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Resistance Exercise and Lower Limb Muscle Strength in Older Adults: A Quasi-Experimental Study

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Abstract

Introduction: Sarcopenia, characterized by progressive declines in muscle mass, strength, and function, is common among older adults and contributes to frailty and loss of independence. Resistance exercise is widely recognized as an effective intervention to mitigate these effects by enhancing cellular metabolism and musculoskeletal function.
Methods: This quasi-experimental study employed a pre-test–post-test control group design. A total of 28 participants from the Amal Bakti Abdie Huffadz Foundation were recruited through total sampling, with 13 allocated to the experimental group and 15 to the control group. The intervention consisted of 12 resistance exercise sessions delivered over six weeks, including five exercise types performed in three sets of 10 repetitions. Muscle mass was assessed using the Karada Scan, while lower limb strength was measured with the Five Times Sit-to-Stand Test (5xSTS). No clinical trial registration or external funding was obtained.
Results: Paired-sample t-tests revealed significant improvements in both muscle mass and lower limb strength in the experimental group ($p = 0.000$, $p < 0.05$) between baseline and post-intervention measurements.
Conclusion: Resistance exercise significantly enhances lower limb muscle mass and strength in older adults with sarcopenia. These findings highlight the importance of structured resistance training programs in geriatric care to counteract age-related musculoskeletal decline.

Keywords
Sarcopenia, Older adults, Exercise therapy, Resistance training, Muscle strength, Lower extremity

Introduction

An increase in life expectancy reflects improvements in public health, but it also contributes to the growing proportion of the elderly population.[1] Older adults experience gradual changes across physical, biological, psychological, and social domains.[2] Physiological changes in aging can lead to a decline in immune function, reducing the body's ability to resist both internal and external stressors.[3] According to Indonesia's Central Statistics Agency (BPS), in 2023, the proportion of older adults in the country reached 11.75%, with South Sulawesi ranking sixth nationally at 11.97%.[4]

Aging is a natural process that causes a progressive decline in the performance and function of body systems, including a reduction in muscle mass and strength—especially in the lower extremities. This decline may reach up to 3% annually after the age of 60 and is referred to as sarcopenia.[5] The term sarcopenia originates from the Greek words *sarx* (muscle) and *penia* (loss). The European Working Group on Sarcopenia in Older People (EWGSOP) defines sarcopenia as a progressive and generalized syndrome of skeletal muscle loss and weakness, associated with risks of disability, poor quality of life, and mortality. According to the EWGSOP, the diagnosis of sarcopenia requires the presence of at least two of the following three criteria: low muscle mass, low muscle strength, and poor physical performance. However, in its 2018 update, the EWGSOP recommended using low muscle strength as the primary indicator for sarcopenia.[6] Globally, the prevalence of sarcopenia is estimated to range from 10% to 27%, with higher rates observed outside of Asia, particularly in Oceania.[7]

Resistance exercise is an effective form of physical training for improving fitness and health in older adults. It has been shown to significantly enhance muscle mass and strength by stimulating cellular metabolism and promoting neuromuscular adaptations.[8] The effectiveness of resistance training depends on several factors, including intensity, frequency, duration, and exercise type.[9] Resistance exercise significantly improves gait speed, grip strength, muscle quality, and functional performance.[10] Moreover, a meta-analysis has indicated that while resistance exercise alone is beneficial, combining it with nutritional support—especially protein supplementation—can amplify the effects on grip strength and functional performance, offering a synergistic benefit.[11]

However, local research specifically evaluating the impact of resistance exercise on older adults with sarcopenia remains limited. A preliminary survey conducted on January 19, 2024, at the Amal Bakti Abdie Huffadz Foundation found that 5 out of 8 elderly individuals interviewed using the SARC-F questionnaire were likely to have sarcopenia.

Based on this background, the present study aims to investigate the effect of resistance exercise on muscle mass and lower extremity strength in older adults with sarcopenia.

