generated cards held in closed envelopes to enrolled 40 subjects who allocated into equal Groups A and B. Then gave each envelope particular number thus state well-randomization. Trial flow is labelled in Fig. 1 based on CONSORT 2010 guidelines [32].

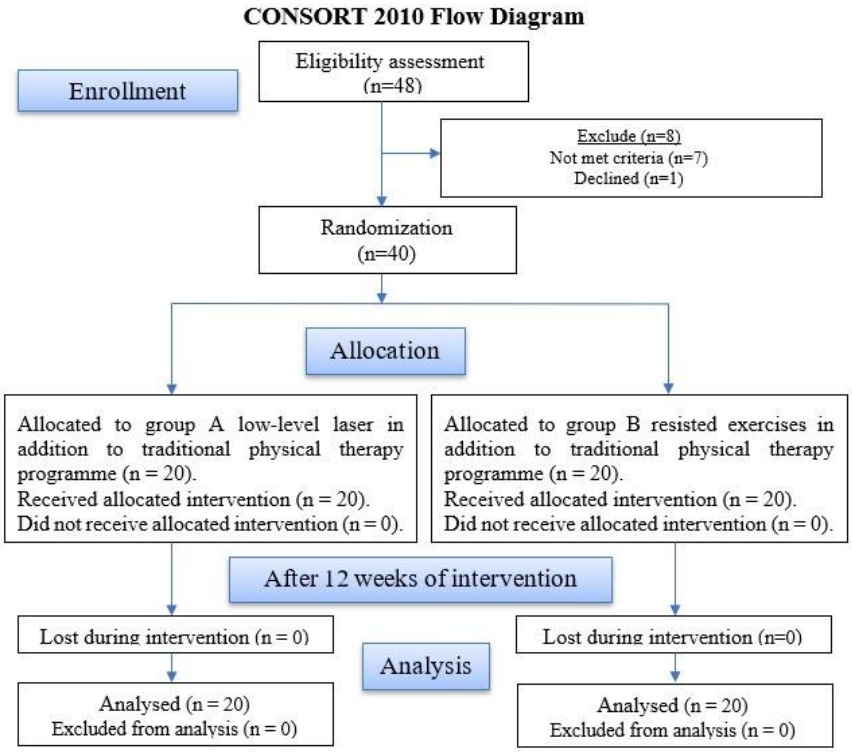

Fig. 1: CONSORT flow chart of the study

Outcome measures

Evaluations were ensured pre- and post- twelve weeks of treatment program.

Primary measures Modified Rodnan skin score (mRSS)

Modified Rodnan skin score is a clinical golden scandalized dermal thickness scoring tool that is reliable, valid, and sensitive in clinical settings [32]. The mRSS has four scores as follows; 0 = addressing 'normal skin' where the examiner appreciates fine wrinkles without dermal thickness/only sponge, 1 = addressing a mild dermal thickness recognized by 2-fingers fine wrinkles acceptable/ low-density polyurethane foam over synthetic sponge, 2 = moderate dermal thickness with difficult in defining folds/ medium polyurethane foam, and 3 = severe dermal thickness with inability to define folds/ high-density polyurethane foam superimposed on synthetic sponge [32].

Secondary outcome measures Serum cortisol level (SCL)

The SCL normal morning range is 9-25 ug/ dL, is known as a recognized laboratory test for its validity and reliability in assessing pain level [33].

Hand dynamometer and Pinch gauge

The hand-held dynamometer (HHD), and Pinch Gauge were utilized to evaluate hand grip, and pinch strengths 'up to 90kg or 200Ibs for HHD, and 22kg or 50Ibs for pinch gauge, both with 0.1kg/Ib accuracy value), based on the American Society Hand Therapists` American Society recommends in standard positions. HHD (Saehan Corporation, Masan, Korea), almost assessed hand grip strength with neutral elbow/ wrist position in right flexion. Regarding both HHD, and pinch gauge as an easily accurate measure along three-seconds post-verbal instructing, then released, and calculate the median of three trials with one-minute rest in-between [34].

Therapeutic device Low-level laser device

Laser device manufactured by Laserex technology Pty. Ltd. Australia, Model M300 laser level, Class III, with maximum average poser 5 milli Watts, Gallian Aluminum Arsenide (Ga-Al-As) with 904 nm wave length, also maximum repetition rate 5 kHz, up to 30 J/cm2, and 2J/cm2 energy density, plus protective eye glasses, and utilized program for post-operative pudendal neuralgia [35].

