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Improving Elderly Knowledge and Readiness Through Community-Based Muscle Weakness Education: A Quasi-experimental Study

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ABSTRACT

Introduction: Muscle weakness is an emerging public health concern among older adults worldwide, serving as a visible, primary symptom of sarcopenia. Sarcopenia is a complex geriatric syndrome characterized by progressive and generalized loss of skeletal muscle mass, strength, and physical function. However, awareness and knowledge regarding its prevention and management remain limited. This study aimed to evaluate the effectiveness of a community-based education program in improving knowledge and readiness among older adults to address muscle weakness.
Methods: This study used a quasi-experimental, nonequivalent control group pretest-posttest design, conducted across six elderly schools in Mataram City and West Lombok, with 120 participants purposively recruited. Participants were divided into an intervention group (n = 60) and a control group (n = 60). The intervention group received two 60-minute multi-component muscle weakness education sessions comprising lectures, booklets, and interactive discussions, while the control group received no intervention. Knowledge and readiness were measured before and one week after the intervention using a validated questionnaire. To account for baseline imbalances and demographic confounding, data were analyzed using Analysis of Covariance (ANCOVA) with robust standard errors clustered at the school level.
Results: At baseline, continuous questionnaire scores did not differ significantly between groups ($p > 0.05$). One week post-intervention, the intervention group's knowledge score increased from 11.23 ± 2.14 to 16.08 ± 1.45 (mean change: 4.85 ± 1.58; within-group d = 3.07), and readiness scores increased from 22.15 ± 4.12 to 29.43 ± 3.18 (mean change: 7.28 ± 3.35; within-group d = 2.18). The control group also showed increases, with a knowledge change of 2.87 ± 1.27 (d = 2.26) and a readiness change of 4.42 ± 4.46 (d = 0.99). Multivariable ANCOVA confirmed that the intervention was independently associated with significantly higher posttest knowledge ($F(1, 115) = 24.32$, $p < 0.001$, $\eta^2p = 0.174$) and readiness scores ($F(1, 115) = 18.54$, $p < 0.001$, $\eta^2p = 0.139$).
Conclusion: A structured, multi-modal community-based educational intervention was associated with greater short-term improvement in knowledge and readiness scores compared to a control condition. This immediate questionnaire-based shift does not establish long-term clinical prevention or sustained behavior change. Integrating this program into community health services, such as Posyandu Lansia, represents a potential future direction warranting longitudinal evaluation of operational feasibility, behavioral retention, and objective physical outcomes.

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INTRODUCTION

Muscle weakness is an emerging public health challenge facing aging populations worldwide, acting as a visible, primary symptom of sarcopenia, a formal term of complex geriatric syndrome characterized by progressive and generalized loss of skeletal muscle mass, strength, and physical function (1). Within community health frameworks, addressing sarcopenia requires robust community health literacy focused on maintaining muscle function in later life. When health literacy is poor, early symptoms are ignored, leading to a cascade of negative outcomes.

In the continuum of geriatric vulnerability, unaddressed muscle weakness serves as a major independent risk factor for clinical frailty, a condition of increased vulnerability to endogenous and exogenous stressors (2). Decreased muscle strength and compromised physical function directly drive functional decline, causing severe difficulty in executing daily living activities and generating an increased risk of falls and fractures (3). Ultimately, this trajectory leads to a loss of independence, a drastic decline in health-related quality of life (HRQoL), increased utilization of health services, and, most worryingly, a well-documented increase in all-cause mortality (4).

For Indonesia, this issue represents a critical public health challenge driven by a rapid demographic transition, with the proportion of its elderly population continuing to increase significantly (5). The logical consequence of this change is a surge in the absolute number of individuals at risk of and suffering from muscle weakness, which will place tremendous pressure on existing health and social systems (6).

Analytically, this wide variance reflects a profound diagnostic ambiguity in Indonesia rather than mere statistical gaps. Data from various local studies show wide and inconsistent variations in prevalence rates. Some community-based studies report relatively moderate rates, ranging from 9.1% to 17.6% (7). However, other studies in large cities like Surabaya and Palembang, as well as national surveys, report much higher rates, reaching 41.8%, 48.4%, and even as high as 50.25% (8). The discrepancy is methodologically driven by the use of different diagnostic criteria (e.g., the European Working Group on Sarcopenia in Older People versus the Asian Working Group for Sarcopenia), the use of varying measurement tools (subjective questionnaires like the SARC-F versus objective methods like DXA or BIA), and most importantly, the absence of standardized localized cut-off values tailored to the unique anthropometric and ethnic diversity of Indonesian older population (9). This diagnostic ambiguity at the clinical and research levels strongly indicates a profound gap in awareness and understanding at the general public level. Therefore, a research approach focused on improving baseline knowledge and readiness is a strategic and logical first step in addressing the root of this problem.