Methods

This study was conducted in the main hall and designated physical exercise area of the Amal Bakti Abdie Huffadz Foundation, Makassar, which is equipped with basic facilities for elderly fitness training. The research design was a quasi-experimental study with two parallel groups (intervention and control), using a non-randomized pre-test and post-test control group design with a 1:1 allocation ratio. No methodological changes occurred after the study began.

The independent variable was resistance exercise, while the dependent variables were lower limb muscle mass and muscle strength. Inclusion criteria were: adults aged ≥60 years, diagnosed with sarcopenia based on a SARC-F score ≥4, willing to participate in the exercise program, and able to stand and sit independently. Exclusion criteria included: individuals with severe neurological disorders, acute cardiac conditions, significant musculoskeletal impairments affecting mobility, or medical contraindications to resistance training.

The sample size was determined using a total sampling method based on all older adults at the foundation who met the inclusion criteria. Due to the limited population, 28 participants were recruited (13 in the intervention group and 15 in the control group). Two participants from the intervention group dropped out before completing the program. The intervention group underwent a resistance exercise program three times per week for four weeks. Each session lasted 45 minutes and included the following exercises targeting lower limb muscles: knee extension, hip hinge, calf raise, hip rotation, and sit-to-stand exercises using resistance bands. The initial intensity was set at 50% of one repetition maximum (1RM) with progressive increments each week. All sessions were supervised by a trained physiotherapist.

The primary outcome was the change in lower limb muscle mass measured before and after the 6-week period using the Omron HBF-375 Karada Scan, a bioelectrical impedance analysis (BIA)-based body composition analyzer. The secondary outcome was lower limb muscle strength assessed using the Five Times Sit to Stand Test (5xSTS), which records the time required for participants to stand up and sit down five times consecutively without using their arms. There were no changes to outcome measures during the study period. No interim analysis or stopping rules were applied due to the small-scale, quasi-experimental design. Participants were not randomly allocated; instead, group assignment was based on participant availability and willingness to engage in the training program. No allocation concealment, random sequencing, or blocking was applied.

Data were collected directly by the research team (primary data). Analysis was performed using SPSS version 26. The Shapiro-Wilk test was used to assess data normality. For normally distributed data, the Paired Sample t-test was used; for non-normally distributed data, the Wilcoxon Signed-Rank Test was applied. A significance level of $p<0.05$ was considered statistically significant. No subgroup or additional analyses were conducted.

Blinding was not feasible due to the nature of the physical intervention. However, outcome assessments were performed by independent assessors not involved in delivering the intervention to minimize potential bias. There were no significant changes to methodology or eligibility criteria during the study period.

Results

To illustrate the flow of participants throughout the study, Figure 1 presents the CONSORT diagram outlining participant recruitment, eligibility assessment, random allocation, intervention/education delivery, follow-up, and inclusion in the final analysis. A total of 40 participants were screened for eligibility; 30 met the inclusion criteria and were randomly allocated to either the intervention (n = 15) or control (n = 15) group. During follow-up, 2 participants from the intervention group withdrew due to time constraints. Therefore, the final analysis included 13 participants in the intervention group and 15 in the control group (see Figure 1).

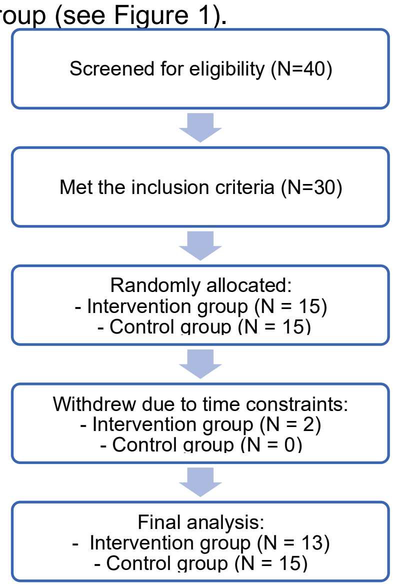

Figure 1. Flowchart of the Study Design

Participant recruitment took place in March 2024, with a follow-up period of four weeks. The study was not terminated early. All randomized participants who received intervention or education were included in the analysis based on the intention-to-treat principle.