Hand grip strength trainer (HGST)

HGST is a rehabilitation device 'SPDTEC, 375 grams, black, plastic metal, 5-60 kg/ 11-133Ib, 11.9Length x 11.9Width' utilized to assist in comprehensive training hand, forearm, and fingers` musculatures [36]. Intervention

Post random allocating subjects within 20 per group: A received Low-level laser, in addition to conventional physical therapy 'time of session is 20 minutes', which included stretching, also active mobility. Where B underwent resisted exercises, plus conventional one 'time of session is 20 minutes', which included stretching, and active range of motion exercises. Both groups had received the same medical care and medications, and they conducted 36 regimen along12 weeks, day after a day.

Low-level laser

Group A participants, only underwent low-level laser program. Initial instructions were given in details prior to the beginning of treatment, and each participant was placed in suitable comfortable sitting position, laser device prepared, and targeted area was cleaned, then 10-exaggerated trigger points in hand dorsum that irradiated '90 seconds for each point' with continuous low-level laser in a perpendicular contact technique of laser probe with light pressure on trigger points. The low-level laser conducted for 15-minutes per session, three sessions per week, over 12 weeks [35].

Resisted exercise program

Group A participants, only underwent resisted exercise training program. The protocol involved particular supervised 5-minutes resisted training utilizing hand grip strength trainer tool. Initial weight intensity of 50-60% of the three-repetition maximum (3RM) during the first- to- six weeks. Later 7- 12 weeks, it raised to 60-70%. From 13-18 weeks, it reached 75%. From 19-24 weeks, it became 75-80% 3RM. By 24-36 weeks, it became 80-85% 3RM, by 5-second held at the range end. Each resistance exercises were 3 sets of 10 repeats [36].

Tab. 1. Resisted training progress

Duration	Training	Sets	Repetitions
1-6 weeks	50-60% 3RM.	3	10
7-12	60-70% 3RM.	3	10
13-18	70-75% 3RM.	3	10
19-24	75-80% 3RM.	3	10
24-36	80-85% 3RM.	3	10

Conventional training protocol

All subjects received conventional protocol along 36 weeks, 3 sessions weekly. It is a specific supervised 20-minutes training, from forearm, hand, then fingers stretch [held along 45 seconds; 3-repeatitions], then active range of motion exercises [37].

Statistical analysis

Across groups compare via unpaired t-test, where gender compared its distribution via chi-squared one. Applied Shapiro-Wilk test to check normally data distribution, finally Levene`s for homogeneity. The ttests were used to state treatment impacts in term of modified Rodnan skin score, serum cortisol level and hand grip strength dynamometer, plus hand gauge strength values. Used statistics were set at $p < 0.05$ significance, at SPSS v. 25 of Windows (IBM, Chicago, IL, USA). No withdrawals along trial protocol.

3.RESULTS

Demographics:

Table 2 for groups features. No apparent differs regarding age, BMI, and sex (> 0.05).

Tab. 2. Compared groups` demographics

	Group A	Group B	MD	t- value	p-value
	Mean ± SD	**Mean ± SD**			
Age (years)	54.25 ± 4.49	54.05 ± 4.58	0.2	0.218	0.830
BMI (kg/m²)	26.85 ±1.18	26.49 ±1.04	0.36	1.41	0.16
Sex, n (%)					
Female	12 (60%)	8 (40%)		$\chi^2 = 0.47$	0.49
Male	11 (55%)	9 (45%)			

SD: Standard deviated; MD: Mean differ; χ2: Chi-squared; p-value: Probability, n: Number, %: percent

Interventional effects in terms of modified Rodnan skin score, serum cortisol level and hand grip strength dynamometer, plus hand gauge strength values:

The remarkable value of intervention, and time were revealed via Mixed MANOVA (99.74 F, 0.001, eta partial square 0.98), also objective intervention value (69.81 F, 0.001, eta partial square 0.79), where time value (1189.65 F, 0.001, eta partial square 0.82).

