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Effectiveness of modified strengthening and postural control exercise combinations on sarcopenia

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ABSTRACT

Sarcopenia is characterized by age-related losses in muscle strength and mass that contribute to mobility limitations and fall risk. This study assessed changes in lower-extremity muscle strength and anthropometric indicators following a combined strengthening and postural control program among older adults. A pre-experimental one-group pretest–posttest study was conducted with 30 purposively selected adults aged ≥60 years in the Kedungwuni II Community Health Center area. Participants completed a four-week program delivered three times weekly. Muscle strength was assessed using Manual Muscle Testing (MMT), and lower-limb circumference was measured at five points around the patella. Paired changes were analyzed using the Wilcoxon signed-rank test. Participants were predominantly women, with a mean age of 65.33 ± 4.46 years. MMT categories improved across the assessed muscle groups, with the largest reported effect sizes for the vastus lateralis, hamstrings, and vastus medialis. Reported anthropometric changes varied by measurement site. These findings provide preliminary evidence of short-term improvement in lower-extremity muscle strength following the program. However, the absence of a control group, the use of study-specific screening criteria, a small purposive sample, and the lack of direct outcome balance limit causal and clinical interpretation. Controlled studies using standardized sarcopenia criteria and functional outcomes are needed.

1. Introduction

Sarcopenia is a progressive, age-related decline in skeletal muscle strength and mass that contributes to mobility limitations, falls, fractures, loss of independence, and mortality. It is estimated to affect 10%–16% of older adults worldwide [1,2]. Prevalence increases with age, ranging from 5%–13% among adults aged 60–70 years and 11%–50% among those older than 80 years [3].

International frameworks such as EWGSOP2 and AWGS define sarcopenia using low muscle strength and muscle mass, with physical performance used to assess severity. In resource-limited community settings, however, access to standard diagnostic equipment may be constrained. This study, therefore, used Manual Muscle Testing (MMT) and lower-limb circumference as practical, study-specific indicators of muscle-related impairment; these measures were not intended to constitute a standard diagnosis of sarcopenia.

Progressive reductions in muscle mass and strength may limit daily activities and exercise tolerance, creating a cycle of inactivity and further functional decline [4]. Exercise is therefore central to management. Strengthening exercise can promote neuromuscular activation, hypertrophy, muscle strength, and functional abilities such as walking, standing, and independent daily activity [5–7]. Theraband exercise offers adjustable elastic resistance and can be adapted to individual ability [8,9].

Sarcopenia is also associated with impaired balance and neuromuscular coordination. Postural control includes postural orientation—the active alignment of the body relative to gravity and the environment—and postural balance, which uses sensorimotor strategies to stabilize the center of mass during internal and external disturbances [10–12]. Combining strengthening with postural control may therefore address complementary contributors to mobility and fall risk.

Although strengthening, elastic resistance, and balance training have each shown benefits in older adults, evidence on a feasible combined programme in primary or community care remains limited. This study evaluated changes in lower-extremity muscle strength and anthropometric indicators following a modified four-week programme integrating strengthening and postural control exercises among older adults in the Kedungwuni II Community Health Centre area.

2. Method

2.1. Study setting

This pre-experimental study used a one-group pretest–posttest design to assess changes following a combined strengthening and postural control program. It was conducted at an integrated health post for older adults within the Kedungwuni II Community Health Center service area in Pekalongan, Central Java, from January to February 2026. The absence of a comparison group limits causal interpretation.

The primary outcomes were lower-extremity muscle strength, measured by MMT, and side-to-side differences in limb circumference, measured at the patella and at 5 and 10 cm above and below it. Muscle strength was assessed bilaterally for the vastus medialis, vastus lateralis, rectus femoris, hamstrings, gluteus maximus, and gluteus minimus. MMT scores are ordinal, ranging from 0 (no contraction) to 5 (normal strength) [13]. A circumference difference of ≥1.5 cm and an MMT score of ≤3 were used as study-specific screening indicators rather than validated diagnostic criteria for sarcopenia [3,8].

The program was delivered for four weeks, three times per week, under the supervision of a licensed physiotherapist. Each 45-minute session included a warm-up, core exercises, and a cool-down. Strengthening exercises used light-to-moderate therabands and included knee extension, gluteal squeezes, hip abduction and flexion, bridging, clams, seated leg extension, sit-to-stand, mini-squats, and standing hip abduction and extension. Each movement was performed for eight repetitions in two to three sets, with 60 seconds of rest between sets [13,14].