Baseline Characteristics

The baseline characteristics of participants in both the experimental and control groups are presented in Table 1, demonstrating comparability between groups prior to the intervention.

Table 1. Baseline Characteristics of Participants

Variable	Intervention Group (n = 13)	Control Group (n = 15)	Total (n = 28)
Sex			
- Male	3 (23.1%)	4 (26.7%)	7 (25.0%)
- Female	10 (76.9%)	11 (73.3%)	21 (75.0%)
Age (years)			
- 60–74	13 (100%)	15 (100%)	28 (100%)
- ≥75	0 (0%)	0 (0%)	0 (0%)
Occupation			
- Housewife	9 (69.2%)	10 (66.7%)	19 (67.9%)
- Retired	3 (23.1%)	4 (26.7%)	7 (25.0%)
- Teacher	1 (7.7%)	1 (6.6%)	2 (7.1%)

Table 1 presents the baseline demographic characteristics of the participants, including sex, age group, and occupation. In both groups, the majority of participants were female and belonged to the 60–74 age group (young-old category). The mean age of all participants was 62.11 ± 3.91 years. The occupational profile shows that most participants were housewives, followed by retirees and teachers.

Muscle Mass Outcomes

Table 2 presents the distribution of muscle mass status in both groups before and after the intervention, highlighting the changes observed following the implementation of the training program.

Table 2. Distribution of Muscle Mass Status Before and After Intervention

Muscle Mass Status	Pre-Test Intervention	Post-Test Intervention	Pre-Test Control	Post-Test Control
Normal	3 (23.1%)	5 (38.5%)	4 (26.7%)	4 (26.7%)
Low	10 (76.9%)	8 (61.5%)	11 (73.3%)	11 (73.3%)

Table 2 shows the muscle mass distribution pre- and post-intervention. In the intervention group, the proportion of participants with normal muscle mass increased from 23.1% to 38.5% after 12 sessions of resistance exercise. Conversely, in the control group, there was no change between pre- and post-test measurements. Descriptive findings from Tables 3 and 4 (see Appendix) indicate that improvements in muscle mass were more prominent among female participants and those working as housewives. All participants were in the 60–74 age group. No participants aged 75 or older were included in the study.

Table 3. Post-Test Muscle Mass by Sex, Age, and Occupation (Intervention Group)

Variable	Normal Mass	Low Mass	Total
Female	4	6	10
Male	1	2	3
Age 60–74	5	8	13
Housewife	3	6	9
Retired	1	2	3
Teacher	1	0	1

Table 4. Post-Test Muscle Mass by Sex, Age, and Occupation (Control Group)

Variable	Normal Mass	Low Mass	Total
Female	3	8	11
Male	1	3	4
Age 60–74	4	11	15
Housewife	4	6	10
Retired	0	4	4
Teacher	0	1	1

Table 5 displays the results of the paired sample t-test, which was conducted to determine the statistical significance of changes in muscle mass within each group before and after the intervention.

Table 5. Paired Sample t-Test Results for Muscle Mass

Group	Mean Difference (kg)	SD	p-value
Intervention	0.509	0.113	0.000
Control	0.041	0.102	0.091

The intervention group showed a statistically significant improvement in muscle mass (p = 0.000). The mean difference in muscle mass was 0.509 (SD = 0.113). In contrast, although the control group also underwent analysis, the result was not statistically significant (p = 0.091), indicating no meaningful clinical change.

Muscle Strength Outcomes

Table 6 presents the distribution of participants' muscle strength status in both groups, assessed before and after the intervention period.

Table 6. Distribution of Muscle Strength Status Before and After Intervention

Muscle Strength Status	Pre-Test Intervention	Post-Test Intervention	Pre-Test Control	Post-Test Control
Good	3 (23.1%)	10 (76.9%)	5 (33.3%)	5 (33.3%)
Weak	10 (76.9%)	3 (23.1%)	10 (66.7%)	10 (66.7%)

Table 6 shows muscle strength distribution. In the intervention group, the proportion of participants with good muscle strength increased markedly from 23.1% at baseline to 76.9% after the intervention. In contrast, no change was observed in the control group; 33.3% of participants maintained good strength across pre- and post-tests. Additional descriptive analyses from Tables 7 and 8 revealed that improvements in muscle strength after intervention were mostly found among female participants, those aged 60–74 years, and participants working as housewives.