Compare within groups:

The A& B groups represented apparent progress on modified Rodnan skin score, serum cortisol level and hand grip strength dynamometer, plus hand gauge strength values post- versus pre-treatment where group A mean differs were1.15(0.789), 10.45(0.11), -10.35(-2.054), -8.4(2.05) respectively, while B were 1.35(-0.024), 10.53(0.0169), -11.5(0.111), -10.58(-2.25) respectively, (Tab. 3-4, Fig. 2).

Compare in-between groups:

No obvious differs at baseline in-between groups (> 0.05). Post-treatment revealed remarkable progress in modified Rodnan skin score (2.58), serum cortisol level (2.17), hand-dynamometer for strength (.54), also Pinch grip strength assessed by pinch gauge (2.67) in A group vs. B group (0.001), (Tabl. 3-4).

Tab. 3. Modified Rodnan skin score and serum cortisol level means for groups posttreatment:

	Group A	**Group B**			
	Mean ± SD	**Mean ± SD**	**t- value**	**p- value**	**Effect size**
mRSS					
Pre-	2.8 ± 0.410	2.85 ± 0.489	-0.567	0.577	
Post-t	1.65 ± 0.489	1.5 ± 0.513	1.371	0.186	2.58
MD (95% CI)	1.15(0.789)	1.35 (-0.024)			
p- value	0.001	0.001			
SCL ug/dL					
Pre-treatment	36.335 ± 0.478	36.385 ± 0.537	-0.858	0.402	
Post-treatment	25.885 ± 0.368	25.855 ± 0.369	3.943	0.001	2.17
MD (95% CI)	10.45(0.110)	10.53(0.169)			
p- value	0.001	0.001			

SD: Standard deviated; MD: mean differ; CI: confidant interval; p-value: probability, effect by Cohen d (mini-0.2, moderate 0.5, extreme 0.8).

Tab. 4. Hand grip strength, and pinch grip strength means for groups posttreatment:

	Group A	**Group B**			
	Mean ± SD	**Mean ± SD**	**t- value**	**p- value**	**Effect size**
Hand grip strength					
Pre-	8.25 ± 2.447	8.5 ± 2.35081	-1	0.330	
Post-treatment	18.6 ± 4.500	20 ± 3.55409	-2.052	0.054	3.54
MD (95% CI)	-10.35(-2.054)	-11.5 (0.111)			
p- value	0.001	0.001			
Pinch grip strength					
Pre-treatment	6.25 ± 2.45	6.27 ± 2.35	-0.02	0.334	
Post-treatment	14.65 ± 4.5	16.85 ± 4.6	80.13	0.001	2.67
MD (95% CI)	-8.4(2.05)	-10.58(-2.25)			
p- value	0.001	0.001			

SD: Standard deviated; MD: mean differ; CI: confidant interval; p-value: probability, effect by Cohen d (mini-0.2, moderate 0.5, extreme 0.8).

