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REHABILITATION IMPACT OF VIVIFRAIL EXERCISE PROGRAM TYPE C ON THE COGNITIVE FUNCTION OF PRE-FRAIL ELDERLY PEOPLE IN THE COMMUNITY

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ABSTRACT

Frailty is a clinical syndrome that increases vulnerability, potentially leading to disability or death. The pre-frail phase is ideal for preventing frailty and improving quality-adjusted life years, particularly through physical exercises that reduce the risk of dementia and cognitive impairment. Multicomponent exercises, such as the Vivifrail Exercise Program, may enhance cognitive function and daily independence by preventing and mitigating frailty through tailored routines. However, its impact on cognitive function in pre-frail elderly people had not been well studied. This study aimed to determine the effect of the Vivifrail Exercise Program Type C on the cognitive function of pre-frail elderly people. This study was a quasi-experiment with a non-randomized control group pretest-posttest design. The sample was chosen by the quota sampling method. Twenty-seven subjects were analyzed, comprising 16 individuals in the exercise group and 11 individuals in the control group. The exercise group participated in the Vivivfrail Type C Exercise Program, with 45-minute sessions conducted biweekly for 12 weeks. The evaluated parameters included the Montreal Cognitive Assessment-Indonesian Version (MoCA-INA) and the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA). The statistical analysis utilized the Kruskal-Wallis test, followed by the post-hoc Mann-Whitney test and independent t-test ($p<0.05$). A path analysis was performed using simple linear regression. The subjects' average ages were 72.2 years in the control group and 67.47 years in the exercise group. The Vivifrail Exercises Program Type C significantly improved the MoCA-INA scores from 20.25 to 24.06. It also increased the LOTCA scores in several domains, i.e., thinking operations and visual perception. The exercise group demonstrated more improvement than the control group ($p=0.032$). An enhancement in cognitive function was particularly observed in elderly women with pre-frailty. In conclusion, the Vivifrail Exercise Program Type C can help improve the cognitive function of the elderly within the community.

Keywords: Vivifrail Exercise Program Type C, quality-adjusted life year, pre-frailty, elderly

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Highlights:
1. This study emphasizes the importance of providing physical exercises to pre-frail elderly individuals, especially in a community setting.
2. This study establishes a foundation for future research to explore the relationship between physical exercise, particularly the Vivifrail Type C Protocol, and cognitive function in pre-frail elderly individuals.

INTRODUCTION

Frailty is a syndrome that indicates vulnerability, and it can lead to disability or death. The five key aspects of frailty are nutritional status, energy levels, physical activity, mobility, and muscle strength. Research has shown a link between frailty and mild cognitive impairment (MCI), a condition referred to as cognitive frailty (Borges et al. 2019). The pre-frail stage presents an optimal opportunity for preventing frailty, which is commonly found among the elderly. Preventive strategies, including physical exercises, have proven effective in preventing disability and cognitive decline. Exercise programs, such as

Vivifrail, serve as general guidelines for a multicomponent physical exercise regimen aimed at preventing and managing frailty and the risk of falls in the elderly. However, their impact on cognitive function in pre-frail elderly individuals had remained uncertain. Additional research is necessary to assess the effectiveness of the Vivifrail Exercise Program for enhancing cognitive function within this population (Borges et al. 2019).

A systematic review conducted by O'Caoimh et al. (2021) highlighted the global variations in frailty prevalence among elderly people, with Africa having the highest rate at 22% and Europe the lowest at 7%. On the other hand, the Frailty Index indicated high prevalence rates in Oceania (31%), Asia (25%), America (23%), and Europe (22%). The overall prevalence rate of frailty was reported to be 25.2%, with an average age of around 74.2 years. Indonesia reported a frailty prevalence rate of 27.4% among outpatients, with 71.1% being classified as pre-frail. In Surabaya, the prevalence was recorded at 5.2% for men and 31.5% for women. In Malang and Pasuruan, 83.3% of the elderly were classified as pre-frail and 14.2% as frail (Setiati et al. 2021, Soenarti et al. 2024).