This burden is further compounded by the high prevalence of modifiable risk factors among older adults in Southeast Asia, including age, female gender, sedentary lifestyle, and the "double burden" of malnutrition, which encompasses general undernutrition and inadequate intake of protein and vitamin D (9). Amid these challenges, health education has emerged as a cornerstone intervention in geriatric health management (10). Strong scientific evidence demonstrated that effective health education programs can improve health literacy, enhance disease understanding, and foster self-management skills among older adults facing chronic diseases (11).

For the elderly population, the most successful educational strategies are multi-modal, combining methods such as lectures with interactive discussions and take-home materials, as this approach has been shown to increase engagement and information retention (12). Indonesia has a unique opportunity to implement such programs at scale through its established public health infrastructure, particularly the country's extensive network of Integrated Service Posts (*Posyandu*) and community elderly schools, which serve as a natural platform for health promotion activities (13).

Despite this infrastructure, a critical gap persists in the existing domestic and international literature. While global research has established the value of physical and nutritional interventions for sarcopenia prevention, previous international educational models rarely evaluate behavioral readiness (the psychological intention to change) alongside raw knowledge, particularly among older cohorts with low formal educational backgrounds. Furthermore, there is a severe dearth of empirical evidence formally evaluating structured, community-based educational interventions specifically designed to improve knowledge and readiness regarding muscle health within local Indonesian community infrastructures. The scientific novelty of this study lies not merely in its geographic context but in its evaluation of an intermediate behavioral outcome (readiness) utilizing a specific, highly scalable community delivery platform (*Sekolah Lansia*) to bridge the gap between clinical diagnostic ambiguity and public health literacy.

To ensure conceptual discipline and validate the measurement instruments, this study is explicitly grounded in an integrated framework combining the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) (14). Within this integrated paradigm, "readiness" is formally defined as an individual's immediate behavioral intention and psychological preparedness to adopt specific sarcopenia-preventive actions—specifically, an expressed willingness to increase dietary protein intake, engage in structured resistance exercises, seek clinical muscle mass screenings, and involve family care networks. Sarcopenia readiness does not assume immediate lifestyle execution, but rather captures the mandatory, upstream affective and motivational state required to overcome deeply entrenched behavioral inertia.

The primary objective of this study was to quantitatively evaluate the effectiveness of a multi-component, community-based muscle weakness education program in improving the short-term knowledge and preparedness of older adults actively participating in elderly schools in Mataram and West Lombok, Indonesia.

METHOD

Study Design and Cluster Allocation

This study used a quasi-experimental design with a non-equivalent control group and a pretest-posttest approach. This design was chosen to evaluate the impact of an educational intervention in a real-world setting where individual-level randomization was logistically infeasible and carried a high risk of cross-group information contamination.

Allocation was executed at the cluster level rather than the individual level. Six community elderly schools were purposefully selected and assigned as institutional clusters. To minimize social contamination, three schools were allocated to the intervention cohort (n = 60) and three separate schools were allocated to the control cohort (n = 60). Clusters were balanced based on geographic segregation to prevent informal communication or sharing of materials between participants of different groups.

Population and Sample Recruitment

The target population comprised older adults registered as active participants within the six selected elderly schools. A purposive sampling technique was applied to recruit exactly 20 participants from each of the six schools, yielding a total sample size of 120 individuals. To resolve a baseline institusional enrolemant parameter, the inclusion criteria required participants to be: (1) aged 55 years or older (aligning with local institutional enrollment policies that admit individuals approaching senior status to foster early preventative care), (2) register as a regular attendance at the elderly school, (3) capable of communicating fluently in Indonesian, and (4) willing to provide written informed consent. Exclusion criteria included severe cognitive impairment (screened via school administrative records), significant sensory deficits, or physical inability to attend the sessions. Because allocation occurred at the institutional level, all eligible seniors within the selected cluster were assigned to the same study arm.

Research Location

The study was conducted in six distinct elderly schools located in urban (Mataram City) and semi-urban (West Lombok Regency) areas of Indonesia. Data collection and the intervention phase were carried out from January to March 2025.

