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The Effect of Neuromuscular Training on Mental Health, Depression, and Quality of Life among Older Women: A Randomized Controlled Trial

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A B S T R A C T

The rapid growth of the global aging population has intensified concerns regarding the physical, psychological, and social well-being of older adults, particularly women, as age-related declines in neuromuscular control, balance, and mental health contribute substantially to reduced functional independence and quality of life. Neuromuscular training (NMT) has emerged as a promising multimodal approach to counteract these effects. This study aimed to evaluate the impact of a structured six-week NMT program on mental health, depression, and quality of life in older women. This quasi-experimental study employed a pretest–posttest design with a control group. Thirty women aged 60–70 years were randomly assigned to either an experimental group (n=15) or a control group (n=15). The experimental group participated in an 18-session NMT program over six weeks, while the control group maintained their usual activities. Mental health, depression, and quality of life were measured using the GHQ-28, Beck Depression Inventory-II, and WHOQOL-BREF questionnaires, respectively. Data were analyzed using analysis of covariance (ANCOVA) in SPSS26, with the level of statistical significance set at $P<0.05$. Preliminary analyses confirmed baseline equivalence between groups ($p>0.05$), and all ANCOVA assumptions were met. After the intervention, NMT produced significant improvements in mental health ($F(1, 27) = 7.93$, $p<0.001$, $\eta^2=0.38$), depression ($F(1, 27) = 2.29$, $p=0.004$, $\eta^2=0.27$), and quality of life ($F(1, 27) = 10.26$, $p=0.001$, $\eta^2=0.32$). These findings indicate that NMT accounted for a substantial proportion of variance in the measured outcomes. Neuromuscular training significantly improved mental health and quality of life while reducing depressive symptoms among older women. As a safe, low-cost, and accessible form of exercise, NMT may serve as an effective strategy to promote psychological well-being and healthy aging in this population.

Keywords: *Psychological well-being; Aging population; Exercise intervention; Geriatric rehabilitation*

1. Introduction

Aging brings significant biological and functional changes, and the World Health Organization defines older adults as those aged 60 and above (1). Regarding the aging process in Iran, Aghaei et al. (2025) reported that population momentum significantly accelerates the country's demographic aging. Despite this rapid increase in the older population, Iran faces substantial challenges in social policy for aging. Consequently, policymakers must implement essential reforms in retirement, healthcare, elderly care, and family support policies (2). Promoting the quality of life among older adults, especially women who face unique physical, social, and psychological challenges, is therefore a critical public health priority (3-5). Older women often experience stress, depression, cognitive decline, and mood disturbances (6, 7). Lee (2025) highlights three interrelated social pathways affecting mental health: material conditions, psychosocial factors, and behavioral patterns, all disproportionately influencing older adults (8). Reduced social interactions further increase the risk of depression in later life (9). Quality of life reflects positive perceptions of physical, psychological, and social well-being, underscoring the key role of mental health in overall life satisfaction for older women (1).

In this regard, Regular physical activity is a cornerstone of healthy aging. At least 150 minutes of moderate-to-vigorous exercise per week can reduce the risk of chronic diseases and age-related functional decline (4, 10). Exercise benefits are specific to the mode and content of training, and guidelines recommend multimodal programs combining aerobic, strength, balance, and flexibility exercises (11, 12). However, adherence often declines as session frequency increases, with time constraints being a common barrier (6). Evidence shows that combining cognitive and resistance training improves cognitive function, mobility, and quality of life among adults over 65 (13). Likewise, resistance and multimodal programs have been associated with better mood, reduced stress, and higher life satisfaction (14). Neuromuscular training (NMT) integrates balance, coordination, strength, and power exercises, enhancing physical fitness and preventing injuries in older adults (15, 16). Studies indicate that NMT improves static and dynamic balance, muscle strength, and overall quality of life (14, 17), and may outperform endurance or traditional strength training in reducing depressive symptoms (3, 18). Despite these benefits, research specifically assessing the independent effects of NMT on mental health, depression, and quality of life in older women remains limited. Therefore, this study aimed to evaluate the impact of a structured neuromuscular training program on these outcomes in this population.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a quasi-experimental design with a pretest-posttest method and a control group to examine the effects of neuromuscular training on mental health, depression, and quality of life in older women. The study was conducted in Tehran, Iran, over a six-week period. A total of 30 women aged 60–70 years were recruited using convenience sampling. Participants were randomly assigned to either the experimental group (n=15) or the control group (n=15). The sample size was determined using G*Power 3.1, considering a medium effect size (f = 0.35), α = 0.05, and statistical power of 0.80, which indicated that 30 participants would be sufficient to detect significant differences between groups. Eligibility criteria included being female, aged 60–70 years, able to walk independently without assistive devices, free from neurological or musculoskeletal disorders, and not taking medications affecting balance or cognitive function. All participants provided written informed consent prior to enrollment. Exclusion criteria included missing more than three training sessions, experiencing illness or injury during the study, participating in other exercise programs, or voluntary withdrawal. All participants were fully informed of the study's objectives, procedures, potential benefits, and risks.

