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The effect of 4 weeks chair-based exercise on cognitive function in the elderly

Roy Mal[1], Mariani Santosa[2], Aila Johanna[3,4], Nawanto Agung Prastowo[2,4], Nelson Sudiyono[2,4], Ignatio Rika Haryono[2,4]*

[1]Faculty of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta, [2]Department of Physiology, School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta, [3]Department of Psychiatry and Behavioral Health, School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia, [4]Atma Jaya Teaching and Research Hospital

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ABSTRACT

Degenerative processes in the central nervous system contribute to in cognitive function decline in the elderly. Physical exercise may prevent this decline. However, elderly people often require modified forms of activity to ensure both safety and effectiveness. This study aimed to investigate the the effect of chair-based exercise (CBE) on cognitive function in elderly people. This study was conducted a two nursing homes using a two-group pretest and posttest experimental design with a control group. All participants were informed about the procedures of study, provided written informed consent, and underwent an initial cognitive assessment using the mini-mental state examination (MMSE). Participants in the intervention group engaged in CBE sessions over a four-week period. Following the intervention, cognitive function was reassessed in both groups. The Wilcoxon signed-rank test was used to analyze within-group changes, while independent t-tests were used to assess between-group differences in cognitive function scores. A significant improvement in cognitive function was observed in the intervention group after the four-week CBE program ($p = 0.008$). Moreover, a significant between-group difference in cognitive score changes was found ($p = 0.003$), favoring the intervention group. In conclusion, a four-week CBE program significantly improved cognitive function among elderly participants. These findings support the use of CBE as an accessible and effective intervention to promote cognitive health in elderly people.

ABSTRACT

Proses degeneratif sistem saraf pusat menyebabkan penurunan fungsi kognitif. Olahraga terbukti dapat mencegah disfungsi kognitif. Namun demikian, lansia memerlukan penyesuaian untuk melakukan aktivitas fisik. Penelitian ini bertujuan mengkaji pengaruh *chair-based exercise* (CBE) terhadap fungsi kognitif pada lansia. Penelitian ini dilakukan di dua Panti Werdha menggunakan desain penelitian eksperimental dengan jenis desain penelitian dua kelompok pretest-posttest dengan kelompok kontrol. Reponden diberikan penjelasan mengenai penelitian, menandatangai surat pernyataan kesediaan ikut penelitian dan menjalani pemeriksaan fungsi kognitif dengan *mini-mental state examination* (MMSE). Responden kelompok intervensi melakukan CBE selama empat minggu. Empat minggu setelahnya, dilakukan pemeriksaan fungsi kognitif kembali pada semua responden. Uji Wilcoxon dilakukan untuk menganalisis perubahan antara pretes dan postes kedua kelompok, dan uji t independen dilakukan untuk melihat perbedaan perubahan fungsi kognitif kelompok intervensi dan control. Terdapat perubahan yang bermakna skor fungsi kognitif pada kelompok intervensi setelah menjalani CBE selama empat minggu ($p = 0{,}008$). Perbedaan bermakna ditemukan antara kelompok intervensi dan kontrol ($p = 0{,}003$). Simpulan, program CBE selama empat minggu meningkatkan fungsi kognitif secara bermakna pada peserta lanjut usia. Temuan ini mendukung penggunaan CBE sebagai intervensi yang mudah diakses dan efektif untuk meningkatkan kesehatan kognitif pada lansia.

Keywords:
chair-based exercise;
cognitive function;
elderly;
mini-mental state examination;
effectivenessp

*corresponding author: ignatio.rika@atmajaya.ac.id

INTRODUCTION

In recent years, the population of elderly individuals has steadily increased in many countries, including Indonesia.[1] According to Law number 13 of 1998, the elderly are individuals aged 60 and above.[2] The Central Statistics Agency stated that the number of elderly people in Indonesia reached 26 million in 2020. Nearly half of this elderly population experiences health problems, which naturally arise from the aging process, causing damage at the cellular and molecular levels and leading to a decline in body functions.[3,4] This process affects multiple systems, including the sensory, musculoskeletal, cardiovascular, respiratory, digestive, metabolic, urinary, nervous, and reproductive systems. Degenerative changes in the central nervous system, particularly, are associated with a decline in cognitive function.[5]

Cognitive impairments in the elderly can be mitigated through engaging activities such as painting, cooking, playing music, gardening, and exercising. Among these, physical exercise is a well-established non-pharmacological therapy shown to reduce cognitive dysfunction. Huang *et al.*,[6] reported that aerobic exercise is particularly effective in addressing cognitive decline. However, due to age-related physical limitations, many elderly individuals require modified forms of exercise. One such adaptation is chair-based exercise (CBE), which utilizes a chair for support and stability. Previous studies have shown that CBE can improve physical function in elderly,[7-9] but its specific effects on cognitive function remain uncertain.