Table 7. Post-Test Muscle Strength by Sex, Age, and Occupation (Intervention Group)

Variable	Good Strength	Weak Strength	Total
Female	8	2	10
Male	2	1	3
Age 60–74	10	3	13
Housewife	7	2	9
Retired	2	1	3
Teacher	1	0	1

Table 8. Post-Test Muscle Strength by Sex, Age, and Occupation (Control Group)

Variable	Good Strength	Weak Strength	Total
Female	4	7	11
Male	1	3	4
Age 60–74	5	10	15
Housewife	4	6	10
Retired	1	3	4
Teacher	0	1	1

Table 9 summarizes the paired sample t-test results evaluating the changes in lower limb muscle strength within each group before and after the intervention.

Table 9. Paired Sample t-Test Results for Muscle Strength

Group	Mean Difference	SD	p-value
Intervention	0.523	0.216	0.000
Control	0.081	0.194	0.000*

*Note: Although statistically significant, the change in the control group did not correspond to changes in strength category.

Both the intervention and control groups showed statistically significant p-values (p = 0.000); however, the increase in muscle strength in the control group was not considered clinically meaningful, as no participants transitioned between strength categories. Therefore, the observed change in the control group may be attributed to random variation or measurement error. The observed mean difference in muscle strength for the intervention group was 0.523 (SD = 0.216; 95% CI not available due to software limitations), confirming a significant improvement post-intervention. No adverse events or side effects were reported throughout the study period.

Discussion

This study demonstrated that resistance exercise had a significant effect on changes in muscle mass and muscle strength among older adults at the Amal Bakti Abdie Huffadz Foundation in Makassar following 12 sessions of training. This finding was supported by the significant differences observed in Karada Scan measurements for muscle mass and the Five Times Sit to Stand Test (FTSTS) scores for muscle strength before and after the intervention. Both measurements showed statistically significant results, with p-values of 0.000 for muscle mass and muscle strength ($p < 0.005$).

These findings indicate that resistance exercise positively influences improvements in muscle mass and strength in older adults with sarcopenia when performed regularly and consistently. The results may be applicable to older populations in similar settings, particularly those residing in nursing homes or senior communities. However, caution is advised in generalizing these findings to other older adult populations, such as those who are actively employed or have severe comorbidities, and further studies are needed.

Resistance exercise is a form of physical activity that involves dynamic and static muscle contractions using external resistance. It is a simple, accessible form of training that requires minimal time, making it a suitable option for older adults.[12] The American College of Sports Medicine (ACSM) recommends resistance training programs to improve muscle mass and strength, which can positively impact functional capacity and cellular metabolic processes.[13] In this study, the resistance exercise program consisted of 12 sessions over four weeks, performed three times per week. The exercises were adapted from previous studies and focused on the lower extremities.[13,14] Five exercises were included: knee extension, calf raise, hip hinge, hip rotation, and sit to stand.

The resistance training protocol for older adults must be based on appropriate exercise dosage, including sets, repetitions, frequency, and intensity, to induce optimal physiological adaptations. This study adopted dosage recommendations from Hurst et al.[15] Generally, training frequency for older adults ranges from one to three sessions per week. Training volume is typically expressed as the total number of sets and repetitions completed during a session.

Common guidelines recommend 2–3 sets per exercise with 6–12 repetitions. Rest periods between sets typically range from 60–180 seconds, and 3–5 minutes between exercises, especially in programs involving older adults. Resistance exercise may attenuate or prevent sarcopenia through multiple mechanisms. At the muscle fiber level, it counteracts pathways involved in the pathogenesis of sarcopenia. Resistance training induces positive changes in inflammation, apoptosis, and muscle fiber regeneration, as well as improvements in fiber function and structure.[15] In terms of muscle function, it enhances muscle quality by increasing the number of sarcomeres, which in turn improves tendon stiffness and elastic elongation capacity. Although muscle mass improvements were observed over the four-week period, it remains to be evaluated whether these changes are primarily due to neural adaptations rather than true structural hypertrophy, as muscle tissue adaptation in older adults generally occurs more slowly than in younger individuals.