2.2. Measure

Mental health was assessed using the General Health Questionnaire (GHQ-28), which consists of 28 items evaluating four domains: physical symptoms, anxiety and sleep disturbances, social dysfunction, and severe depression, with seven items per subscale (19). Responses are rated on a 4-point Likert scale, with scores ranging from 0 to 84, where 0–21 indicates optimal mental health, 22–42 at-risk status, 43–63 moderate risk, and 64–84 severe

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condition. The GHQ-28 has demonstrated high reliability and validity in elderly Iranian populations, with a Cronbach's alpha of 0.79 in this study (20). Depression was measured using the Beck Depression Inventory-II (BDI-II), a 21-item questionnaire assessing the severity of depressive symptoms on a 0–4 scale. The BDI-II can be completed individually or in groups and has been validated for use among Iranian older adults (21). Quality of life was assessed using the WHOQOL-BREF, a 26-item instrument covering four domains: physical health, psychological well-being, social relationships, and environmental health.

Responses are rated on a 5-point Likert scale, with higher scores indicating greater subjective quality of life. The WHOQOL-BREF has demonstrated satisfactory reliability among older Iranian populations (22).

2.3. *Intervention*

The experimental group participated in an 18-session neuromuscular training program over six weeks, with three 60-minute sessions per week. All sessions were conducted indoors under the supervision of certified exercise professionals, ensuring participant safety and adherence. Each session was structured into three phases: a 15-minute warm-up including stretching and moderate walking drills, a 40-minute main training phase focused on neuromuscular and balance-based exercises, and a 5-minute cool-down involving light stretching and relaxation techniques. The training program aimed to enhance proprioception, balance, coordination, and core stability. Exercises included single-leg stances, tandem walking, step-ups, and balancing tasks on unstable surfaces (e.g., foam pads), as well as upper- and lower-body coordination drills and functional movements simulating activities of daily living. The detailed exercise protocol is presented in Table 1. The control group did not receive any exercise intervention and continued their usual daily routines. Following the intervention, all participants underwent post-test assessments using the same validated questionnaires under standardized conditions.

Table 1

Neuromuscular Training Program (FITT Principles)

Component	Exercise Type & Description	Sets × Reps / Duration	Intensity / Load	Frequency
Warm-up	Stretching, moderate walking	15 min continuous	Low	3 sessions/week
Balance & Stability	Single-leg stance, tandem walking, step-ups, unstable surface balance	3 × 12–15 reps each	Bodyweight, controlled tempo	3 sessions/week
Coordination	Upper & lower body coordination drills, functional daily-life movements	3 × 12–15 reps each	Low to moderate	3 sessions/week
Core Stability	Planks, bridging, and dynamic core exercises	3 × 30–45 sec holds	Bodyweight	3 sessions/week
Cool-down	Stretching and relaxation techniques	5 min continuous	Low	3 sessions/week

Intensity was kept low to moderate, ensuring safety for older adults.

Progression was achieved by increasing balance difficulty (e.g., foam pads) and coordination complexity.