Therefore, this study aimed to investigate the impact of CBE on cognitive function in the elderly. Unlike previous studies, this study focuses exclusively on CBE, without adding memory training or other cognitive enhancement interventions.

MATERIAL AND METHODS

Study design and subjects

This study involved 36 participants who met the inclusion and exclusion criteria and completed the study. Participants were randomly assigned to either the intervention group (n = 18) or the control group (n = 18). The study employed a two-group pretest-posttest experimental design with a control group. The study was conducted in two nursing homes, one designated as the intervention group site and the other as the control group site.

The inclusion criteria included individuals aged ≥60 yr, difficulty standing for extended periods (≥30 min), and a minimum education level of nine yr. The exclusion criteria included uncontrolled medical conditions (e.g., hypertension or diabetes mellitus). These physical limitations hinder participation in the mini-mental state examination (MMSE) or chair-based exercises (CBE), language barriers, and inability to follow instructions. Dropout criteria included inability to continue participation due to unforeseen obstacles or failure to complete at least eight chair-based exercise sessions.

Procedure

Participants were provided information about the study, signed informed consent forms, and underwent a baseline cognitive function assessment using the MMSE. The intervention group participated in CBE sessions twice weekly for four wk, while the control group received no intervention. After four wk, all participants underwent a follow-up MMSE assessment.

The MMSE was chosen as the cognitive function measurement tool. It has been adapted for the Indonesian population, demonstrating a sensitivity of 88% and specificity of 96%.[10] Additionally, the MMSE shows good to

excellent test-retest reliability, ranging from 0.67 to 0.93.[11]

Intervention

Chair-based exercise sessions were conducted for 35 min each, consisting of a 3 min warm-up, 27 min of main exercises, and a 5 min cool-down. The sessions were led by a trained instructor who had received guidance on the CBE protocol. The intervention was conducted from August to October 2023.

Warm-up movements included arm swings, arm reaches, and body twists. Arm swing was done by flexing the elbows and then swinging the arms from the shoulders. Arm reach was performed by holding the sides of the chair using the right hand, raising the left hand, reaching toward the ceiling, and slowly leaning to the right side and holding. Repeat this for the other side. Body twist was conducted by placing the left hand on the right knee and the right hand behind the back or side of the chair, then slowly turning the upper body and head towards the right arm, holding and repeating on the opposite side. The warm-up was continued with other movements and ended with slow marching.

Main exercise movements were generally performed with a faster marching rhythm and included Shoulder circles, by relaxing arms by body sides, moving both shoulders in a forward circular motion, and repeating in the reverse direction; Bicep curls, by placing both hands on thighs, bending the right elbow and bring toward right shoulder and slowly lower back down alternate right and left arms; Leg extensions, by holding the side of the chair, raise the right foot as straighten the leg out in front, holding for 5 sec and slowly lower back down, alternate right and left leg; Leg circles, by holding the sides of the chair, straighten the right leg out in front and point the toes, make 3 circles to the right and 3 circles to the left, alternate right and left leg. All movements were alternated between the right and left sides and adapted for medium intensity.

Cool-down exercises included chest stretch, by reaching behind the body with both arms and aiming to hold the back of the chair, pressing the chest forwards and upwards until feeling a stretch across the chest; Leg stretch, by sliding forward on the chair and straighten the right leg out in from with the heel to the floor and toes pointing to the ceiling, place both hands on left thigh, slowly lean forward while keeping the back straight and chest out until feel a stretch in the back of right leg, repeat on the opposite side.

The study was approved by the Ethics Committee of Atma Jaya Catholic University of Indonesia (ref. no. 06/09/KEP-FKIKUAJ/2023). All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki.