Instrumentation or Tools

The researchers developed two instruments:

Knowledge Questionnaire – 20 True/False questions (score range 0–20). This instrument evaluated factual comprehension of muscle health across three specific domains: pathophysiology of muscle loss (5 items), modifiable risk factors (7 items), and preventive lifestyle behaviors (8 items). It comprised 20 True/False items, with a total score range of 0 to 20; higher scores indicated superior knowledge

Readiness Questionnaire – 10 items on a 4-point Likert scale (score range 10–40). This instrument operationally defined "readiness" as an individual's behavioral intention and perceived self-efficacy to adopt preventive actions against muscle weakness, guided by the Transtheoretical Model of behavior change. It assessed two main domains: intent to modify physical activity/nutrition (5 items) and confidence in overcoming barriers to

exercise (5 items). Items were scored on a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree), yielding a score range of 10 to 40; higher scores reflected advanced motivational readiness to act.

Both instruments were pilot-tested with 30 seniors from a non-participating elderly school and demonstrated acceptable validity ($r \geq 0.30$) and high reliability (Cronbach's Alpha = 0.84) for the continuous Likert scale (readiness). For the dichotomous True/False scale (knowledge), we have updated our statistical methodology to use the Kuder-Richardson Formula 20 (KR-20), which is the mathematically appropriate metric for binary item structures, achieving a robust coefficient of 0.78

Data Collection Procedures

Baseline data were collected in Week 1 using both questionnaires for all participants. During Weeks 1–2, the intervention group received two 60-minute educational sessions delivered by two qualified community health nurses using a standardized guidebook through a multimodal approach (booklet, lecture, and interactive discussion) covering four modules: introduction, symptoms and risk factors, prevention strategies, and the role of family and community. The curriculum spanned four progressive modules: Module 1 (Introduction to muscle health and sarcopenia), Module 2 (Identifying symptoms and modifiable risks), Module 3 (Preventive lifestyle strategies, including resistance exercise and protein/Vitamin D optimization), and Module 4 (The role of family and community support). Attendance was recorded via sign-in sheets, and a 100% attendance threshold was maintained for the intervention group analysis. The control group continued their routine activities without receiving any additional education. In Week 3 (one-week post-intervention), the same questionnaires were administered again to all participants as a posttest.

Data Analysis and Covariate Control

Data were analyzed using statistical software (SPSS Version 26). Descriptive statistics (frequencies, percentages, means, SD) were calculated to characterize the sample profile. The Shapiro-Wilk test was utilized to assess the data normality. To evaluate baseline equivalence between the intervention and control groups, categorical demographic characteristics (e.g., age categories, sex, education, and employment status) were compared using the Chi-square test, while baseline questionnaire scores were analyzed using the independent samples t-test.

To control for baseline score differences and potential demographic confounding inherent to non-randomized designs, the primary intervention effects were evaluated using Analysis of Covariance (ANCOVA). Two separate ANCOVA models were constructed: one for the posttest knowledge score and one for the posttest readiness score. In each model, the study group (Intervention vs. Control) served as the primary fixed factor predictor, while its respective baseline pretest score was entered as a continuous covariate. To further control for extraneous confounding, demographic covariates showing significant baseline subgroup variations—specifically, chronological age category and employment status—were also entered into the models as covariates.

The magnitude of the adjusted intervention effect was expressed using the adjusted mean difference between groups along with its 95% Confidence Interval (CI). Practical significance was evaluated by calculating the partial eta squared (η^2_p) effect size from the ANCOVA output, where values of 0.01, 0.06, and 0.14 represented small, medium, and large effects, respectively. Because the educational intervention was allocated at the school level (k = 6), participants nested within the same cluster may share unobserved social and environmental traits. Due to the small number of clusters, a full multilevel mixed-effects model was methodologically unfeasible. To account for this limitation while maintaining statistical conservatism, all primary ANCOVA standard errors and corresponding p-values were adjusted using a cluster-robust Huber-White sandwich estimator clustered at the school level. The significance level for all tests was set at α=0.05.

Ethical Approval

This study was approved by the Research Ethics Committee (15/KEP/INKES/Y.III/V/2025). Written informed consent was obtained from all participants. Data confidentiality and the right to withdraw at any stage were ensured.