2.4. *Data Analysis*

The Shapiro-Wilk test was used to verify the normality of continuous variables, confirming that all variables met the assumption for parametric testing ($p>0.05$). Levene's test confirmed homogeneity of variance between groups ($p>0.05$). Between-group comparisons were performed using ANCOVA, while within-group differences were assessed with paired t-tests. Statistical analyses were conducted using SPSS26, with a significance threshold set at $p<0.05$. Results indicated that neuromuscular training significantly improved mental health, reduced depressive symptoms, and enhanced quality of life among older women.

3. Findings and Results

A total of 30 older women successfully completed the study, with 15 participants assigned to the experimental group and 15 to the control group. Participants' ages ranged from 60 to 70 years, with a mean age of 63 ± 1.24 years in the experimental group and 64 ± 1.37 years in the control group. The average height and weight of participants in the experimental group were 156 ± 2.43 cm and 63 ± 1.28 kg, respectively, whereas those in the control group were 158 ±

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1.09 cm and 64 ± 0.63 kg. Independent t-test analyses revealed no statistically significant differences between the two groups in age, height, or weight ($p>0.05$), confirming the homogeneity of participants' baseline characteristics. All participants demonstrated adequate adherence to the study protocol, with an attendance rate exceeding 90%, and no adverse events or injuries were reported throughout the intervention period. Before performing the main analyses, preliminary tests were conducted to verify the baseline equivalence of the experimental and control groups and to confirm that the assumptions required for ANCOVA were satisfied. The Shapiro–Wilk test indicated that all continuous variables were normally distributed ($p>0.05$), and Levene's test confirmed the homogeneity of variances across groups ($p>0.05$). Additionally, the assumption of homogeneity of regression slopes was met ($p>0.05$), ensuring the appropriateness of the ANCOVA procedure. Independent t-test results showed no significant differences between the experimental and control groups in pretest scores for mental health, depression, or quality of life ($p>0.05$). These findings confirmed that both groups were statistically comparable at baseline, allowing any subsequent differences to be attributed to the neuromuscular training intervention rather than pre-existing disparities. Finally, the findings revealed that neuromuscular training had a significant positive effect on mental health ($F(1, 27) = 7.93$, $p<0.001$, $\eta^2=0.38$), depression ($F(1, 27) = 2.29$, $p=0.004$, $\eta^2=0.27$), and quality of life ($F(1, 27) = 10.26$, $p=0.001$, $\eta^2=0.32$). The observed effect sizes (η^2) indicate that the intervention accounted for a substantial proportion of variance in these outcomes (Table 2).

Table 2

ANCOVA results for posttest scores between groups

Variable	Experimental M ± SD	Control M ± SD	$F_{(1,27)}$	P-value	Partial η^2
Mental Health (GHQ-28)	10.30 ± 0.85	23.33 ± 0.57	7.937	0.001	0.38
Depression (BDI-II)	3.20±8.63	4.46 ± 12.87	2.291	0.004	0.27
QoL (WHOQOL-BREF)	53.64 ± 5.07	39.03 ± 6.18	10.263	0.001	0.32

ANCOVA controlled for pretest scores. All tests were conducted with $\alpha = 0.05$

To further examine the effects of the intervention, paired sample t-tests were conducted within each group to compare pretest and posttest scores for mental health, depression, and quality of life. The results demonstrated significant improvements in all three variables among participants in the experimental group following six weeks of neuromuscular training ($p < 0.05$). Specifically, mental health scores increased markedly, depressive symptoms decreased significantly, and quality of life scores improved across all domains. In contrast, the control group showed no statistically significant changes from pretest to posttest in any of the measured outcomes ($p > 0.05$). These findings indicate that the observed improvements were directly attributable to the neuromuscular training intervention rather than external or temporal factors.

In summary, the neuromuscular training intervention led to meaningful improvements in mental health, reductions in depressive symptoms, and significant enhancement in quality of life among older women. These findings underscore the efficacy of structured neuromuscular exercise as a multifaceted approach to promoting psychological well-being and overall life satisfaction in this population.