Statistical analysis

Numerical data were presented as mean ± standard deviation (SD) for normally distributed variables or as median (minimum–maximum) for non-normally distributed variables. Categorical data were presented as frequencies and percentages. Comparisons of pre- and post-measurements for numerical data were analyzed using a paired t-test or a non-parametric alternative, while comparisons between groups were assessed using an independent t-test. The Chi-square test was used to evaluate associations between categorical variables. One-way Anova followed by post hoc analysis was used to compare three numerical groups. Two-way Anova was conducted to examine the effects of group and time. Statistical analyses were performed using SPSS version 27.0, with significance level set at $p < 0.05$.

RESULTS

The characteristics of the participants are summarized in TABLE 1.

Most participants were ≤74 y.o., female, and had a junior high school level of education. Additionally, the majority had a pre-intervention MMSE score of ≥24. Chi-square test showed no significant differences in the distribution of age groups, gender, education level, or pre-intervention MMSE scores ($p > 0.05$).

TABLE 2 presents the comparison of pre-intervention MMSE scores across different variable groups. No significant difference was observed in pre-intervention MMSE scores between participants aged ≤74 yr and those >74 yr ($p = 0.257$), as well as between male and female participants ($p = 0.463$). However, a significant difference in MMSE scores based on education level ($p = 0.049$). Further analysis showed that participants with a university education level had significantly higher MMSE scores than those with only a junior high school education ($p = 0.030$).

TABLE 3 compares MMSE scores within and between groups (pre- and post-intervention). The Shapiro-Wilk test indicated that MMSE scores were not normally distributed ($p < 0.05$), so the Wilcoxon test was used for analysis. Results showed no significant difference in pre-test MMSE scores between the intervention and control groups ($p = 0.37$), while the post-test MMSE score in the intervention group was significantly higher than in the control group ($p < 0.001$). The Wilcoxon test also revealed no significant pre-post difference in MMSE scores within the control group ($p = 0.31$) but a significant increase within the intervention group ($p = 0.008$).

The difference in pre-post MMSE scores between groups was found to be normally distributed ($p > 0.05$). An independent t-test showed that the improvement in MMSE scores was significantly greater in the intervention group compared to the control group ($p = 0.003$).

TABLE 4 presents the effects of time and intervention on MMSE scores. There was no significant effect of time alone ($p = 0.07$), but a significant effect of the intervention was observed ($p = 0.03$). Furthermore, the interaction between time and intervention significantly affected MMSE scores ($p < 0.01$).

TABLE 1. Characteristics of participants

Characteristics	Intervention [n (%)]	Control [n (%)]	Total [n (%)]	p
Age				
≤74 yr	8 (44.4)	13 (72.2)	21 (58.3)	0.61
>74 yr	10 (55.6)	5 (27.8)	15 (41.7)	
Gender				
Male	5 (27.8)	5 (27.8)	10 (27.8)	0.65
Female	13 (72.2)	13 (72.2)	26 (72.2)	
Education				
Junior high school	8 (44.4)	10 (55.6)	18 (50.0)	
Senior high school	9 (50.0)	5 (27.8)	14 (38.9)	0.48
University	1 (5.6)	3 (16.7)	4 (11.1)	
Pre-test MMSE score				
≥24	11 (61.1)	66.7	23 (63.9)	0.32
<24	7 (38.9)	33.3	13 (36.1)	

Note: Levene's test for age, gender, education, and pre-test score between the intervention and control groups yielded p-values > 0.05

TABLE 2. Comparison of the pre-intervention MMSE scores according to group variables

Characteristics	Pre-intervention MMSE score		p
	Mean ± SD	Median (min-max)	
Age			
≤74 yr	24.1±4.7	25 (8-29)	0.257
>74 yr	22.1±5.9	24 (8-29)	
Gender			
Male	24.3±4.6	25 (16-29)	0.463
Female	22.9±5.5	24 (8-29)	
Education			
Junior high school	21.3±5.8	24 (8-28)	
Senior high school	24.5±4.1	25 (16-29)	0.049
University	27.5±2.4	28.5 (24-29)	

TABLE 3. Cognitive function in the elderly intervention and control group

Variable	Control group	Intervention group	p
Pre-test MMSE score	24.0 (8-29)	25.0 (8-29)	0.37*
Posttest MMSE score	23.0 (8-30)	27.5 (12-29)	<0.01*
MMSE pre-post score difference (Δ)	-0.6±2.2	2.1±2.7	<0.01#
p#	0.31	0.008	

Note: *Wilcoxon test; #Independent t test

TABLE 4. The effect of time and intervention on the MMSE score

	Mean square	F	p
Time	10.9	3.5	0.07
Time*Intervention	32.0	10.3	0.03
Intercept	40233.4	769.1	<0.01