Beyond its benefits for muscle mass and strength, resistance exercise offers several additional advantages for older adults. According to the *Physical Activity Guidelines for Older Adults* by the American Academy of Family Physicians, resistance training may reduce the risk of mortality, cardiovascular disorders, stroke, type 2 diabetes mellitus, hypertension, and certain cancers.[13] It also supports the maintenance of muscle mass during weight loss and plays a role in obesity management by enhancing muscle mass, which leads to improved metabolism and increased caloric expenditure. Consequently, resistance exercise is recommended as a therapeutic approach for obesity and metabolic syndrome.[16] Improved muscle strength, as reflected in decreased FTSTS time, may directly contribute to enhanced functional capacity in older adults, including sit-to-stand transitions, balance control, and fall prevention.

Lower extremity resistance exercise using elastic bands can also reduce fall risk among older adults. This type of training improves gait speed, flexibility, balance, and quality of life, and may help prevent injury.[17] However, a study by another group reported no significant effects of elastic band resistance exercise, potentially due to low training volume (only twice weekly with two sets per session), low statistical power (attributed to participants' lack of prior resistance training experience and access to health care), and inclusion of participants who used walking aids.[18] This highlights the importance of designing safe and effective exercise programs to prevent injury in older populations. Several meta-analyses have confirmed that while resistance training improves strength and physical performance in older adults, its effects on outcomes such as skeletal muscle mass (SMM), appendicular skeletal muscle index (ASMI), or leg lean mass (LLM) remain variable.[19] Although the majority of studies support the benefits of resistance exercise in older adults, discrepancies in outcomes may be due to variations in training volume or participant characteristics. This underscores the necessity of individualized program design tailored to the physical capacity of each older adult.

This study has several limitations. The small sample size and single-center design limit the generalizability of the findings to broader older adult populations. The four-week intervention period also restricts the ability to observe long-term changes. Moreover, the study did not account for other factors potentially influencing muscle mass, such as nutritional status or daily physical activity levels. Future research should consider longer intervention durations, larger and more diverse populations, and include additional variables that may affect muscle health outcomes.

Conclusion

This study demonstrated that resistance exercise had a significant effect on improving lower extremity muscle mass and strength in older adults with sarcopenia at the Amal Bakti Abdie Huffadz Foundation. Following 12 training sessions, the number of participants with normal muscle mass increased from three to five, while those with low muscle mass decreased from ten to eight. Similarly, the number of participants with good muscle strength increased substantially from three to ten, and those with low strength decreased from ten to three. These findings were supported by objective measurements using the Karada Scan and the Five Times Sit to Stand Test, with the paired sample t-test showing a p-value of 0.000 ($p < 0.05$), indicating statistically significant changes before and after the intervention.

Based on these results, resistance exercise can be considered an effective strategy for enhancing muscle health in older adults with sarcopenia. It is recommended that older adults continue performing resistance exercise regularly as a preventive and therapeutic approach to maintaining or improving muscle mass and strength. For future research, it is suggested to extend the duration of the intervention to more than 12 sessions, incorporate a greater variety of exercises, and utilize standardized and adjustable chairs for all participants to ensure more accurate and generalizable outcomes.

Author Contribution

Khalishah Salsabila: Conceptualization, methodology, data collection, data analysis, and manuscript drafting.
Andi Rahmaniar Suciani Pujiningrum: Methodology, supervision, and critical revision of the manuscript.
Ita Rini: Data interpretation, supervision, and validation.
Bustaman Wahab: Project administration, resources, and review of the final manuscript.
All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing, Hasanuddin University (Approval No. 671/UN4.18.3/TP.01.02/2024). Written informed consent was obtained from all participants prior to data collection.