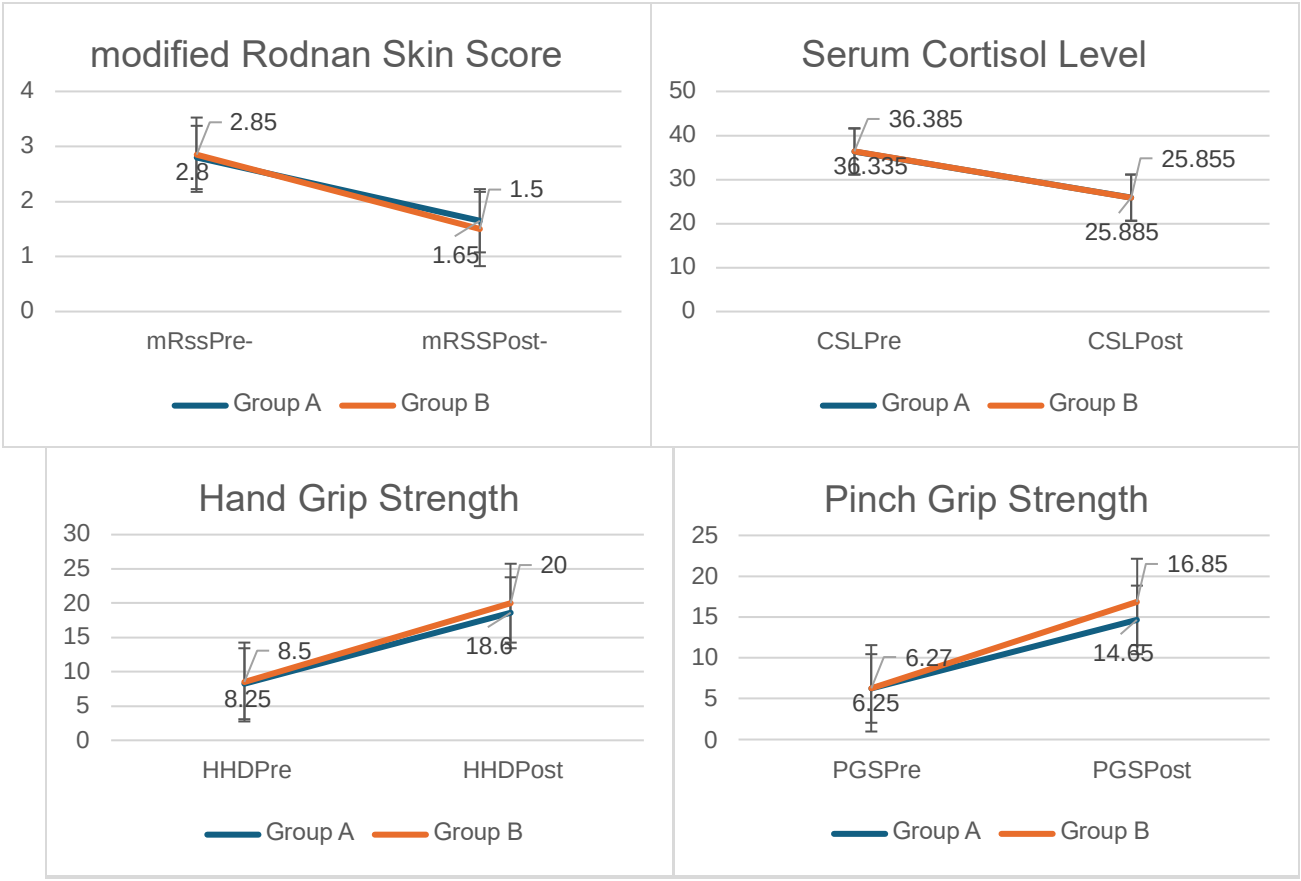

Fig. 2: Groups gained means margins for (i) mRSS (ii) CSL (iii)HHD (iv)PGS.

4.DISCUSSION

This clinical trial stated that low-level laser and resisted training combined with conventional rehabilitation protocol had remarkable gains on hand functioning in systemic sclerosis individuals. Overall post-treatment analysis revealed great gains in modified Rodnan skin score, serum cortisol level, and hand grip strength, and pinch grip strength for B group over A one (< 0.001).

The improvements in hand grip strength dynamometer, plus hand gauge strength in group A was -10.35(-

2.054), -8.4(2.05) respectively, where B were -11.5(0.111), -10.58(-2.25) respectively.

Resisted exercises therapeutic gains in hand functioning among systemic sclerosis subjects ensured via HHD, and pinch gauge with numerous explainations.

Recently, Cassalia et al. [38] has stated that fractional CO2 therapeutic laser could enhanced the longterm remodeling tissues based on esthetic and functional reported therapeutic gains, while hyaluronic acid fillers effectively permit underlying dermal atrophy or loss, plus accelerate long-lasting esthetic improvements.

In the same line, a recent clinical trial conducted by Guo et al. [39] has ensured that usage of yttrium aluminum garnet (Er: YAG) forms on mice morphea sort represented apparent pathological reduction features in terms of severity through dermal thinning, reduced fibrosis thus improve systemic sclerosis illness and improves underlying tissues quality through enhanced evidence over localized scleroderma.

De Olivera et al. [40] came in line with current clinical trial through their conclusion regarding recommending usage of low-level laser therapy along 6-sessions where they stated actual reduction of discomfort and regaining better quality of life for scleroderma patients.

A recent recommendation provided by Spinella et al. [41] who stated that utilizing EmoLED® plus debridement therapy permits curable features for systemic sclerosis by around 41.6% with recorded improvements in affected regions either length, width, wound or pain measures. Therefore, they ensured the positive therapeutic benefits of EmoLED®.

