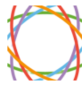
KMANPUB  Health Nexus Vol. 4 No. 3 (2026): 1-11

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Effect of Telerehabilitation-Based Dynamic Neuromuscular Stabilization Exercises on Cardiorespiratory Fitness and Strength in Overweight and Obese Older Women

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ABSTRACT

The present study aimed to investigate the effect of a six-week telerehabilitation-based Dynamic Neuromuscular Stabilization (DNS) exercise program on cardiorespiratory fitness and upper and lower extremity strength in overweight and obese older women. This research was a quasi-experimental study with a pretest-posttest design including a control group. The statistical population consisted of overweight and obese older women living in Mashhad, Iran. The research sample included 30 participants aged 60 to 75 years with a body mass index above 25 kg/m², who were selected using convenience sampling and randomly assigned to two groups: experimental (n = 15) and control (n = 15). The experimental group received a six-week DNS exercise protocol (six sessions per week, including three supervised remote sessions and three home sessions) via telerehabilitation. Cardiorespiratory fitness was assessed using the 2-Minute Step Test. Upper extremity strength was measured separately for the left and right arms using the 30-Second Arm Curl Test. Lower extremity strength was assessed using the 30-Second Chair Stand Test. All measurements were conducted at pretest and posttest stages. Analysis of covariance was used for data analysis at a significance level of $p < 0.05$. The results showed a significant difference between the experimental and control groups for cardiorespiratory fitness ($F = 586.88$, $p = 0.001$, $\eta^2 = 0.95$). A significant difference was also observed for lower extremity strength ($F = 267.00$, $p = 0.001$, $\eta^2 = 0.90$). However, no significant differences were found between the two groups for left upper extremity strength ($F = 0.350$, $p = 0.550$, $\eta^2 = 0.002$) or right upper extremity strength ($F = 0.12$, $p = 0.770$, $\eta^2 = 0.005$). A six-week telerehabilitation-based Dynamic Neuromuscular Stabilization exercise program may be an effective and practical intervention for improving cardiorespiratory fitness and lower extremity strength in overweight and obese older women. However, this protocol did not significantly improve upper extremity strength, highlighting the principle of training specificity. Telerehabilitation-based DNS may provide an accessible home-based exercise option for enhancing selected physical fitness outcomes in this population.

Keywords: *Dynamic Neuromuscular Stabilization, Telerehabilitation, Cardiorespiratory Fitness, Strength, Overweight and Obese Older Women*

1. Introduction

The global demographic landscape is undergoing a profound shift, characterized by an unprecedented increase in the aging population. This demographic transition is accompanied by a parallel epidemic of obesity, creating a significant public health challenge (1, 2). Among older adults, obesity is not merely a cosmetic issue but a potent accelerator of physiological decline, profoundly impacting both metabolic and mechanical health (3). The confluence of aging and obesity creates a synergistic detrimental effect on multiple body systems, particularly the cardiorespiratory and musculoskeletal systems. In older women, the age-related decline in respiratory function marked by decreased lung elastic recoil, reduced chest wall compliance, and weakened respiratory muscles is further exacerbated by the restrictive effects of central adiposity, which mechanically impedes diaphragmatic excursion (4). This leads to a significant reduction in cardiorespiratory fitness, a critical marker of health and a strong predictor of all-cause mortality (5).

Simultaneously, the progressive loss of muscle mass and strength, known as sarcopenia, is compounded by obesity, a condition termed sarcopenic obesity (6). This condition creates a vicious cycle where excessive fat mass infiltrates muscles, reducing their quality and force-generating capacity, while physical inactivity due to reduced mobility further exacerbates both conditions. For older women, adequate lower extremity strength is a fundamental prerequisite for maintaining functional independence, enabling essential tasks such as rising from a chair, climbing stairs, and maintaining postural stability (7). The decline in these physical capacities not only diminishes the quality of life but also significantly increases the risk of falls and institutionalization (3). Therefore, interventions that can simultaneously target cardiorespiratory fitness and muscular strength are of paramount importance for this vulnerable population.