Frailty is influenced by multiple internal and external risk factors. Internal risk factors include lifestyle imbalance, physical inactivity, low vitamin D levels, and psychological conditions such as depression and apathy (Vaughan et al. 2015, Lorenzo-López et al. 2017, Rossi et al. 2021). Additionally, Satake & Arai (2020) have asserted that environmental factors, such as the presence of a partner, may also contribute to the development of frailty. Certain diseases, including diabetes, chronic kidney disease, obesity, cardiovascular diseases, and human immunodeficiency virus (HIV), increase the risk of frailty. Nutritional intake, particularly protein and micronutrients, plays a crucial role in preventing frailty, in addition to regular physical activity. Frailty is characterized by multisystem dysregulation, including chronic inflammation and immune activation, which lead to diminished homeostasis and increased vulnerability to morbidity and mortality (Martin & Ranhoff 2021). Key systems involved in the pathogenesis of frailty include the inflammatory and immune systems, musculoskeletal system, and endocrine system, with chronic inflammation being the central mechanism. This chronic inflammation is often linked to factors such as persistent infections, potentially resulting in other conditions such as sarcopenia, osteopenia, and hormonal imbalances, hence further exacerbating frailty (Davies et al. 2018, Buchebner et al. 2019).

Cognitive frailty is characterized by the simultaneous presence of physical frailty and cognitive impairment. This condition may manifest without dementia, although it is often marked by a clinical dementia rating (CDR) of 0.5. Furthermore, this condition suggests increased vulnerability to stressors and may represent a pre-dementia stage or mild cognitive impairment (Petridou 2020). Mild cognitive impairment can manifest in various forms, such as amnestic or non-amnestic types, and frequently precedes Alzheimer's disease. Several assessment tools, notably the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA), can be used to evaluate cognitive function (Zhuang et al. 2021). Cognitive training and stimulation are among cognitive rehabilitation strategies that can maintain or enhance cognitive function in older adults. Physical exercises have been demonstrated to provide beneficial effects on cognitive function, potentially through mechanisms such as the increased production of brain-derived neurotrophic factor (BDNF) (Yoon et al. 2018, Nay et al. 2021). Brigola et al. (2015) suggested that exercises offer psychological and social benefits, such as improved mood and sleep quality. Additionally, it has been shown that older adults may experience a reduced risk of falls through exercises. This benefit can be attained by enhancing physical capabilities, including strength and balance (Enderlin et al. 2015, Sánchez-Sánchez et al. 2022a).

The Vivifrail Exercise Program is an international exercise initiative aimed at preventing frailty and reducing fall risks among the elderly. Started in 2015 with support from the United Kingdom's Erasmus Plus Program, it involves collaboration across several European countries and emphasizes the evaluation of elderly health according to functional ability parameters rather than solely through disease indicators. The program, used by over 5,000 healthcare professionals and benefiting around 15,000 individuals, integrates strength, balance, endurance, and flexibility exercises tailored to individual needs according to assessments such as the Short Physical Performance Battery (SPPB) (Izquierdo et al. 2021). Vivifrail has exhibited effectiveness in improving grip strength, walking speed, balance, and cognitive function while also reducing the risk of falls. Its effectiveness has been noted in both short-term (4 weeks) and long-term (24 weeks) training sessions. Various countries have reported positive outcomes from this exercise program, including improved maximum oxygen consumption (VO_2 max), reduced fatigue, and enhanced cognitive function in the elderly (Casas-Herrero et al. 2019, Sánchez-Sánchez et al. 2022b). In this study, the aim was to determine whether the Vivifrail Exercise Program Type C could improve cognitive function in pre-frail elderly individuals within the community setting.