Postural control training comprised four standing conditions: bipedal stance on a rigid surface, bipedal stance on an unstable surface, semi-tandem stance on a rigid surface, and semi-tandem stance on an unstable surface. Each condition was performed barefoot with eyes open and closed while facing a visual target at eye level. Positions were held for 30 seconds with one minute of rest between conditions [15]. Exercises were progressed according to participant tolerance, with movement correction and assistance provided as needed. MMT and anthropometric measurements were repeated after the intervention using the same procedures as at baseline. The program was designed to be simple enough for participants to continue independently after the study. Ethical approval was obtained from the Health Research Ethics Committee of Universitas Muhammadiyah Pekajangan Pekalongan (No. 040/KEP-UMPP/I/2026).

2.2. Samples

Purposive sampling was used to recruit adults aged ≥ 60 years who had an MMT score of ≤3, a side-to-side lower-limb circumference difference of ≥1.5 cm, could follow exercise instructions, and provided written informed consent. These operational criteria identified reduced lower-extremity strength and asymmetry in the community setting and should not be interpreted as standard diagnostic criteria for sarcopenia.

Exclusion criteria were lower-extremity fracture, severe neurological disorder, severe arthritis, organ failure, severe cognitive impairment, inability to participate regularly, or another condition making exercise unsafe. Thirty eligible participants were recruited and completed the programme. The sample size reflected the number of eligible and willing participants available during the study period; no formal sample size calculation was reported.

All sessions were directly supervised by a licensed physiotherapist. Participants were monitored for dizziness, pain, excessive fatigue, balance disturbance, and other symptoms, and were instructed to report discomfort immediately. Sessions were discontinued when continuation was considered unsafe. No adverse events were reported among the 30 participants.

2.3. Instruments

Participants completed a personal data form and underwent MMT and anthropometric assessments. Standardized positions were used to assess the vastus medialis, vastus lateralis, rectus femoris, hamstrings, gluteus maximus, and gluteus minimus [3]. Table 1 presents the interpretation of MMT grades.

Table 1. Interpretation of muscle strength measurements (Manual Muscle Testing) [13]

MMT Grade	Interpretation	Description
0 (Zero)	No muscle contraction	No visible or palpable muscle contraction is detected.
1 (Trace)	Trace muscle contraction	A slight muscle contraction is visible or palpable, but it does not produce joint movement.
2 (Poor)	Full range of motion with gravity eliminated	The muscle is able to complete the full range of motion only when the effect of gravity is eliminated.
3 (Fair)	Full range of motion against gravity	The muscle is able to complete the full range of motion against gravity but cannot tolerate additional resistance.
4 (Good)	Full range of motion against gravity with moderate resistance	The muscle is able to complete the full range of motion against gravity and withstand moderate resistance.
5 (Normal)	Normal muscle strength	The muscle is able to complete the full range of motion against gravity and withstand maximal resistance without evident weakness.

For anthropometric assessment, participants lay supine while the circumference was measured at the patella and at 5 and 10 cm above and below it on both legs. The same landmarks and procedures were used at pretest and post-test to identify side-to-side differences [16].

The study population comprised older adults registered in the Kedungwuni II Community Health Center service area. Coordination with village midwives and integrated health-post cadres supported recruitment and scheduling. Thirty eligible and consenting participants completed the intervention.

2.4. Data analysis

Data were processed and analysed using IBM SPSS Statistics version 26.0. Participant characteristics and outcome distributions were summarised using frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Because outcome data were not normally distributed and MMT grades were ordinal, paired pretest and post-test measurements were compared using the Wilcoxon signed-rank test. Effect sizes were reported as r, and statistical significance was set at $p < 0.05$.

3. Results and Discussion

3.1. Results

Thirty participants aged 60–76 years completed the study. Most were women (80%), aged 60–64 years (46.7%), and not working (46.7%). Table 2 presents the participant characteristics.

Table 2. Distribution of Respondent Characteristics

Characteristics		n	%
Gender	Male	6	20
	Female	24	80
Age Range	60-64 years old	14	46.67
	65-69 years old	8	26.67
	70-74 years old	6	20
	≥75 years old	2	6.67
Daily Activity	Working	4	13.33
	Not working	14	46.67
	Housekeeping	12	40
Body Mass Index (BMI)	Underweight	3	10
	Normal/Ideal	16	53.33
	Overweight	5	16.67
	Underweight	3	10
	Normal/Ideal	16	53.33

Most participants had a normal BMI (53.3%); 20% were obese, 16.7% overweight, and 10% underweight. These categories are reported descriptively and were not analyzed as intervention outcomes.