A custom-built low-level laser device '850nm infrared; 660nm red, and 405nm violet' utilized for irradiating a 10 J/cm2 twice weekly along three weeks, followed by a couple of months follow-up has reported a safe, feasible and well-tolerated therapeutic intervention for systemic sclerosis populations that published by Hughes et al. [42]. That came in line with current clinical trial, and could ensured that low-level laser permits acceptable efficiency for curing cutaneous ulcers, plus permitting apparent antibacterial benefits mainly against staphylococcus aureus that known as a photosensitizing agent. Photochemical, and photothermal low-level laser benefits accelerates systemic sclerosis ischemic curing mainly based on low-level laser photosensitizer features.

A recent clinical trial has ensured the recommendation for systemic sclerosis patients for remaining active through participating in moderate-loaded resisted exercise training enhance modulation of most clinical features of systemic sclerotic population involving pulmonary manifestation [43].

A recent clinical trial conducted by Fade et al. [17] had stated that regular exercising could modulated as aa anti-inflammatory modality for managing numerous chronic illnesses i.e., systemic sclerosis or diabetes mellitus that ensured via inflammatory markers modulation. Thus, Fade and his colleagues stated that safe, structured exercise training could be an effective strategy for systemic sclerosis [17]. Earlier clinical trial conducted by 2016; it was stated that intense pulsed light could improve inter-ridge distance in between whom suffering from microstomia of systemic sclerosis [44].

In the same line, a recent clinical trial conducted by Retameiro et al. [45] has stated that application of therapeutic low-level laser, plus resisted exercise intervention permits curable restoration of musculoskeletal strength, and permits significant restoration of the morphological features of articular surfaces that came in line with current clinical trial. Where an earlier clinical trial conducted by Alexanderson et al [46] had stated that active participation in an eight weeks protocol of an aerobic-exercise intervention has reported acceptable positive therapeutic benefits in terms of musculoskeletal aerobic capacity, and endurance that recorded using Borg RPE scale, sixminutes' walk test, and functional index, plus overall assessing questionnaire, and 36-life quality short-scale as outcome measures.

In brief, intensive hand physical therapy could provide favorable long-term beneficial gain in hand functioning parameters. Those therapeutic benefits were reported by Horvath and his colleagues who conducted a clinical trial on thirty-one systemic sclerosis patients in form of hand stretching, ergotherapy protocol in term of baths either mud or warm, whirlpool modality, plus soft tissue massage along three-weeks physical therapy intervention those revealed obvious therapeutic gains in terms of health assessment questionnaire, upper extremity joints` disabilities index, anatomical hand one, as well Functioning hand Cochin outcome measures [47].

On the other hand, regarding verifying scleroderma individuals 'focused-Network approach program that was reported as limited valuable as an exercise protocol for managing systemic sclerotic patients [48].

Therefore, current clinical trial supports the application of both the low-level laser, plus the traditional physical therapy program in form of the resisted exercise training had a valuable effect in the improving functioning hands of systemic sclerotic individuals.

Clinical relevancy:

Current trial conclusions stated obvious gains at all measures that ensured therapeutic efficacy of both low-level lasers, and resisted exercises in combined with traditional physical therapy program for rehabilitation of hand function rehabilitation in patients with systematic sclerosis. These findings imply that both low-level lasers, and resisted exercises in combined with traditional physical therapy program accelerates managing plans among targeted patients therefore recommend the studied protocols.

Limits and strength:

Stated valuable both low-level lasers, and resisted training, ensured its safety, and efficacy that built integrated evidence in term of rehabilitating approach in managing function of hands in systemic sclerotic individuals. Current trial limits might be follow-up lackage, a restricted protocol time, also degenitalized capability because of particular subjects features here (i.e., only conscious ones' ages range 45- 60 years old), plus minimal response variations to intervention protocol.

To maximize visualized evidence regarding both low-level lasers, and resisted exercises in patients with systemic sclerosis experience significant hands` functional limitations, extended follow-up trials, national trials, in line to stated actual both low-level lasers, and resisted exercises effectiveness in patients with systemic sclerosis who experience significant hands` functional limitations. Extended clinical trial targeting wider populations may be vital to ensure that gains. As well, further clinical trials needed to evaluate cost-benefits either low-level laser, nor resisted exercises, plus utilized rehabilitating approaches to visualized economical value, clinically. Real value for national validation of such managing approach to ensure variation within age, and degree of suffers` clinical scleroderma stages, and functional restrictions.