MATERIALS AND METHODS

This study employed a quasi-experimental research design incorporating a non-randomized control group pretest-posttest design. The research was conducted from November 2023 until March 2024 in Ardirejo Village, Kepanjen District, Malang, Indonesia. The Health Research Ethics Committee of the Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia, issued the ethical clearance for this study under reference No. 81/EC/KEPK/03.2022 on 31/3/2022. The study population consisted of elderly individuals over 60 years of age who were community members of Ardirejo Village and willing to participate in all activities conducted in the study for 12 weeks. The participants were subjected to data collection regarding age, height, weight, body mass index (BMI), Barthel Index, nutritional status, handgrip strength, balance, and cognitive function. The subjects' nutritional status was assessed using the Mini Nutritional Assessment-Short Form, the EuroQol-5 Dimension (EQ-5D), and the Short Physical Performance Battery. The Timed Up and Go (TUG) test and the Berg Balance Scale were employed in the measurement of balance. The subjects' cognitive function was determined according to the Montreal Cognitive Assessment-Indonesian Version (MoCA-INA) and the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) results (Wang et al. 2014, Kang et al. 2018).

In accordance with the exercise recommendations for older adults outlined by Izquierdo et al. (2021), the subjects were categorized into robust, pre-frail, and frail groups depending on their baseline characteristic measurements. Subjects in the pre-frail group were then divided into control and intervention groups. The intervention group was designated to participate in the Vivifrail Exercise Program Type C, whereas the control group did not receive any training or education. The Vivifrail Exercise Program Type C was conducted twice a week for a period of 12 weeks.

The outcomes were assessed in accordance with the Montreal Cognitive Assessment-Indonesian Version (MoCA-INA) and the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA). The collected data were analyzed to determine the impact of the Vivifrail Exercise Program Type C on cognitive function improvement in pre-frail elderly individuals. This analysis was performed for both the intervention and control groups. The study employed a quota sampling method, which involved selecting a sample from the population with specific characteristics until the desired quota was met (Yang & Banamah 2014). The timeframe for sample collection was 8 weeks. Each group in the study consisted of ten participants.

The data obtained were analyzed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). The data were presented as mean ± standard deviation (SD), frequency (n), and percentage. The Shapiro-Wilk test was employed to assess the normality of the data distribution. The Kruskal-Wallis test was used for statistical analysis, followed by the post-hoc Mann-Whitney test along with the independent t-test. Additionally, simple linear regression was used for performing the path analysis. A value of $p<0.05$ was considered statistically significant (Ostertagová et al. 2014).

RESULTS

This study took place in Kepanjen District, Malang, Indonesia, with the exercise group consisting of elderly residents from Adi Santoso Street and the control group from the Aisyiah Study Group of Nurul Hidayah Mosque. The quota sampling resulted in 28 selected participants: 17 in the exercise group and 11 in the control group. The exercise group underwent Vivifrail Exercise Program Type C twice a week for 12 weeks, while the control group maintained their daily routines without additional exercise. Cognitive function and physical performance were assessed using MoCA-INA, SPPB, and EQ-5D. Two participants from the exercise group and one from the control group dropped out, leaving 26 participants for final analysis. The data were analyzed using descriptive and inferential statistics. Table 1 displays the baseline characteristics of the participants.

This study included patients with an average age of 72.2 years in the control group and 67.47 years in the exercise group. The oldest patients in both groups were 79 years old, while the youngest was 67 years in the control group and 60 years in the exercise group. The control group's average BMI was 28.0 before and after the study, while the exercise group's BMI slightly decreased from 24.54 to 24.48. The control group's average systolic blood pressure was 136 mmHg, compared to 148 mmHg in the exercise group. The average SPPB scores were 7.44 in the control group and 8.00 in the exercise group, whereas the average MoCA-INA scores were 22.0 in the control group and 20.18 in the exercise group. These data provided an overview of the study participants. A t-test for hypothesis testing was conducted with a 5% error level to analyze the results, preceded by a normality test.

Table 1. Baseline characteristics of the study participants.