Traditional exercise programs, while effective, often face barriers to long-term adherence among older adults with obesity, including lack of accessibility, transportation difficulties, and fear of stigma in conventional gym environments (8). In this context, telerehabilitation has emerged as a promising alternative, offering a means to deliver supervised, home-based exercise interventions using digital communication technologies. Recent evidence has demonstrated that telerehabilitation is effective and comparable to standard, in-person care for improving physical function and health outcomes in various clinical populations, including those with cardiorespiratory and musculoskeletal conditions (9-11). For instance, structured telerehabilitation programs have been shown to improve physical fitness, quality of life, and cardiorespiratory function in overweight and obese individuals, as well as in older adults with chronic diseases (12, 13). This delivery model offers the potential to overcome traditional barriers to exercise participation, providing a convenient, flexible, and accessible approach to health promotion (14).

While the delivery method is critical, so is the specific content of the exercise intervention. Dynamic Neuromuscular Stabilization (DNS) is a rehabilitative approach rooted in developmental kinesiology, based on the premise that the maturation of the central nervous system establishes innate, ideal movement patterns during early childhood (5, 15). DNS aims to restore and optimize these “ideal” intra-abdominal pressure regulation and integrated spinal stabilizing system (ISSS) function through specific exercises that mimic developmental positions (16, 17). The core principle involves training the deep stabilizers of the spine, particularly the diaphragm in its dual role as both a respiratory and postural muscle, to work in synergy with the abdominal wall, pelvic floor, and multifidus muscles (16). This coordinated activation establishes a stable base from which the limbs can move efficiently, enhancing overall motor control, postural stability, and force transfer (10, 18). A growing body of literature supports the efficacy of DNS in diverse populations. It has been shown to improve functional capacity and postural control in overweight and obese individuals (19), enhance core muscle activation and contractility (19), and reduce pain and disability in patients with chronic low back pain (9). Furthermore, DNS exercises have proven effective for improving motor control, cardiovascular fitness, and respiratory performance in overweight and obese women by emphasizing the integrative function of the diaphragm, thereby directly enhancing chest mobility and breathing efficiency (5). The application of DNS in geriatric rehabilitation is particularly compelling. DNS exercises address key age-related impairments by promoting intra-abdominal pressure

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regulation, improving thoracoabdominal volume regulation, and enhancing postural alignment (20). Studies have demonstrated that DNS-based stabilization exercises can improve balance, walking function, lower extremity strength, and quality of life in older adults (21). By emphasizing the integrated function of the diaphragm and deep stabilizing system, DNS may support both postural control and breathing mechanics (5). However, limited evidence is available on telerehabilitation-based DNS programs targeting cardiorespiratory fitness and limb strength in overweight and obese older women. Therefore, the present study aimed to investigate the effect of a six-week telerehabilitation-based DNS exercise program on cardiorespiratory fitness and upper and lower extremity strength in overweight and obese older women.

2. Methods and Materials

2.1. Study Design

The present study employed a quasi-experimental design with a pretest-posttest control group framework. This design was chosen to evaluate between-group changes following a structured, home-based telerehabilitation intervention while comparing outcomes against a non-intervention control group over a six-week period.

2.2. Participants and Setting

The statistical population consisted of overweight and obese older women residing in Mashhad, Iran. Participants were recruited from community-based senior social and sports centers. Eligibility was determined based on the following criteria: female sex, age between 60 and 75 years, a body mass index (BMI) exceeding 25 kg/m², and voluntary willingness to participate in the research program. A convenience sampling method was employed to select 30 eligible volunteers from those who responded to a public announcement. The sample size was calculated with a confidence level of 95% and a statistical power of 80% using G*Power software version 3.1.9.6. After initial screening, eligible participants were randomly assigned using a simple randomization procedure into an experimental group (n = 15) and a control group (n = 15).