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RESULTS

A total of 120 older adults from six community elderly schools were assigned to either the intervention (n=60) or the control group (n=60). Demographic and clinical characteristics for the all sample are detailed in Table 1. Most participants were aged 60–70 years, categorized as "young-old" (69.1%), a pre-geriatric cohort aged 55–59 years comprised 19.2% (n=23) of the sample, reflecting early-preventative enrollments in local community elderly schools. Gender distribution was predominantly female (85.8%), and a large majority of participants reported low formal education levels, with 70.0% having no schooling or not graduating from elementary school. Most respondents lived within a nuclear family structure (51.6%) and reported low monthly incomes.

Employment status differed between groups, with more participants in the intervention group economically active, mainly in the informal sector. Most respondents had low income, potentially limiting access to health resources. Marital status was largely married, followed by widowed/divorced. These demographic profiles provide an essential context for interpreting the intervention's effects on knowledge and readiness.

Independent-samples t-tests and Chi-square analyses confirmed that there were no statistically significant baseline variations between the intervention and control groups regarding age, sex, education, income, or baseline questionnaire scores ($p > 0.05$), establishing robust baseline comparability.

Table 1. Demographic and Clinical Characteristics of Respondents at Community Elderly Schools in Mataram City and West Lombok (n = 120)

Variable	Catergory	Total Sample (n=120) n (%)	Intervention Group (n=60) n (%)	Control Group (n=60) n (%)	Between-group p-value
Age	< 60 years	23 (19.2)	11 (18.3%)	12 (20.0%)	
	60–70 years	83 (69.1)	42 (70.0%)	41 (68.3%)	
	71–80 years	7 (5.8)	4 (6.7%)	3 (5.0%)	0.948
	> 80 years	7 (5.8)	3 (5.0%)	4 (6.7%)	
Sex	Male	17 (14.2)	8 (13.3%)	9 (15.0%)	0.793
	Female	103 (85.8)	52 (86.7%)	51 (85.0%)	
Education	No schooling / not graduated	84 (70.0)	41 (68.3%)	43 (71.7%)	
	Elementary school	32 (26.6)	17 (28.3%)	15 (25.0%)	0.612
	Junior high school	1 (0.8)	0 (0.0%)	1 (1.7%)	
	University	3 (2.5)	2 (3.3%)	1 (1.7%)	
Occupation	Housewives	44 (36.6)			
	Laborers	32 (26.6)			
	Retirees	3 (2.5)			
	Traders	9 (7.5)			
	Farmers	6 (5.0)			
	Self-employed	1 (0.8)			
	Unemployed	22 (18.3)			
	Others	3 (2.5)			
Income (Rp)	≤ 500.000	102 (85.0)			
	501.000 – 1.000.000	16 (13.3)			
	1.000.001 – 1.500.000	1 (0.8)			
	> 2.500.000	1 (0.8)			
Marital status	Married	52 (43.3)			

	Widowed/ husband deceased	60 (50.0)
	Divorced	7 (5.8)
	Widowed/wife deceased	1 (0.8)
Living together	Alone	22 (18.3)
	Nuclear family	62 (51.6)
	Extended family	36 (30.0)
Non-Communicable Diseases (NCDs)	Hipertension	50 (41.6)
	Diabetes mellitus	5 (4.1)
	Heart disease	2 (1.6)
	Stroke	1 (0.8)
	Gout	6 (5.0)
	Rheumatism	1 (0.8)
	Others	3 (2.5)
	Hypertension & Diabetes	7 (5.8)
	None	45 (37.5)

Source: Primary Data
Note: p-values calculated via Chi-square tests for categorical distributions and independent t-tests for continuous

Comparative Intervention Effects on Knowledge and Readiness

Statistical analyses revealed that both cohorts experienced increases in knowledge and readiness scores from pretest to posttest ($p<0.05$). However, between-group comparison on the final change score confirmed that the intervention group achieved a significantly greater magnitude of improvements compared to the control group ($p<0.05$).

For the knowledge domain, the intervention group's mean scores increased from 11.23± 2.14 at baseline to 16.08 ± 1.45 at posttest, representing a major change of 4.85 ± 1.58 (95% CI:[4.44, 5.26]; Cohen's d=3.07). Concurrently, the control group's mean knowledge score also increased over the study period, shifting from 11.45 ± 1.98 to 14.32 ± 1.62, for a mean change of 2.87 ± 1.27 (95% CI:[2.54, 3.20]; Cohen's d=2.26). Despite this parallel improvement in the control arm, an independent-samples t-test calculated on the change scores verified that the knowledge gains in the intervention cohort were significantly higher than those of the control cohort ($p < 0.001$).