4. Discussion and Conclusion

The findings of the present study provide compelling evidence that neuromuscular exercise interventions can enhance mental health and overall quality of life among older women. Significant reductions in GHQ-28 subscale scores, including anxiety, somatic complaints, and depression, underscore the potential of neuromuscular training as a holistic approach to psychological well-being in aging population (23). These results are consistent with those reported by Graham et al. (2025), who demonstrated that physical activity interventions improve both physical and mental health outcomes across a variety of clinical populations (24). Similarly, Ahmadi et al. (2023) found that participation in structured sports programs significantly

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benefits mental health among both male and female participants (25). while Sedighian et al. (2020) emphasized that combining exercise with psychological therapy can lead to greater improvements in women's mental health (26). Previous research has suggested that the physiological benefits of neuromuscular exercise, such as enhanced balance, coordination, and muscle strength, contribute to greater autonomy and confidence in older adults, ultimately improving life satisfaction (27). The present study extends these findings by showing that neuromuscular training also alleviates depressive symptoms in older women. In this regard, Fusco et al. (2018) reported that neuromuscular-based strength training produces greater psychological improvements than endurance-based interventions (28). Similarly, Mahmoudi et al. (2022) observed that exercise programs improve depressive symptoms, several dimensions of quality of life, muscular strength, and body composition in elderly individuals (29). Supporting these outcomes, Cunha et al. (2022) found that a 12-week resistance training program reduced depressive and anxiety symptoms regardless of participants' baseline strength or cognitive status (30). A comprehensive meta-analysis by Kashi et al. (2023) further confirmed that resistance and neuromuscular training can enhance multiple dimensions of quality of life and reduce depressive symptoms among older adults (31). Moreover, Niazi et al. (2022) identified a strong association between physical activity, life satisfaction, and physical independence in the elderly, reinforcing the notion that regular exercise contributes to improved functional capacity and well-being (32). Likewise, Ahmadi et al. (2017) emphasized the critical role of physical activity in enhancing the quality of life among older adults, given the growing elderly population (33). In a large-scale study of 633 older women, Linnonen et al. (2007) reported that increased physical activity reduced disability and improved independence and life satisfaction (34). Complementing these findings, Valtueña et al. (2024) concluded that neuromuscular strength training is more effective than traditional resistance training in improving health-related quality of life (35).

One of the key strengths of the current study lies in its multimodal neuromuscular training protocol, which integrates balance, strength, and coordination components. This comprehensive approach addresses multiple dimensions of physical and psychological functioning that are particularly relevant to aging populations. The use of well-validated instruments such as the GHQ-28, Beck Depression Inventory II (BDI-II), and WHOQOL-BREF enhances the reliability and comparability of the results. Furthermore, the study's focus on older women, an often underrepresented group in intervention research, adds valuable insight into gender-specific exercise outcomes. Random allocation of participants and the inclusion of a control group strengthen the study's internal validity. Importantly, the intervention was cost-effective, easily implemented, and conducted in a real-world environment, underscoring its feasibility for integration into community-based health promotion programs.

Nevertheless, this study has some limitations. The relatively small sample size limits the generalizability of the findings, and the absence of long-term follow-up data restricts conclusions about the sustainability of benefits. Future research should replicate these results with larger and more diverse populations, using longitudinal designs to evaluate long-term psychological and functional outcomes. Comparative studies examining distinct neuromuscular components, such as balance-focused versus strength-focused interventions, may also yield more specific recommendations for program optimization.

In conclusion, the present study contributes to the growing body of evidence supporting the inclusion of neuromuscular training in geriatric care and health promotion programs. This intervention proved feasible and effective in improving mental health, reducing depressive symptoms, and enhancing overall quality of life among older women. The findings have important implications for healthcare professionals, policymakers, and community organizations aiming to promote healthy aging through accessible, engaging, and evidence-based exercise programs. Despite its limitations, this research highlights neuromuscular training as a promising, low-cost, and practical approach for fostering psychological resilience and well-being in later life.

Authors' Contributions

All authors contributed substantially to the conception and design of the study. Material preparation, data collection, and data analysis were carried out collaboratively

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by all authors. The first draft of the manuscript was jointly written, and all authors contributed to revising and refining subsequent versions. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

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

This study was approved by the Ethics Committee of the Exercise and Sport Sciences Research Center, Iran, under the ethics code IR-ECSCRI-e3633. Written informed consent was obtained from all participants prior to their inclusion in the study.

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