Inclusion criteria were: confirmation of musculoskeletal health by a specialist physician; no history of acute respiratory or cardiac diseases in the preceding three months; the physical capability to perform light-to-moderate intensity exercise; access to a smartphone or tablet and proficiency in using messaging applications; and provision of written informed consent. Exclusion criteria were: the presence of any active chronic pulmonary disease, such as chronic obstructive pulmonary disease (COPD) or asthma; a history of abdominal or thoracic surgery within the past six months; use of medications affecting the respiratory or central nervous system; participation in similar exercise programs within the past three months; voluntary withdrawal from the study; failure to complete the required assessments; engagement in parallel physical activities during the study period; and absence from two consecutive sessions or more than three sessions in total throughout the intervention.

2.3. Procedures

Following the public announcement, interested volunteers attended an initial session at the designated research facility. They were thoroughly informed of the study's objectives and procedures and subsequently provided written informed consent. Demographic information, including age, marital status, education level, medical history, and current medications, was collected via a questionnaire. A physical activity level questionnaire was also administered to confirm the absence of concurrent participation in similar exercise programs. After a final medical clearance by a specialist physician, baseline (pretest) assessments were conducted for all eligible participants. Assessments included measurement of weight and BMI, as well as the standardized physical fitness tests described below. A separate orientation session was held to thoroughly familiarize participants with test execution and the exercise protocol.

Upon completion of pretest assessments, participants were randomly allocated to the experimental or control group. The experimental group underwent a six-week, remote-based Dynamic Neuromuscular Stabilization (DNS) exercise protocol delivered via messaging software. Three sessions per week were supervised remotely, and three additional sessions were completed as home practice. The control group received no structured exercise intervention and was instructed to continue routine daily activities

throughout the study period. Following the six-week intervention, posttest assessments were conducted for both groups under the same conditions and using the same instruments as the pretest. Characteristics of the participants are presented as mean ± standard deviation in Table 1.

Table 1

Characteristics of participants (Mean ± SD)

Variable / Groups	Age (year)	Height(Cm)	Weight (Kg)	BMI (Kg/m²)
Control	66.40±4.50	151.10±5.80	71.54±8.97	31.48±4.83
DNS	66.24±4.14	153.33±3.72	76.69±9.29	31.45±3.20

2.4. Intervention

The exercise protocol was designed based on the principles of Dynamic Neuromuscular Stabilization and developmental kinesiology. The exercises included breathing exercises based on developmental movement patterns, together with correction and practice of breathing patterns. Exercise difficulty was progressed through developmental positions and movement complexity rather than external load. The protocol was implemented for six weeks with a frequency of six sessions per week, including three 60-minute remotely supervised training sessions and three home-training sessions. Diaphragmatic breathing exercises were performed in three sets for each pattern from week one to week six: the first set included 10 repetitions with 2 seconds of inhalation, 4 seconds of exhalation, and 60 to 90 seconds of rest; the second set included 15 repetitions with 3 seconds of inhalation, 6 seconds of exhalation, and 60 to 90 seconds of rest; and the third set included 20 repetitions with 4 seconds of inhalation, 8 seconds of exhalation, and 120 to 150 seconds of rest.

In the first week, exercises included diaphragmatic breathing in six positions: supine, prone, side-lying with hip and knee joints at 45 degrees, supine 90/90 with feet resting on a wall, sitting on a chair, and standing with the back to the wall and feet 15 cm away from the wall. In the second week, exercises included prone position with forearm support, breathing in supine 90/90 position with arms by the side, supine 90/90 position with hands on abdomen, creeping position, simultaneous flexion and extension of both arms, and transitions between positions. In the third week, exercises included supine 90/90 position with shoulder flexion at 90 degrees, rolling patterns, prone position with trunk and thighs lifted off the floor, supine position with hip and knee flexion at 135 degrees, combined arm movements, rolling with greater range of motion, contralateral arm and leg movement toward each other, and hip flexion and extension. In the fourth week, exercises included quadruped positions with different angles, oblique half-sitting and oblique sitting positions, sequential and simultaneous lifting of hands and knees off the floor, and transitions between positions. In the fifth week, exercises included quadruped position with forward movement of one arm, upright sitting position, side plank, forward movement of one leg, simultaneous forward movement of contralateral arm and leg, standing up from hip flexion, and transitions between positions. In the sixth week, exercises included transitions from previous positions, bear position, squat position, standing position, and transitions between bear, squat, and standing positions. The instructor taught the exercises through verbal explanation, visual demonstration, and remote feedback through the telerehabilitation platform. Execution errors were corrected verbally and visually to promote appropriate alignment of the pelvis, spine, rib cage, and scapulae. The six-week DNS training protocol is illustrated in Figure 1 (22).