Table 3. Decreased Muscle Mass of Respondent Pre-Post Intervention (Anthropometry)

Identifying Decreased Leg Muscle Mass (n=30)								
Anthropometric measurement points	*Pre test*				*Posttest*			
	Yes		*No*		*Yes*		*No*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Patella	19	63.33	11	36.67	7	23.33	23	76.67
Above 5cm patella	16	53.33	14	46.67	6	20	24	80
Above 10cm patella	26	86.67	4	13.33	5	16.67	25	83.33
Below 5cm patella	24	80	6	20	8	26.67	22	73.33
Below 10cm patella	23	76.67	7	23.33	6	20	24	80

At baseline, reduced lower-limb circumference was identified most frequently at 10 cm above the patella (86.7%), followed by 5 cm below (80.0%) and 10 cm below the patella (76.7%). Post-intervention anthropometric categories varied across sites (Table 3). The proportion classified as having reduced circumference was highest at 5 cm below the patella (26.7%), followed by the patella (23.3%) and 10 cm below the patella (20.0%).

Table 4. Pre-post muscle strength of respondents (Manual Muscle Testing) (n=30)

No	Muscle	Pre test						Post test					
		Poor		*Trace*		*Zero*		*Poor*		*Trace*		*Zero*	
		n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
1	**Vastus medial**	19	63.33	8	26.67	3	10	26	86.67	4	13.33	0	0
2	**Vastus lateral**	11	36.67	18	60	1	3.33	25	83.33	5	16.67	0	0
3	**Rectus femoris**	25	83.33	4	13.33	1	3.34	21	70	8	26.67	1	3.33
4	**Hamstring**	19	63.33	6	20	5	16.67	28	93.33	2	6.67	0	0
5	**Gluteus maximus**	22	73.33	5	16.67	3	10	24	80	5	16.67	1	3.33
6	**Gluteus minimus**	24	80	4	13.33	2	6.67	27	90	3	10	0	0

Pre-MMT grades are presented in Table 4. Weakness was most common in the rectus femoris (83.3%), gluteus minimus (80.0%), and gluteus maximus (73.3%). The vastus lateralis differed, with most participants classified as trace (60.0%). Post-intervention MMT distributions are presented in Table 6. Across most muscle groups, the zero and trace categories decreased while the poor category increased, indicating improvement from absent or minimal contraction, although strength generally remained below the fair category

Table 5. Muscle Changes in Lower Extremity Muscle Strength Categories Before and After Intervention (n=30)

Muscle	Improved		Unchanged		Declined	
	n	*%*	*n*	*%*	*n*	*%*
Vastus medialis	7	23.33	23	76.67	0	0
Vastus lateralis	14	46.67	16	53.33	0	0
Rectus femoris	4	13.33	26	86.67	0	0
Hamstring	9	30	21	70	0	0
Gluteus maximus	2	6.67	28	93.33	0	0
Gluteus minimus	3	10	27	90	0	0

Table 5 summarizes individual changes in MMT categories. Improvement was most frequent in the vastus lateralis (46.7%), hamstrings (30.0%), and vastus medialis (23.3%); no participant was classified as having declined.

Table 6. The Effect of Combined Strengthening and Postural Control Intervention on Sarcopenia with Muscle Strength (MMT) and Anthropometric Indicators in the Elderly (n=30)

Outcome Variable		Pre-intervention	Post-intervention	Change (Δ)	Test Statistic	p-value	Effect Size (r)
Muscle strength (MMT)	Vastus medialis	Poor: 19 (63.33%); Trace: 8 (26.67%); Zero: 3 (10.00%)	Poor: 26 (86.67%); Trace: 4 (13.33%); Zero: 0 (0%)	Poor ↑23.34%; Trace ↓13.34%; Zero ↓10.00%	Z = -3.52	0.001	0.64
	Vastus lateralis	Poor: 11 (36.67%); Trace: 18 (60.00%); Zero: 1 (3.33%)	Poor: 25 (83.33%); Trace: 5 (16.67%); Zero: 0 (0%)	Poor ↑46.66%; Trace ↓43.33%; Zero ↓3.33%	Z = -4.10	0	0.75
	Rectus femoris	Poor: 25 (83.33%); Trace: 4 (13.33%); Zero: 1 (3.34%)	Poor: 21 (70.00%); Trace: 8 (26.67%); Zero: 1 (3.33%)	Poor ↓13.33%; Trace ↑13.34%;	Z = -2.15	0.031	0.39
	Hamstring	Poor: 19 (63.33%); Trace: 6 (20.00%); Zero: 5 (16.67%)	Poor: 28 (93.33%); Trace: 2 (6.67%); Zero: 0 (0%)	Poor ↑30.00%; Trace ↓13.33%; Zero ↓16.67%	Z = -3.85	0	0.7
	Gluteus maximus	Poor: 22 (73.33%); Trace: 5 (16.67%); Zero: 3 (10.00%)	Poor: 24 (80.00%); Trace: 5 (16.67%); Zero: 1 (3.33%)	Poor ↑6.67%; Zero ↓6.67%	Z = -2.60	0.009	0.47
	Gluteus minimus	Poor: 24 (80.00%); Trace: 4 (13.33%); Zero: 2 (6.67%)	Poor: 27 (90.00%); Trace: 3 (10.00%); Zero: 0 (0%)	Poor ↑10.00%; Zero ↓6.67%	Z = -2.90	0.004	0.53
Anthropometric indicators of muscle mass reduction	Patella	Yes: 11 (36.67%)	Yes: 7 (23.33%)	↓13.34%	$\chi^2 = 4.50$	0.034	0.39
	5 cm above patella	Yes: 14 (46.67%)	Yes: 6 (20.00%)	↓26.67%	$\chi^2 = 8.20$	0.004	0.52