References

1. Akbar F, Darmiati GM, Suci A. Pemberdayaan lanjut usia dengan senam di Desa Rumpa Kecamatan Mapilli Kabupaten Polewali Mandar. Community Pengawas Din Kesmas. 2021;3(1):19.
2. Cahyadi A, Mufidah W, Susilowati T, Susanti H, Dwi Anggraini W. Menjaga kesehatan fisik dan mental lanjut usia melalui program posyandu lansia. J Pengabdi Masy Darul Ulum. 2022;1(1):52–60
3. Chairil C, Della R. Pengaruh hidroterapi terhadap penurunan tekanan darah pada lansia di UPT Pelayanan Sosial Tresna Werdha Provinsi Riau. J Pengabdi UntukMu NegeRI. 2022;6(1):194–198
4. Badan Pusat Statistik. Statistik penduduk lanjut usia 2023. Jakarta: BPS; 2023.
5. Aryana IGPS. Sarkopenia pada lansia: problem, diagnosis dan tatalaksana. Panuduh Atma Waras; 2021.
6. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(4):601 (erratum) doi removed.
7. Petermann-Rocha F, Balntzi V, Gray SR, et al. Global prevalence of sarcopenia and severe sarcopenia: a systematic review and meta-analysis. J Cachexia Sarcopenia Muscle. 2022;13(1):86–99.
8. Vikberg S, Sörlén N, Brandén L, et al. Effects of resistance training on functional strength and muscle mass in 70-year-old individuals with pre-sarcopenia: a randomized controlled trial. J Am Med Dir Assoc. 2019;20(1):28–34.
9. Abou Sawan S, Nunes EA, Lim C, McKendry J, Phillips SM. The health benefits of resistance exercise: beyond hypertrophy and big weights. Exerc Sport Mov. 2023;1(1).
10. M-W S, S-W J, S-W K, et al. Effects of 16 weeks of resistance training on muscle quality and muscle growth factors in older adult women with sarcopenia: a randomized controlled trial. Int J Environ Res Public Health. 2021;18(13):6762.
11. Geng Q, Zhai H, Wang L, Wei H, Hou S. The efficacy of different interventions in the treatment of sarcopenia in middle-aged and elderly people: a network meta-analysis. Med (United States). 2023;102(27):e34254.
12. Santoso YS, Kristianto H. Resistance band exercise dalam meningkatkan kesehatan lansia: a systematic review. NersMid J Keperawatan Kebidanan. 2021;2(1):23–31.
13. Al Gifarin MY, Nafiah N, Yahya Y, Herry H. Efektivitas modifikasi latihan resistensi terhadap peningkatan massa dan kekuatan otot pada kejadian sarkopenia. J Physiotherapy Health Sci. 2023;6(2):23–29.
14. Hurst C, Robinson SM, Witham MD, et al. Resistance exercise as a treatment for sarcopenia: prescription and delivery. Age Ageing. 2022;51(2):1–10.
15. Wahono D, Niluh NP, Tantri A, Sunarti S, Nurlaila N, Gadis G. Sarcopenia, exercise, and fall incidence in the elderly population. J Kedokt Brawijaya. 2014;28(1):35–39.
16. Lestari US, Asnar E, Suhartati S. Efek perbedaan intensitas latihan resistance elastic band terhadap indeks massa tubuh (IMT). J Biomedik JBM. 2022;14(1):17.
17. Setiawan AIM, Wibisono H. Literature review: pengaruh resistance exercise dengan elastic band untuk ekstremitas bawah terhadap walking speed pada lanjut usia. Indones J Physiother. 2021;1(1):27.
18. Saeterbakken AH, Bårdstu HB, Brudeseth A, Andersen V. Effects of strength training on muscle properties, physical function, and physical activity among frail older people: a pilot study. J Aging Res. 2018;2018:8916274.
19. Chen N, He X, Feng Y, Ainsworth BE, Liu Y. Effects of resistance training in healthy older people with sarcopenia: a systematic review and meta-analysis of randomized controlled trials. Eur Rev Aging Phys Act. 2021;18(1):1–19.