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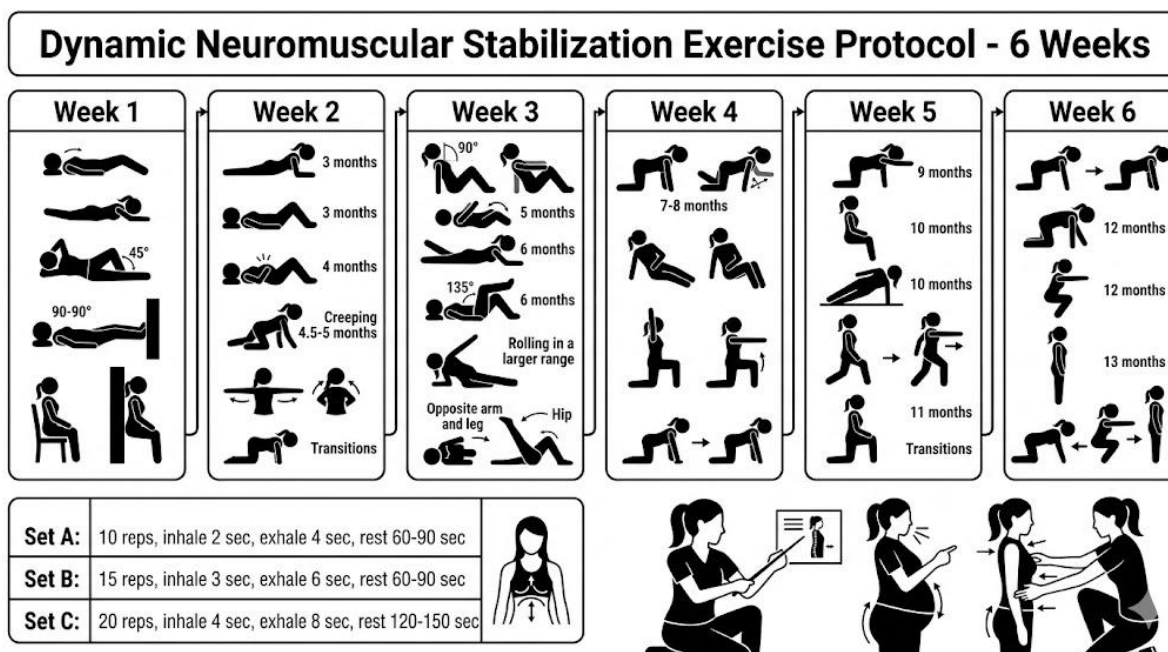
Figure 1

The DNS training protocol.



2.5. Measures

Although the intervention was delivered remotely, all measurements were conducted at a single fixed location (an indoor gymnasium) under standardized environmental conditions (temperature 20-22°C, relative humidity 40-50%) at a consistent time of day (9:00-11:00 AM). Prior to testing, participants completed a 5-minute light warm-up. Each test was performed three times, and the best score was recorded. A minimum 30-second rest interval was provided between trials to minimize the effect of fatigue. To reduce assessment bias, all tests were administered by an experienced assessor (an M.Sc. in exercise physiology) who was blinded to the participants' group allocation.