Similarly, for the readiness scores pattern. The intervention group demonstrated a robust score surge from 22.15 ± 4.12 at baseline to 29.43 ± 3.18 at posttest, yielding a mean change of 7.28 ± 3.35 (95% CI:[6.42, 8.15]; Cohen's d=2.18). Crucially, the control group also tracked an upward trajectory over the three weeks, moving from 21.98 ± 4.35 to 26.40 ± 3.82, which translated to a notable mean change of 4.42 ± 4.46 (95% CI:[3.27, 5.57]; Cohen's d=0.99). An independent-samples t-test conducted on these gain scores confirmed that the intervention cohort achieved significantly higher readiness improvements than the control group ($p < 0.001$).

The baseline questionnaire exposure, informal peer information sharing, or routine developmental activities within the elderly schools may explain the parallel score increases observed in the control group. However, the between-group variance remained highly significant, verifying the superior short-term performance of the structured, multimodal program (Table 2).

Table 2. Comparison of the Difference in Mean Scores (Posttest − Pretest) between the Intervention and Control Groups

Variable	Groups	Baseline		Mean Difference (SD)	95% CI of the Changes	Between group p-value	Within-group effect size (Cohen's d)
		Pretes Mean (+/- SD)	Posttest Mean (+/- SD)				
Knowledge score	Intervention (n=60)	11.23± 2.14	16.08± 1.45	4.850 (1.582)	[4.44, 5.26]	<0.001	3.07
	Control (n=60)	11.45± 1.98	14.32 ± 1.62	2.867 (1.268)	[2.54, 3.20]		2.26
Readiness score	Intervention (n=60)	22.15± 4.12	29.43± 3.18	7.283 (3.345)	[6.42, 8.15]	<0.001	2.18
	Control (n=60)	21.98± 4.35	26.40± 3.82	4.417 (4.458)	[3.27, 5.57]		0.99
Knowledge score	Intervention (n=60)	11.23± 2.14	16.08± 1.45	4,850 (1,582)	[4.44, 5.26]	<0,001	3.07
	Control (n=60)	11.45± 1.98	14.32 ± 1.62	2,867 (1,268)	[2.54, 3.20]		2.26
Readiness score	Intervention (n=60)	22.15± 4.12	29.43± 3.18	7,283 (3,345)	[6.42, 8.15]	<0,001	2.18
	Control (n=60)	21.98± 4.35	26.40± 3.82	4,417 (4,458)	[3.27, 5.57]		0.99

Subgroup Variations and Associated Factors

To eliminate data redundancy, the isolated bivariate screening profiles were synthesized to identify individual participant characteristics associated with continuous outcome changes (Table 3). Chronological age was significantly associated with both knowledge improvements (p=0.032) and readiness score variations (p = 0.041). Participants aged 60–70 years demonstrated the highest mean score improvements (knowledge change: 4.75 ± 1.58; readiness change: 7.21 ± 3.41), whereas participants older than 80 years recorded the lowest mean score increase. Additionally, employment status was significantly associated with outcomes; older adult who remain economically active achieved significantly higher score improvements than their non-working peers (p<0.05). In contrast, demographic variables including gender, education tier, income level, and marital status showed no statistically significant associations with either knowledge or readiness improvement (p>0.05). These findings suggest that chronological age and ongoing employment are classified as variables that are associated with the community-based educational outcome rather than definitive predictors or independent determinants.

Table 3. Bivariate Associations between Respondent Characteristics and Knowledge and Readiness Scores

Characteristic	Category	Knowledge Mean ± SD	p-value	Readiness Mean ± SD	p-value
Ages	< 60 year	4.35 ± 1.45	**0.032**	6.90 ± 3.12	**0.041**
	60–70 year	4.75 ± 1.58		7.21 ± 3.41	
	71–80 year	3.90 ± 1.33		5.85 ± 2.98	
	> 80 year	3.65 ± 1.25		5.50 ± 2.87	
Sex	Male	4.60 ± 1.50	0.514	7.05 ± 3.25	0.628
	Female	4.80 ± 1.56		7.15 ± 3.40	
Education	Low	4.70 ± 1.55	0.651	7.10 ± 3.35	0.722
	Higher	4.85 ± 1.60		7.20 ± 3.38	
Occupation	Not working	4.20 ± 1.42	**0.027**	6.35 ± 3.10	**0.033**
	Working	4.95 ± 1.58		7.40 ± 3.45	
Income	Low	4.65 ± 1.54	0.582	7.00 ± 3.28	0.695
	High	4.85 ± 1.57		7.25 ± 3.36	
Marital status	Marriage	4.80 ± 1.55	0.711	7.20 ± 3.38	0.809
	Not married/widowed/widower	4.65 ± 1.53		7.00 ± 3.30	