5.CONCLUSION

Both low-level lasers, and resisted exercises in combined with traditional physical therapy program are equivalent effectively enhance hand grip strength, in addition to function rehabilitation throughout systematic sclerosis management.

Acknowledgement: Much appreciation to the participants.

Conflict of interest: No conflict nor interest.

Funding: No funds received.

REFERENCES

[1] Stocker JK, Cup EHC, Vonk MC, van den Hoogen FHJ, Nijhuis-van der Sanden MWG, Bert Staal J, et al. What moves the rheumatologist? Unravelling decision making in the referral of systemic; sclerosis patients to health professionals: A qualitative study. Rheumatol Adv Pract. 2018;2(2):1-7.

[2] Denton CP, Khanna D. Systemic sclerosis. Lancet 2017; 390:1685-99.

[3] Pettersson H, Akerstrom A, Nordin A, Svenungsson E, Alexanderson H, Bostrom C. Selfreported physical capacity and activity in patients with systemic sclerosis and matched controls. Scandinavian journal of rheumatology. 2017;46(6):490-5.

[4] Liem SIE, Meessen J, Wolterbeek R, Ajmone Marsan N, Ninaber MK, Vliet Vlieland TPM, et al. Physical activity in patients with systemic sclerosis. Rheumatology international. 2018;38(3):443-53.

[5] Sandler RD, Matucci-Cerinic M, Hughes M. Musculoskeletal hand involvement in systemic sclerosis. Semin Arthritis Rheum. 2020; 50:329-34.

[6] Mitropoulos A, Gumber A, Crank H, Akil M, Klonizakis M. The effects of upper and lower limb exercise on the microvascular reactivity in limited cutaneous systemic sclerosis patients. Arthritis research & therapy. 2018;20(1):112.

[7] Moore DF, Kramer E, Eltarboulsi R, Steen VD. Increased morbidity and mortality of scleroderma in african americans compared to non-african americans. Arthritis Care Res. 2019;71(9):1154-63.

[8] Bairkdar M, Rossides M, Westerlind H, Hesselstrand R, Arkema EV, Holmqvist M. Incidence and prevalence of systemic sclerosis globally: a comprehensive systematic review and meta-analysis. Rheumatology (Oxford) 2021;60(7):3121-33.

[9] Mouthon L, Poole JL, Physical and occupational therapy. In: Varga J, Denton C, Wigley F, Kuwana M, Allanore Y, editors. Scleroderma: From pathogenesis to comprehensive management. New York: Springer. 2017.Pp:603-13.

[10] Toci AL, Madison Hyer J, Silver RM, Nietert PJ, Hant FN. Systemic sclerosis and perceptions of quality in primary care. Am J Med Sci. 2016;351(5):447-51.

[11] 11.Whyte J, Dijkers MP, Fasoli SE, Ferraro M, Katz LW, Norton S, et al. Recommendations for reporting on rehabilitation interventions. Am J Phys Med Rehabil. 2021;100(1):5-16.

[12] Meyer T, Tilly C. Reporting of patients' characteristics in rehabilitation trials: an analysis of publications of RCTs in major clinical rehabilitation journals. Eur J Phys Rehabil Med. 2020;56(6):829-35.

[13] Amiri M, Kumbhare D. Randomized controlled trials in non-pharmacological rehabilitation research: a scoping review of the reporting of sample size calculation, randomization procedure, and statistical analyses. Eur J Phys Rehabil Med. 2020;56(6):790-8.

[14] Discepola MN, Carboni-Jiménez A, Kwakkenbos L, Henry RS, Boruff J, Krishnan A, et al. Effects of non-pharmacological and non-surgical interventions on health outcomes in systemic sclerosis: protocol for a living systematic review. BMJ Open. 2021;11:e047428.

[15] Stöcker JK, Schouffoer AA, Spierings J, et al. Evidence and consensus-based recommendations for non-pharmacological treatment of fatigue, hand function loss, Raynaud's phenomenon and Digital ulcers in patients with systemic sclerosis. Rheumatology 2022; 61:1476–86.

[16] Mugii N, Hamaguchi Y, Maddali-Bongi S. Clinical significance and usefulness of rehabilitation for systemic sclerosis. 2018;3(1):71-80.