2.6. Anthropometric Measurements

Weight was measured using a digital scale with an accuracy of 0.1 kg, and height was measured using a wall-mounted stadiometer with an accuracy of 0.5 cm. Body Mass Index (BMI) was subsequently calculated using the standard formula: weight (kg) divided by the square of height (m^2).

2.7. Cardiorespiratory Fitness

Cardiovascular endurance was assessed using the 2-Minute Step Test. The minimum stepping height, defined as the midpoint between the patella and the iliac crest, was first determined and marked on a wall or adjacent chair for each participant. Participants were then instructed to march in place for two minutes, raising each knee to the marked height. The assessor counted the number of times the right knee reached the target height, with the total count recorded as the participant's score (23, 24).

2.8. Upper Extremity Strength

Upper body strength was evaluated using the 30-Second Arm Curl Test. In a seated position, each participant performed as many bicep curls as possible in 30 seconds using a 1.5 kg dumbbell. The left and right arms were tested separately, with the elbow kept close to the torso and moved through a full 90-degree range of motion (23).

2.9. Lower Extremity Strength

Lower body strength was assessed using the 30-Second Chair Stand Test. Participants were instructed to sit in the

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middle of a standard chair (approximately 43 cm height) with their arms crossed over their chest and to complete as many full sit-to-stand cycles as possible within 30 seconds. The total number of completed stands was recorded (23).

2.10. Statistical Analysis

All data were expressed as mean ± standard deviation (SD). The normality of data distribution was examined using the Shapiro-Wilk test, and homogeneity of variances was verified with Levene's test. Given the fulfillment of these assumptions, analysis of covariance (ANCOVA) was used to compare posttest scores between the experimental and control groups, using pretest scores as the covariate to control for baseline differences. The F statistic, p value, and eta-squared effect size were reported for each outcome. All statistical analyses were performed using SPSS software version 26, with a significance level set at $p < 0.05$. Graphs were created using Microsoft Excel 2016.

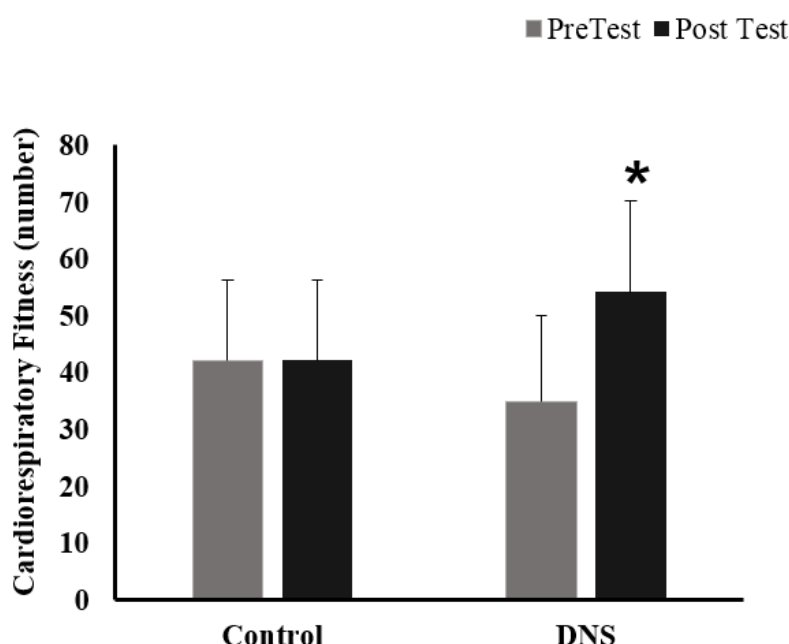
3. Findings and Results

3.1. Cardiorespiratory Fitness

The analysis of covariance indicated a significant difference between the dynamic neuromuscular stabilization exercise group and the control group for cardiorespiratory fitness ($F = 586.88$, $p = 0.001$, $\eta^2 = 0.95$) (Figure 2).