Characteristics		Control group			Exercise group		
		n	%	Mean±SD	n	%	Mean±SD
Sex	Female	8	80		11	64.7	
	Male	2	20		6	35.3	
Formal education	<12 years	3	30		11	64.7	
	>12 years	7	70		6	35.3	
Occupation	Employed	0	0		6	35.3	
	Unemployed	10	100		11	64.7	
Age		10		72.20±3.91	17		67.47±6.61
BMI		10		28.0±5.72	17		24.54±3.55
MoCA-INA		10		22.00±2.11	17		20.18±2.35
Systolic BP		10		136.40±23.76	17		148.88±20.68
SPPB		10		7.44±0.69	17		8.00±0.86
Comorbidities	Diabetes	1	10		2	11.7	
	Hypertention	4	40		4	23.5	
	Coronary disease	1	10		1	5.8	
i-ADL		10		6.6 ± 0.52	17		6.1±1.26
EQ-5D	0-25	0			0		
	26-50	0			0		
	51-75	8			2		
	76-100	2			15		

Legends: Nominal data are presented as frequencies and percentages, while numerical data are expressed as means ± standard deviations (mean±SD). BMI=body mass index; MoCA-INA=Montreal Cognitive Assessment-Indonesian Version; BP=blood pressure; SPPB=Short Physical Performance Battery; i-ADL=instrumental activities of daily living; EQ-5D=EuroQol-5 Dimension.

Table 2 shows significant improvements in the MoCA-INA scores of pre-frail elderly individuals after performing the Vivifrail Exercise Program Type C, with scores increasing from an average of 20.25±2.41 to 24.06±4.48. The LOTCA examination also revealed significant improvements in the visual perception domain (i.e., shape identification and overlapping figures) and thinking operation domain (i.e., categorization and pictorial sequence) following the exercises. However, no significant changes were observed in the LOTCA domains of orientation, visual perception (i.e., object identification and object constancy), praxis, visuomotor organization, and memory.

A comparison of the MoCA-INA scores between the control and exercise groups is presented in Table 3. According to the table, the MoCA-INA results indicated a difference (Δ) in the scores before and after intervention between the control and exercise groups. The control group had an average increase of 1.1, whereas the exercise group exhibited an increase of 3.81, with a value of p=0.032. This demonstrated a significant difference in the increase in MoCA-INA scores between the control and exercise groups. Therefore, it was suggested that the Vivifrail Exercise Program Type C could significantly impact the MoCA-INA scores in elderly individuals who performed the exercises compared to the control group.

Table 2. Comparison of the MoCA-INA and LOTCA pretest-posttest results for the intervention group.

	Mean±SD	Median	p
MoCA-INA			
Pretest	20.25±2.41		0.003*
Posttest	24.06±4.48		
LOTCA			
Orientation			
Time (pretest)		4	1.000
Time (posttest)		4	
Place (pretest)		4	0.317
Place (posttest)		4	
Visual perception			
Object identification (pretest)		4	1.000
Object identification (posttest)		4	
Shape identification (pretest)		3	0.014*
Shape identification (posttest)		4	
Overlapping figures (pretest)		3	0.046*
Overlapping figures (posttest)		4	
Object constancy (pretest)		3	0.157
Object constancy (posttest)		3	
Praxis			
Praxis (pretest)		3	0.317
Praxis (posttest)		3	
Thinking			

operation		
Categorization (pretest)	3	0.021*
Categorization (posttest)	4	
Pictorial sequence (pretest)	3	0.046*
Pictorial sequence (posttest)	4	
Visuomotor organization		
Copying geometric (pretest)	3	0.083
Copying geometric (posttest)	4	
Two-dimensional model (pretest)	3	0.083
Two-dimensional model (posttest)	3	
Pegboard (pretest)	3	0.083
Pegboard (posttest)	3	
Colored block (pretest)	3	0.564
Colored block (posttest)	3	
Puzzle (pretest)	3	0.317
Puzzle (posttest)	3	
Memory		
Memory (pretest)	3	0.157
Memory (posttest)	4	

DISCUSSION

There were significant differences in average age, sex ratio, BMI, systolic blood pressure, and EQ-5D between the exercise and control groups at the beginning of this study. However, there were no significant differences in the physical performance and MoCA-INA scores, indicating relatively homogeneous conditions for the study's outcomes (Table 2). Cognitive frailty is a condition characterized by mild cognitive impairment in pre-frail individuals. Mild cognitive impairment is indicated by a MoCA-INA score of 18–24 points, while physical performance is assessed using the SPPB with a score of 7–9 (Petridou 2020).