[17] Frade S, Cameron M, Espinosa-Cuervo G, Suarez-Almazor M, Lopez-Olivo MA. Exercise and physical therapy for systemic sclerosis. Cochrane Database Syst Rev. 2022;2022(3):CD0014902.

[18] Sydow E, Arat S, Nijs G, Severi S, Westhovens R, Lenaerts J, et al. An explorative study evaluating feasibility and effectiveness of two different exercise programs in systemic sclerosis associated microstomia. Journal of Scleroderma and Related Disorders. 2018; Conference (Supplement 1):197.

[19] Mitropoulos A, Gumber A, Akil M, Klonizakis M. Exploring the microcirculatory effects of an exercise programme including aerobic and resistance training in people with limited cutaneous systemic sclerosis. Microvascular research. 2019; 125:103887.

[20] de Oliveira NC, Portes LA, Pettersson H, Alexanderson H, Bostrom C. Aerobic and resistance exercise in systemic sclerosis: State of the art. Musculoskeletal care. 2017;15(4):316-23.

[21] Mitropoulos A, Gumber A, Crank H, Akil M, Klonizakis M. Investigating the effectiveness and feasibility of exercise on microvascular reactivity and quality of life in systemic sclerosis patients: study protocol for a feasibility study. Trials. 2018;19(1):647.

[22] Gokcen N, Badak SO, Sarpel T, Sertdemir Y, Erken E. The efficacy of a home-based, delfadministered hand exercise program for patients with systemic sclerosis: a randomized controlled, evaluator-blind, clinical trial. J Clin Rheumatol. 2022;28: e422-9.

[23] Uras C, Mastroeni S, Tabolli S, et al. A comparison between two educational methods in the rehabilitation of the microstomia in systemic sclerosis: a randomized controlled trial. Clin Rehabil 2019; 33:1747-56.

[24] 24.Retameiro ACB, Nerves M, Tavares Alde F, Boaro CDT, Rodriguez DFS, Leal TSda S, Costa RM, Bertolini GRF, Ribeiro LFC. Resistance exercise and low-level laser therapy improves grip strength and morphological aspects in the ankle joint of wistar rats with experimental arthritis. Anat Rec (Hoboken). 2023;306(4):918-632.

[25] Dougherty DH, Kwakkenbos L, Carrier ME, Salazar G, Assassi S, Baron M, et al. The Scleroderma Patient-Centered Intervention Network (SPIN) Cohort: baseline clinical features and comparison to other large scleroderma cohorts. Rheumatology. 2018; 57:1623-31.

[26] Denton CP, Hughes M, Gak N, Vila J, Buch MH, Chakravarty K, et al. BSR and BHPR guideline for the treatment of systemic sclerosis. Rheumatology. 2016; 55:1906-10.

[27] Kwakkenbos L, Østbø N, Carrier ME, Nielson WR, Fedoruk C, Levis B, et al. Randomized feasibility trial of the Scleroderma Patient-centered Intervention Network Self-Management (SPIN-SELF) program. Pilot Feasibility Study. 2022; 8:45.

[28] Nordlund J, Henry RS, Kwakkenbos L, Carrier ME, Levis B, Nielson WR, et al. The Scleroderma Patient-centered Intervention Network Self-Management (SPIN-SELF) Program: protocol for a two-arm parallel partially nested randomized controlled feasibility trial with progression to full-scale trial. Trials. 2021; 22:856.

[29] Hughes M, Herrick AL. Digital ulcers in systemic sclerosis. Rheumatology (Oxford). 2017; 56:14-25.

[30] Avci P, Gupta A, Sadasivam M, et al. Low-level laser (light) therapy (LLLT) in skin: stimulating, healing, restoring. Semin Cutan Med Surg. 2013; 32:41–52.

[31] Khanna D, Furst DE, Clements PJ, Allanore Y, Baron M, Czirjak L, et al. Standardization of the modified Rodnan skin score for use in clinical trials of systemic sclerosis. Journal of Scleroderma and Related Disorders 2017;2(1):11-8.

[32] Hopewell S, Boutron I, Moher D. CONSORT and its extensions for reporting clinical trials. Principles and practice of clinical trials. 2020: 1-5.