Multivariable Analysis of Intervention Effects

To isolate the independent association of the educational program while strictly controlling for baseline scores, age, and employment status, multivariable ANCOVA models were executed (Table 4). For the knowledge domain, after adjusting for pretest scores and demographic covariates, enrollment in the multimodal educational intervention was associated with a significantly higher posttest knowledge score compared to the control condition ($F(1, 115) = 24.32$, $p < 0.001$). The adjusted mean difference between the groups was 1.98 points (95% CI: [1.42, 2.54])). The partial eta squared value ($\eta^2_p = 0.174$) indicated a large practical effect size, demonstrating that the program accounted for 17.4% of the unique variance in posttest knowledge scores when controlling for baseline imbalances. For the readiness domain, the ANCOVA model confirmed a parallel, positive independent association. After controlling for baseline readiness scores, age, and working status, participants in the intervention arm achieved significantly higher posttest readiness metrics than their control counterparts ($F(1, 115) = 18.54$, $p < 0.001$). The adjusted mean difference between the arms was 2.86 points (95% CI:[1.95, 3.77]). The partial eta squared score ($\eta^2_p = 0.139$) reflected a robust effect size, confirming that the intervention explained 13.9% of the variance in short-term readiness intention. These multivariable outcomes confirm that the community-based educational program maintains a highly robust, independent association with short-term score improvements, even after mathematically neutralizing baseline variations and demographic confounding.

Table 4. Multivariable ANCOVA Models Evaluating the Independent Association of the Intervention with Posttest Scores (n = 120)

Dependent Variable and Predictors	Adjusted Mean Categories	95% Confident Interval (CI)	*F*-statistic (df)	p-value	Practical Effect Size (η^2_p)
Model 1: Posttest Knowledge					
Intervention Group (vs. Control)	1.983	[1.421, 2.545]	24.32 (1, 115)	**<0.001**	**0.174 (Large)**
Baseline Pretest Knowledge Covariate	-	-	12.14 (1, 115)	0.001	0.095
Age Category Covariate	-	-	4.12 (1, 115)	0.045	0.035
Employment Status Covariate	-	-	1.08 (1, 115)	0.301	0.009
Model 2: Posttest Readiness					
Intervention Group (vs. Control)	2.866	[1.954, 3.778]	18.54 (1, 115)	**<0.001**	**0.139 (Large)**
Baseline Pretest Readiness Covariate	-	-	8.45 (1, 115)	0.004	0.068
Age Category Covariate	-	-	2.31 (1, 115)	0.131	0.020
Employment Status Covariate	-	-	4.87 (1, 115)	0.029	0.041

Note: Models control for baseline pretest scores, age category, and employment status simultaneously. Adjusted mean difference applies to the Intervention group relative to the Control reference arm.

Overall, the findings demonstrate that the muscle weakness education program was effective in improving knowledge and readiness among community-dwelling older adults. The effects were consistent across respondent characteristics but were most pronounced in younger-old adults (60–70 years) and those who remained employed. In contrast, participants aged >80 years and those not working achieved relatively lower scores, highlighting the need for more intensive and adaptive strategies for these groups. Tailored approaches, such as shorter but more frequent sessions, simplified visual media, and direct assistance in practicing preventive physical activities, are recommended to optimize intervention outcomes.

DISCUSSION

Interpretation of Key Findings and Potential Pathways

The multivariable Analysis of Covariance (ANCOVA) confirms that a structured, community-based, multimodal muscle weakness education intervention was independently associated with significantly improved short-term intermediate knowledge and readiness scores among older adults compared with a control situation. This demonstrates that a combination of interactive lectures, group discussions, and high-quality visual media serves as an effective mechanism for immediate, short-term classroom learning (15).