DISCUSSION

Of the 36 participants involved in this study, approximately 36.1% were likely to have cognitive disorders. This finding is consistent with the study conducted by Wreksoatmodjo *et al.*,[12] which reported that 37.8% of the elderly population in Jakarta has poor cognitive function.[12] The majority of participants were aged between 60 ang 74 yr. In this study, participants under the age of 74 yr still have MMSE scores that can not be considered as having cognitive disorders. In contrast, participants aged ≥74 yr have scores that can be categorized as having cognitive disorders. The distribution of scores indicates that with

aging increasing, cognitive function tends to decline. This finding aligns with a study by Taniguchi *et al.*,[13] which suggests that cognitive function remains relatively in-tact between the ages of 65-75 yr, and a slow decline occurs between the ages of 80-90 yr, followed by a rapid decline after the age of 90. Brain atrophy, neuron degeneration, and changes in neurotransmitters in the central nervous system are identified as causes of cognitive function decline.[14]

The participants in this study were predominantly female. This is consistent with data from the Central Statistics Agency indicating that 51.81% of the elderly population in Indonesia is female.[15] The MMSE scores for male participants were higher compared to female participants. This finding aligns with a study by Ambo-hamsah *et al.*,[14] which states that women are at a higher risk of experiencing cognitive decline. This is attributed to a decrease in the production of estrogen, a hormone that plays a crucial role in maintaining brain function during menopause. Additionally, social factors such as lower educational levels among women, the role of being a housewife, and other factors contribute to this trend.[16]

Half of the participants in this study completed their education up to junior high school. The elderly group with an education level of junior high school completion obtained the lowest MMSE scores, while the elderly groups with high school and university education had higher scores. This indicates that lower levels of education are associated with a higher possibility of cognitive function decline. This finding is consistent with the study of Riskiana and Mandagi, which states that individuals with lower levels of education are more likely to experience cognitive disorders due to the limited intellectual stimulation they receive.[17]

This study indicates the influence of CBE on the changes in cognitive function among the elderly in the intervention group. However, no significant changes were observed in the control group. In the intervention group, there was an increase in the median score from 25.0 in the pre-test to 27.5 in the post-test. The test conducted on the changes in cognitive function between the intervention and control groups revealed a significant difference. Therefore, it can be concluded that CBE improves cognitive function in the elderly.

The results of this study are consistent with the literature review conducted by Schoene *et al.*,[18] which includes three similar studies indicating that CBE can enhance cognitive function. One of these studies, conducted by Thurm *et al.*[19] involved moderate-intensity multimodal physical movement training twice a week for 45 min over 10 wk. The intervention included physical activities performed while sitting and repetitive memory training.[18,19] These findings are also supported by a study conducted by Sauliyusta *et al.*,[20] suggesting a connection between physical activity, especially exercise, and cognitive function in the elderly. However, it is worth noting that daily activities such as painting, cooking, gardening, and others may also influence cognitive function.[5]

The results of this study are also consistent with the study conducted by Juniarti *et al.*,[21] which implemented a physical exercise and reading therapy program for four wk in the intervention group. The study found significant changes in the intervention group but no significant changes in the control group. There were significant differences between the intervention and control groups when comparing the two groups. Unlike in the intervention group, the lack of significant changes in the control group may be attributed to the absence of regular cognitive stimulation.

Improvement in cognitive function is usually associated with neuroplasticity. Exercise is considered a factor that

could improve neuroplasticity. Several studies reported that exercise can induce structural changes, such as an increase in gray matter in the frontal and hippocampal regions and a reduction in damage to gray matter. Additionally, exercise stimulates the release of neurotrophic factors, such as peripheral BDNF, which increases neuroplasticity in the brain and enhances blood flow, thereby increasing nutrient intake to the brain.[22]

The limitations of this study include not considering the daily activities of the participants, which could influence their cognitive function. Although there is a control group for comparison in this study, it can not be denied that the daily activities between the two groups may differ due to using two different nursing homes.

CONCLUSION

This study demonstrates that 4 wk of CBE can positively impact cognitive function in the elderly. It is recommended that further study establish exclusion criteria for participants whose daily activities may influence their cognitive function. Additionally, intervention and control groups should be placed in comparable environments to minimize potential confounding factors.

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