This study, conducted in Ardirejo Village, Kepanjen District, Malang, Indonesia, found significant differences in the MoCA-INA scores between the exercise and control groups. This indicates that the Vivifrail Exercise Program Type C may improve MoCA-INA scores in elderly individuals with pre-frailty, thus enhancing cognitive function through physical exercise. The 12-week multicomponent training program has been shown to improve intrinsic capacity, particularly in locomotion, cognition, and vitality, among community-dwelling elderly individuals with pre-frail or frail conditions and mild cognitive impairment in comparison with usual care. A previous study detected a significant increase in the cognitive domain in an intervention group after 12 weeks of the Vivifrail Exercise Program (β=0.80; 95%CI=0.03, 1.57; p<0.05) compared to the control group (n=36) (Sánchez-Sánchez et al. 2022a).

Table 3. Comparison of changes (Δ) in the MoCA-INA scores between the control and intervention groups.

Groups	Mean±SD	p
Control	1.1±1.45	0.032
Exercise	3.81±4.32	

Legends: The paired t-test was used in the MoCA-INA score analysis. An asterisk (*) signifies any statistical significance (p<0.05).

As described by Lee & Kim (2018), the LOTCA subtests measure aspects such as orientation, visual perceptions, spatial perceptions, praxis, visuomotor organizations, thinking operations, and memory. In this study, the orientation subtest showed no significant change between the pretest and posttest results. The maximum score for both the time and place orientation subtests is four points. This suggests that physical exercise helps maintain cognitive function in the orientation domain for elderly individuals with pre-frail conditions. Multicomponent exercise interventions have been introduced by integrating cognitive stimulation into exercise sessions and combining it with resistance or aerobic training. These multicomponent exercises can be implemented simultaneously or sequentially. However, the combination of physical and cognitive interventions has not demonstrated additional cognitive benefits compared to cognitive training alone. Despite that, its physical benefits may pose it as an attractive strategy for maintaining both cognitive and physical health in older adults (Gavelin et al. 2021).

This study revealed significant improvements in the LOTCA visual perception subtest. Mild cognitive impairment cases are typically characterized by a decline in various cognitive functions, including visual and spatial perceptions. Elderly people may be unaware of the impact of mild cognitive impairment on their daily activities, despite experiencing deterioration in memory and visual perception. It is crucial to maintain postural stability, as aging can reduce binocular vision function and increase the risk of balance disorders, which leads to a higher risk of falls (Chang et al. 2021).

Additionally, it has been demonstrated that regulating adult neurogenesis and angiogenesis is crucial for the function and volume of the dentate gyrus. Exercises increase cerebral blood volume in the dentate gyrus, which corresponds to enhanced neurogenesis, cognitive function, and cardio-pulmonary capacity. An hour of aerobic exercise has been shown to increase cerebral blood volume and neurogenesis in the dentate gyrus. This is supported by evidence that exercises boost synaptic plasticity through fibronectin type III domain-containing protein 5 (FNDC5)/irisin-αV/β5 integrin signaling. A meta-analysis of 12,820 adults over 50 years revealed that moderate-intensity physical exercise for 45–60 minutes can enhance cognitive function (Lei et al. 2019).