However, since psychological constructs were not independently isolated via validated scales in this study, the underlying behavioral mechanisms remain to be empirically verified. The observed immediate cognitive improvements may be tentatively rooted in cognitive learning theory, where highly structured, multisensory engagement serves as a compensatory mechanism to mitigate age-related short-term memory limitations (16). Furthermore, the marked shift in readiness may tentatively reflect the alterations within the participants' latent health beliefs frameworks—such as elevated perceived susceptibility to sarcopenia or enhanced self-efficacy—which ultimately stimulated an immediate intention to adopt preventive actions (16,17). Our subgroup variations further indicated that younger elderly (60-70 years) and those maintaining active employment status achieved greater score improvements. To avoid overstating these associations, these parameters must be interpreted purely as plausible, hypothetical pathways rather than established structural mechanisms. Younger older adults and economically active individuals probably possess higher baseline cognitive reserves, superior baseline physical mobility, greater routine exposure to diverse social environments, and more frequent independent access to daily information health nodes. While these unmeasured individual traits may create a more fertile baseline for absorbing, processing, and retaining community health education materials (18,19). Further structural equation modeling is required to empirically disentangle their independent mediation effects.

Critical Distinction Between Educational and Clinical Outcomes

A critical temporal paradox arises when analyzing these outcomes: while a brief, two-session educational curriculum was associated with prominent, measurable score improvements within one week, these acute gains must not be conflated with durable learning, stable behavioral adaptation, or long-term clinical prevention. To maintain strict scientific accuracy, a fundamental distinction must be made between these intermediate educational outcomes and actual clinical or behavioral endpoints.

Immediate cognitive gains and short-term readiness (expressed as behavioral intention) represent introductory, intermediate psychological states. According to health behavior literature, these immediate questionnaire-based shifts are highly volatile and inherently vulnerable to an acute "decay effect," where information retention and initial motivation sharply decline without permanent reinforcement loops. True preventive behavior execution—such as executing regular resistance exercise routines or permanently modifying protein intake—operates at a completely different, downstream behavioral level (14).

This study did not measure physical muscle decline, muscle strength, clinical frailty, fall risks, actual dietary intake, objective physical activity levels, or health-related quality of life. Therefore, the data support conclusions regarding short-term health literacy and motivational changes alone. No broader claims regarding clinical prevention, physiological changes, or long-term health outcomes can be supported by these findings.

Furthermore, the construct of "readiness" must be interpreted with extreme caution and must not be treated as empirical evidence that participants will actually adopt preventive practices in their daily lives. Readiness represents a psychological intention, which is highly distinct from sustained behavioral execution. Even if an older adult expresses an optimal readiness score to prevent muscle weakness, they face formidable, deeply entrenched systemic, socioeconomic, and personal barriers when attempting to translate that classroom readiness into physical practice.

In community settings, these real-world barriers frequently include musculoskeletal pain, a lack of instrumental family or caregiver support, limited geographic or physical access to safe exercise facilities, low financial income to purchase high-quality protein-rich foods, chronic underlying diseases, and a pervasive fear of injury during physical exertion. Consequently, while the intervention successfully shifted immediate intention, it

cannot be assumed to drive actual lifestyle modifications without extensive, ongoing structural and environmental support frameworks.

According to the findings of this study, while the between-group differences achieved high statistical significance ($p < 0.001$), evaluating the practical, real-world utility of these metrics is essential for public health applications. The 4.85-point mean increase in knowledge within the intervention group represents more than an abstract statistical shift; conceptually, it signifies a transition from baseline ambiguity to the mastery of core prevention concepts. Practically, this gain reflects an improved capacity to correctly identify early warning signs of sarcopenia (e.g., slow walking speed, frequent falls) and articulate the fundamental roles of protein intake and resistance training.

Similarly, the 7.28-point increase in readiness marks a meaningful shift in behavioral intention. In practical terms, this degree of improvement indicates that participants moved past passive awareness and achieved an active preparedness to execute lifestyle modifications. This includes an expressed commitment to participating in structured community exercise sessions, increasing daily dietary protein consumption, and proactively consulting local health practitioners for muscle mass screenings.

Comparison with Previous Studies

These findings are consistent with earlier research highlighting the importance of active participation and multisensory strategies in adult education (20,21). Previous studies also report that socially and economically active older adults maintain better functional health and demonstrate greater motivation to preserve it (22,23). This is supported by psychosocial mechanisms, where engagement in productive activities enhances self-confidence and a sense of purpose, which drive healthy behaviors (24,25). Moreover, the non-significant effects of sociodemographic variables such as gender, education, and income align with research showing that participatory, tailored approaches can minimize disparities and make interventions accessible to diverse groups of older adults (26,27).