[33] Almallah MM, Hajeer MY and Almahdi WH et al., (2020): Assessment of a single versus double application of low-level laser therapy in pain reduction following orthodontic elastomeric separation: a randomized controlled trial. Dent Med Probl; 57(1):45-52.

[34] Allanore Y, Simms R, Distler O. Systemic sclerosis. Nat Rev Dis Primers. 1:15002.

[35] Azadholi B, Baker RY. Laer applications in surgery. Ann Transl Med. 4(23):452.

[36] Bennell KL, Dobson F, Hinman RS. Exercise in osteoarthritis: Moving from prescription to adherence. Best Practice & Research Clinical Rheumatology, 28(1), 93-117.

[37] Boniface G, Gandhi V, Norris M. A systematic review exploring the evidence reported to underpin exercise dose in clinical trials of rheumatoid arthritis. Rheumatology. 10.1093/rheumatology/keaa150.

[38] Cassalia F, Federico S, Danese A, Franceschin L, Amato S, Gratteri F, Battilotti C, Caroppo F, Zappia E, Bennardo L, Fortina AB, Nistico SP. Advances in the management of localized scleroderma: A systematic review of laser therapy and injectable filler approaches. J Pers Med. 2024; 14(8):872-881.

[39] Guo Q, Cen J, He M, Huang D, Tang Z, Xiong H. Fractional erbium: yttrium aluminum garnet laser in the treatment of morphea mouse model. J Cosmet Dermatol. 2023; 22:3282-3290.

[40] De Oliveira AB, Sardella JC, Bufalino A, Miotto LN, Ferrisse TM, Brighenti FL. Low-level laser therapy for

xerostomia control in a patient with scleroderma: Clinical case report. Pathol Oral Radiol. 2020;129(1): e107-111.

[41] Spinella A, de Pinto M, Galluzzo C, Testoni S, Macripo P, Lumetti F, Parenti L, Megnani L, Sandri G, Bajocchi G, Starnoni M, De Santis G, Salvarani C, Giuggioli D. Photobiomodulation therapy: A new light in the treatment of systemic sclerosis skin ulcers. Rheumatol Ther. 2022; 9:891905.

[42] Hughes M, Moore T, Manning J, Wilkinson J, Samraj P, Dinsdale G, Roberrts C, Rhodes LE, Herrick AL, Murray A. A feasibility study of a novel low-level light therapy for digital ulcers in systemic sclerosis. J Dermatol Treat. 2018;30(3):251-257.

[43] Liem SIE, Vliet Vlieland TPM, Schoones JW, De Vries-Bouwstra JK. The effect and safety of exercise therapy in patients with systemic sclerosis: a systematic review. Rheumatology Advances in Practice 2019;3(2): rkz044.

[44] Comstedt LR, Svensson A, Hesselstrand R, Lehti L, Rubin AT. Effects of intense pulsed light in microstomia in patients with systemic sclerosis: A pilot study. J Cosm LASER Ther. 2016;19(3):143-148.

[45] Retameiro ACB, Neves M, Tavares AL, Boaro CT, Rodriguez DFS, Leal TSS, Costa RM, Bertolini GRF, Ribeiro LFC. Resistance exercise and low-level laser therapy improves grip strength and morphological aspects in the ankle joint of wistar rats with experimental arthritis. Anat Rec (Hpboken). 2023;306(4):918-932.

[46] Alexanderson H, Bergegard J, Bjornadal L, Nordin A. Intensive aerobic and muscle endurance exercise in patients with systemic sclerosis: a pilot study. BMC Res Notes. 2014:7:86.

[47] Horvath J, Balint Z, Szep E, Deiszinger A, Minier T, Farkas N, Torok E, Horvathne Papp E, Komjati D, Mando Z, Czirjak L, Varju C. Efficacy of intensive hand physical therapy in patients with systemic sclerosis. Experi Rheumatol. 2017;35(s106):159-166.

[48] Kwakkenbos L, Carrier M-E, Welling J, Levis B, Levis AW, Sauve M…Luc Mouthon on behalf of the SPIN Investigators. Randomized controlled trial of an internet-based self-guided hand exercise program to improve hand function in people with systemic sclerosis: the scleroderma patient-centered intervention Network hand exercise program (SPIN-HAND) trial. Trials. 2022; 23:994-1002.