Figure 2

*Pretest-posttest descriptive values for cardiorespiratory fitness. *Significant between-group difference at posttest after adjustment for pretest scores (p = 0.001).*



3.2. Left Upper Extremity Strength

The analysis of covariance indicated no significant difference between the dynamic neuromuscular stabilization exercise group and the control group for left upper extremity strength ($F = 0.350$, $p = 0.550$, $\eta^2 = 0.002$) (Figure 3).

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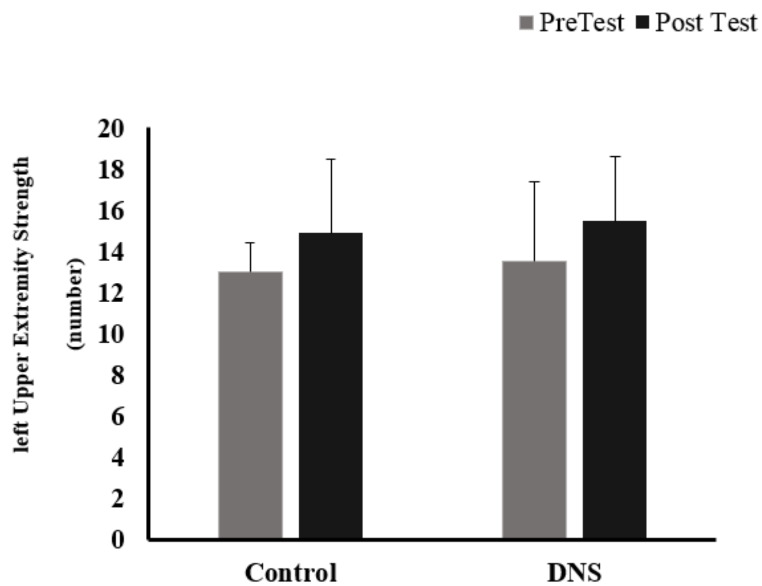
Figure 3

Pretest-posttest descriptive values for left upper extremity strength.

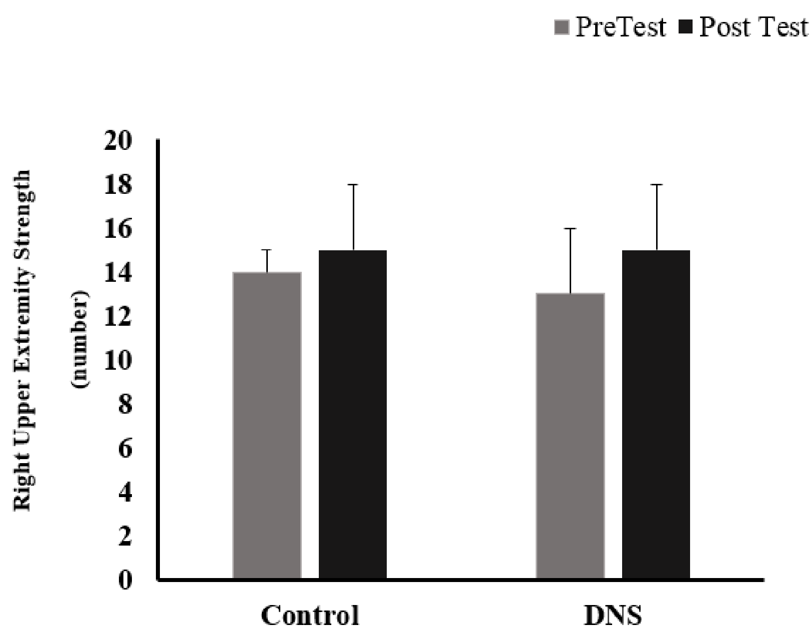


3.3. Right Upper Extremity Strength

The analysis of covariance indicated no significant difference between the dynamic neuromuscular stabilization exercise group and the control group for right upper extremity strength ($F = 0.12$, $p = 0.770$, $\eta^2 = 0.005$) (Figure 4).

Figure 4

Pretest-posttest descriptive values for right upper extremity strength.