Limitations and Cautions

This study has several limitations. First, its quasi-experimental design cannot fully eliminate the risk of selection bias, even though baseline characteristics were matched between groups. Second, the outcomes were measured only immediately after the intervention, which serves as an inadequate proxy for permanent habit formation, long-term memory retention, or sustained physical readiness. Educational interventions targeting older populations frequently experience a "decay effect," where initial cognitive and behavioral gains progressively decline over subsequent months without structured reinforcement. Third, external factors such as family support, health status, and personal motivation were not assessed in depth, even though they may strongly influence behavior change and program success. These limitations suggest that the findings should be interpreted with caution, particularly regarding generalizability and sustainability over time. To transform immediate readiness into permanent health habits, community frameworks cannot rely on isolated educational events. Instead, they must incorporate regular booster education sessions, structured family care networks to reinforce compliance at home, and environmental modifications within local seniors' spaces to support ongoing physical activity.

Broader variables, including objective physical activity levels, general clinical health status, and social support matrices, should be incorporated to gain a more comprehensive understanding of factors that enhance program outcomes. Developing adaptive educational modules tailored specifically for the oldest-old (>80 years) using simplified language, high-frequency repetition, and tactile visuals is highly recommended to bridge the subgroup gaps identified in Table 4. Additionally, integrating this intervention into routine community-based services such as Posyandu Lansia, established exercise groups, or religious gatherings, alongside training active seniors to serve as peer facilitators, represents a vital strategy to ensure institutional scalability and nationwide sustainability.

Recommendations for Future Research

Future studies should adopt longitudinal designs with repeated measurements (e.g., at 3, 6, and 12 months) to evaluate the sustainability of the intervention’s effects and map the rate of knowledge decay. Broader variables, including objective physical activity levels, general health status, and social support metrics, should be incorporated to gain a more comprehensive understanding of factors that enhance program outcomes. Developing adaptive

educational modules tailored specifically for the oldest-old (>80) years, using simplified language, high frequency repetition, and tactile visuals, is highly recommended to bridge the subgroup gaps identified in Table 4. Additionally, integrating this intervention into routine community-based services such as Posyandu Lansia, established exercise groups, or religious gatherings, alongside training active seniors to serve as peer facilitators, represents a vital strategy to ensure institutional scalability and nationwide sustainability.

CONCLUSION

This study demonstrated that a structured, community-based, multimodal educational intervention was associated with short-term improvements in intermediate knowledge and readiness scores among selected communities of older adults in elderly schools. Subgroup variations indicated that chronological age and ongoing employment status were significant factors associated with intermediate outcomes, whereas other baseline sociodemographic variations showed no significant associations. Because long-term behavioral compliance or physiological variations were not tracked, these findings do not state or imply that the curriculum directly prevents muscle decline, improves functional status, or enhances health-related quality of life. The integration of this program in routine community health activities, such as Posyandu Lansia or primary healthcare services, represents a potential public health strategy that requires substantial further evaluation. Before institutional scaling can be recommended, future longitudinal investigations are essential. These subsequent studies must incorporate extended follow-up periods to map knowledge decay, introduce rigorous cluster-aware statistical analyses to account for school-level variations, utilize independently validated readiness instruments, and measure direct behavioral or objective physical outcomes.

This study contributes to the international geriatric health promotion and preventive public health literature by providing an empirical model of how targeted, multimodal education can alter immediate cognitive and motivational states in older populations with low formal educational backgrounds. Rather than relying solely on its localized Indonesian geographic context for novelty, this investigation speaks directly to broader global debates concerning the operationalization of sarcopenia-related health literacy and the architecture of behavioral readiness in resource-constrained community settings.

AUTHOR CONTRIBUTIONS STATEMENT

A.S: Conceptualization, Methodology, Investigation, Writing Original Draft, Review & Editing, Supervision, Project Administration.
R.R.M: Conceptualization, Methodology, Formal Analysis, Data Curation, Writing Original Draft.
H.K: Methodology, Validation, Resources, Review & Editing.
N.S: Investigation, Data Curation, Writing Original Draft.
S: Investigation, Resources, Review & Editing.
D.N: Investigation, Visualization, Review & Editing.
N.K.M: Resources, Investigation, Project Administration.
M.S.H: Resources, Investigation, Validation.
S: Methodology, Formal Analysis, Supervision, Review & Editing, Validation.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest regarding this study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors acknowledge the use of AI-assisted technologies (ChatGPT and Grammarly) to improve the clarity, structure, and grammar of the manuscript. All content was reviewed and validated by the authors to ensure accuracy and originality

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