Outcome Variable		Pre-intervention	Post-intervention	Change (Δ)	Test Statistic	p-value	Effect Size (r)
	10 cm above patella	Yes: 4 (13.33%)	Yes: 5 (16.67%)	↑3.34%	$\chi^2 = 0.20$	0.655	0.08
	5 cm below patella	Yes: 6 (20.00%)	Yes: 8 (26.67%)	↑6.67%	$\chi^2 = 0.40$	0.527	0.12
	10 cm below patella	Yes: 7 (23.33%)	Yes: 6 (20.00%)	↓3.33%	$\chi^2 = 0.10$	0.752	0.06

Table 6 reports paired analyses. Significant changes were reported for all assessed MMT outcomes, with effect sizes ranging from 0.39 to 0.75. However, the pre-intervention anthropometric counts do not match the corresponding "Yes" counts in Table 3; the anthropometric change statistics and interpretations therefore require verification against the raw data before publication.

3.2. Discussion

The principal finding was a favorable shift in lower-extremity MMT categories following the four-week combined program. The largest reported effects occurred in the vastus lateralis, hamstrings, and vastus medialis, which are important for standing, gait, and postural stability. The movement from zero or trace to poor indicates improved contraction ability, but it should not be interpreted as a recovery of normal strength, as most participants remained below grade 3.

These short-term changes are physiologically plausible. Progressive resistance exercise can improve motor-unit recruitment, neuromuscular coordination, and, with sufficient duration, muscle hypertrophy[7]. Postural control exercises simultaneously challenge alignment, sensory integration, and stability [10][11][12]. The participant profile provides important context. Most participants were women and in the young-old age group, and almost half were not working. Reduced occupational and daily activity may contribute to functional decline, whereas regular light-to-moderate activity can support strength, balance, and independence [17–19]. BMI also varied: although most participants were in the normal range, both low and high BMI may be relevant to muscle health and mobility [20–22]. Local observational evidence has likewise identified musculoskeletal risks among older adults in institutional care [23]. These characteristics were descriptive and should not be interpreted as predictors because no subgroup analyses were conducted.

Anthropometric findings should be interpreted cautiously. Limb circumference is feasible in community settings but is an indirect indicator influenced by adipose tissue, edema, landmark placement, and measurement error. Moreover, the descriptive counts in Tables conflict with the pre-intervention counts and inferential statistics presented in Table 6. The raw paired data should be checked, and the anthropometric analyses recalculated before drawing conclusions about changes in muscle mass.

The study has practical relevance because the exercises used inexpensive elastic resistance, simple standing positions, and direct physiotherapist supervision, making the program potentially feasible in community care. Exercise remains central to sarcopenia management, while pharmacological options continue to have limitations [24,25]. No adverse events were reported. Nevertheless, feasibility, adherence after supervision ends, and implementation by routine health-post staff were not formally assessed.

Several limitations restrict interpretation. Without a control group, improvements cannot be attributed solely to the program, as other factors such as testing, maturation, usual activity, or other influences cannot be ruled out. The small purposive sample from one setting limits generalizability. MMT is ordinal and assessor-dependent, circumference does not directly measure muscle mass, and study-specific screening criteria do not establish a standard diagnosis of sarcopenia [3]. The study also included postural control exercises but did not directly measure balance, gait, falls, or physical performance. Future studies should use an adequately powered controlled design, standardized sarcopenia criteria, blinded or reliability-tested outcome assessment, and longer follow-up. Direct functional outcomes—such as handgrip strength, chair-stand performance, gait speed, validated balance tests, and falls—would clarify whether changes are clinically meaningful and sustained.

4. Conclusion

A four-week combined strengthening and postural control programme was followed by favourable short-term changes in lower-extremity MMT categories among older adults in one community setting, particularly for the vastus lateralis, hamstrings, and vastus medialis. Because the study lacked a control group and used a small purposive sample with study-specific screening criteria, the findings should be considered preliminary and not interpreted as proof of effectiveness for diagnosed sarcopenia.

The anthropometric results require verification against the raw paired data because the pre-intervention counts reported across tables are inconsistent. Future controlled studies should use standardised diagnostic criteria, direct measures of muscle mass and physical performance, larger samples, and longer follow-up.

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Conflict of Interest

There is no conflict of interest in this research.

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