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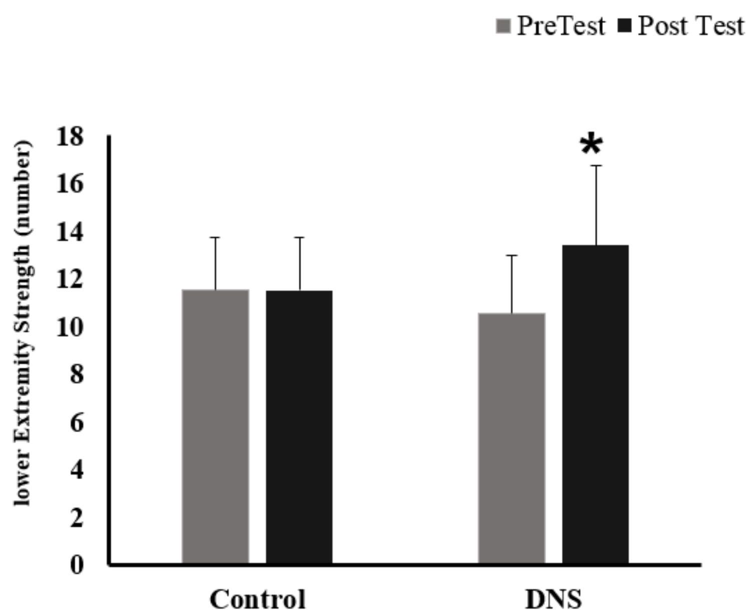
3.4. *Lower Extremity Strength*

The analysis of covariance indicated a significant difference between the dynamic neuromuscular stabilization exercise group and the control group for lower extremity strength (F = 267.00, p = 0.001, $\eta^2 = 0.90$) (Figure 5).

Figure 5

*Pretest-posttest descriptive values for lower extremity strength. *Significant between-group difference at posttest after adjustment for pretest scores (p = 0.001).*



4. Discussion

The present study aimed to investigate the effect of a six-week telerehabilitation-based Dynamic Neuromuscular Stabilization (DNS) exercise program on cardiorespiratory fitness and upper and lower extremity strength in overweight and obese older women. The findings showed a mixed pattern of results: significant improvements were observed in cardiorespiratory fitness and lower extremity strength, whereas no significant changes were detected in upper extremity strength for either the left or right arm. The primary and most robust finding was the substantial improvement in cardiorespiratory fitness within the DNS training group. This result is consistent with evidence supporting DNS exercises for improving respiratory and cardiovascular performance. Binabaji et al. (2025) demonstrated that a six-week DNS intervention improved cardiovascular fitness and respiratory performance in overweight and obese women, attributing these changes to improved diaphragm function and chest mobility (5). Similarly, Mohammad Rahimi et al. (2020) reported that DNS-based breathing exercises improved chest mobility and spirometric indices in individuals with poor posture (25, 26). The likely explanation relates to the DNS emphasis on the diaphragm as both a respiratory and postural muscle (15, 16). In overweight and obese older women, central adiposity may mechanically restrict diaphragmatic excursion and reduce breathing efficiency (19, 27). DNS exercises performed in developmental positions may improve thoracoabdominal coordination, chest expansion, and functional breathing patterns (20). Because the present study used field-based fitness tests rather than direct physiological measurements, mechanisms such as diaphragm function, pulmonary gas exchange, and oxygen extraction should be interpreted as plausible explanations rather than directly measured outcomes.