This study did not reveal any significant changes for the praxis subtest. Praxis is the ability to plan and execute complex and coordinated motor movements. This finding does not align with existing evidence, which indicates that multicomponent exercises have more beneficial effects on praxis than no influence at all. A study conducted by Sink et al. (2015) on the Lifestyle Interventions and Independence for Elders (LIFE) Study investigated the effects of physical activity interventions on older adults at a high risk for disability. While benefits in physical mobility and reduced disability risk were found in the study, there was no significant change in praxis abilities. Factors that might influence these findings include the duration and intensity of exercise, the methods used to assess praxis, and the characteristics of the participants. Another study suggests that exercise programs yielding better outcomes in the praxis component incorporate multicomponent training with cognitive exercises, which shall be conducted for five months or longer, three days a week for 30 to 45 minutes per session, or over 24 weeks with a frequency of five days per week and 65 minutes per session (Tarazona-Santabalbina et al. 2016).

For the visuomotor organization subtest, there were no significant changes observed in this study. This finding corroborates a prior study carried out by Eggenberger et al. (2015), who found that multicomponent training positively affects locomotive function, balance, and cognitive aspects. Despite general cognitive improvements, the study did not find any significant improvement in the visuomotor organization domain. A combined approach of physical and specific cognitive training might be more effective in enhancing visuomotor skills in the elderly.

Significant results were found in the thinking operation subtest in this study. Similarly, a study reported by Alghadir et al. (2016) indicated that moderate-intensity aerobic exercise over 24 weeks could enhance several cognitive domains, including thinking operations. Before the exercises, the average total score for this domain was 9.6±2.65, which increased to 31.5 ± 2.6 after the exercises. The proposed mechanism for this improvement is the reduction in levels of high-sensitivity C-reactive protein (hs-CRP). This marker indicates chronic inflammation associated with various clinical conditions, including cognitive decline and depression in older adults. The improvement in cognitive abilities, particularly in motor praxis, visuomotor organization, attention, and concentration, was significantly correlated with decreased hs-CRP levels and increased physical activity in all participants.

In the context of the memory subtest, there were no significant changes observed in this study. Consistent with the findings of this study, Sink et al. (2015) also noted that the LIFE Study did not show significant improvements in memory function despite enhancements in physical mobility. This suggests that cognitive domains may not uniformly respond to physical exercises, possibly due to the type of exercise not being optimal for memory function.

Strength and limitations

This study, taking place in Ardirejo Village, Kepanjen District, Malang, Indonesia, was the first to examine the effects of the Vivifrail Exercise Program Type C on cognitive function in pre-frail elderly individuals within a community setting. This study provides insights into the significant cognitive benefits of biweekly exercises conducted for 12 weeks in 45-minute sessions, compared to longer durations of 12 to 24 weeks. This suggests that appropriate exercise dosage (i.e., frequency, duration, and intensity) can effectively improve cognitive function in pre-frail elderly residents of Ardirejo Village through the Vivifrail Exercise Program Type C.

The limitations of this study include the differing number of samples in the control and exercise groups, which might be insufficient to represent the overall profiles of the pre-frail elderly individuals. The considerable age difference between the two groups might also introduce bias in how cognitive function was described for each group. Additionally, the LOTCA measurement was not performed for the control group due to the lengthy time required for the examination, resulting in the control group's reluctance to participate.

CONCLUSION

The Vivifral Exercise Program Type C has a positive effect on cognitive function in pre-frail elderly individuals within the elderly resident community of Ardirejo Village, Kepanjen District, Malang, Indonesia. Cognitive function improved in pre-frail individuals who participated in the exercise program biweekly for 12 weeks as measured by the Montreal Cognitive Assessment-Indonesian Version (MoCA-INA) and the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA), particularly in the domains of thinking operations and visual perception.

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Conflict of interest

None.

Ethical consideration

This study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia, under reference No. 81/EC/KEPK/ 03.2022 dated 31/3/2022.

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Author contribution

SS, DIL, MBN, HL, and TH contributed to the conception and design of this study. SS and HL collected, assembled, analyzed, and interpreted the data. SS, DIL, and MBN drafted the article. SS, DIL, MBN, and TH contributed to the critical revision of the article for important intellectual content. All the authors gave their final approval to the final article.

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