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The results also demonstrated a significant and clinically meaningful increase in lower extremity strength. This finding is in strong agreement with previous research that has established the efficacy of DNS-based stabilization exercises for improving lower limb muscle function in various populations. Ziya and Saki (2025) reported significant gains in lower extremity strength in older women with low back pain following a stabilization exercise program (11). Similarly, Ziya, Saki, and Arjipour (2026) found that DNS exercises, both alone and combined with the Feldenkrais method, significantly improved hip muscle strength in elderly women (24). The mechanisms underlying this strength improvement are multifactorial. DNS exercises are fundamentally designed to optimize the proximal stability necessary for distal mobility and force generation. By training the integrated spinal stabilizing system, DNS creates a stable, central anchor point from which the hip and knee extensors can generate force more efficiently (11). The progressive nature of the protocol, which advanced from static stability holds to dynamic, closed-kinetic-chain exercises like wall squats, sit-to-stand transitions, and controlled eccentric lowering, provided a direct and progressively overloaded stimulus for the quadriceps, hamstrings, and gluteal muscles (1, 21). In the context of obesity and aging, where muscle quality is often compromised by fatty infiltration (sarcopenic obesity), the enhanced neuromuscular coordination and motor unit recruitment facilitated by DNS can lead to rapid gains in functional strength that may precede significant muscle hypertrophy (6). Moreover, the emphasis on achieving ideal joint centration during loaded movements may have reduced aberrant joint stress, allowing participants to perform strength-building movements with greater confidence and less discomfort, a critical factor in this population .

In contrast to the gains in cardiorespiratory fitness and lower body strength, no significant changes were observed in upper extremity strength for either arm. This null finding can be explained by the specific design and focus of the exercise protocol (28). The DNS intervention implemented in this study prioritized the core stabilization system and lower extremities through weight-bearing, closed-kinetic-chain movements (29). The protocol did not include specific isolated resistance exercises for the biceps or other upper arm muscles, and the 30-Second Arm Curl Test is a specific measure of elbow-flexor strength and endurance (24, 30). Although some DNS exercises require shoulder-girdle stabilization during quadruped positions, this stimulus may have been insufficient to induce meaningful adaptation in the elbow flexors. This interpretation is consistent with the principle of training specificity and with studies showing that the benefits of core-focused stabilization programs are strongest for the trained musculature and functional tasks (31, 32). Therefore, the absence of significant upper-extremity gains is consistent with the content of the intervention rather than a contradiction in the results.

Several limitations of the present study should be considered when interpreting the findings. The study included a relatively small sample and used convenience sampling, which may limit generalizability. The control group received no active comparison intervention, so nonspecific effects related to attention, motivation, and contact with the instructor cannot be fully separated from the specific effects of DNS exercises. The intervention was delivered by telerehabilitation, but outcome assessments were performed onsite; therefore, future studies should report remote monitoring procedures, adherence, and safety outcomes in greater detail. Further trials with larger samples, active control groups, longer follow-up periods, and direct physiological measures such as spirometry, cardiopulmonary exercise testing, dynamometry, and diaphragm ultrasonography are recommended.

Future research should compare different frequencies, durations, and intensities of telerehabilitation-based DNS training to clarify dose-response relationships and optimize exercise prescription. Future studies should also examine hybrid interventions that combine DNS with targeted upper extremity resistance exercises to address the lack of arm-strength improvement observed in the present study. Finally, comparisons between telerehabilitation-based DNS, in-person DNS, and other remote exercise modalities would help determine the relative practicality and cost-effectiveness of this delivery approach.

5. Conclusion

Based on the results, a six-week telerehabilitation-based DNS program may be a practical intervention for improving cardiorespiratory fitness and lower-extremity strength in overweight and obese older women. The lack of significant

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improvement in upper-extremity strength emphasizes the specificity of training and suggests that targeted resistance exercises may be needed when upper-limb strength is a primary goal.

Authors' Contributions

All authors contributed substantially to the study and to manuscript development, and all approved the final version.

Declaration

The authors declare that artificial intelligence tools were used only to assist with language editing, translation, and improvement of the manuscript's readability. All conceptualization, study design, data collection, data analysis, interpretation of findings, and final approval of the manuscript were performed by the authors. The authors take full responsibility for the accuracy, integrity, and originality of the content.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study placed a high emphasis on ethical considerations. Informed consent obtained from all participants, ensuring they are fully aware of the nature of the study and their role in it. Confidentiality strictly maintained, with data anonymized to protect individual privacy. The study adhered to the ethical guidelines for research with human subjects as outlined in the Declaration of Helsinki.

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