Research Article

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Effects Of Exergame Balance Training On Dementia-Related Quality Of Life And Self-Efficacy In Patients With Mild Cognitive Impairment: A Randomized Controlled Trial

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Abstract

Objective: *To determine the effects of exer-game balance training on dementia level, quality of life, and self-efficacy in older adults with mild cognitive impairment (MCI), comparing wobble board and stable-surface training.*

Design: *Randomized controlled trial.*

Setting: *Physiotherapy Department, Railway General Hospital, Rawalpindi, Pakistan.*

Participants: *Thirty-two patients with MCI (18 experimental, 14 control) were randomly allocated using sealed envelopes.*

Interventions: *The experimental group performed exer-game balance training on a modified wobble board, while controls trained on a Nintendo Wii Fit platform. Both groups completed 24-minute sessions, three times weekly for eight weeks.*

Measures: *Outcomes included dementia-related quality of life (DEMQOL), cognition (MoCA), dementia level (CDR), and self-efficacy (General Self-Efficacy Scale), assessed at baseline and eight weeks.*

Results: *Both groups showed significant within-group improvements (p≤0.05). Between-group differences were significant for MoCA (p=0.02) and CDR (p=0.05), but not DEMQOL (p=0.46) or self-efficacy (p=0.74).*

Conclusion: *Both training modalities effectively improved cognition, dementia level, quality of life, and self-efficacy in older adults with MCI.*

Keywords: Mild cognitive impairment, Exer-game , Balance training, Quality of life

Introduction

Cognitive function is central to every day functioning and to social relationships and independence (1). Mild cognitive impairment (MCI) refers to a transitional stage between normal brain function and dementia in which there is measurable cognitive change that is not yet sufficiently impairing to interfere significantly with an individual's function (2). The world prevalence of MCI is estimated as 15–20% of adults age 60 years and older, increasing from 6.7% of those between 60 and 64 years to 37.6% of those over 85 years old (3). The ranges vary widely from region to region from 2.24% in Pennsylvania to 71.6% in Thailand (4). Dementia incidence in Pakistan in 2013 was around 0.15 million and there was very low public awareness (5). MCI is more likely to occur in women and the type that mainly affects memory is the most common and is strongly linked to progression to Alzheimer's disease (6,7).

In people with MCI, quality of life (QOL) is a multidimensional concept that includes psychological health, physical functioning, social involvement and self-efficacy(8). Health-related quality of life (HRQOL) is significantly impacted by sleep disturbances, depression and anxiety, which are both prevalent and documented in MCI (9). Self-efficacy, which is the self-confidence to engage in behaviors that will result in the desired performance attainment, has been shown to play an important mediating role between cognitive function and QOL (10). MCI frequently co-occurs with decreased self-efficacy, which is associated with lower participation in daily activities, greater fear of falling and less overall well-being (11).

There are several non-pharmacological treatments that have been studied to enhance cognition and QOL in MCI. Aerobic exercise has been reported to increase the volume of the hippocampus and have beneficial effects on executive function and cerebral blood flow (12). A range of computer-based and game-based cognitive training exercises enhance memory, attention and reasoning in MCI individuals (13). Physical and cognitive training (e.g., simultaneous aerobic and cognitive tasks as in memory games) also has positive effects on combined physical and cognitive tasks and executive functioning (14). Recently, virtual reality (VR) interventions and exergaming (active video games with physical activity) have shown to be promising strategies to address cognitive and physical domains in older adults with MCI (15). Exergames with platforms like Nintendo Wii Fit, in particular, have been found to increase static and dynamic balance, decrease fear of falling and improve motor function in MCI (16). Although these studies have focused on cognitive and physical outcomes, there is a limited number of studies that specifically focused on the effects of exergame balance training on dementia-related quality of life and self-efficacy in patients with MCI (17-20).

The evidence to date is weak regarding the impact of structured exergame balance training (stable platform or wobble board) on the level of dementia, dementia related quality of life and self-efficacy in older people with MCI. Comparative effectiveness of balance training modalities is critical in designing individualized evidence-based balance rehabilitation programs for this population.

The purpose of the present study is to identify the effect of exergame balance training on patients with MCI dementia level, dementia related QOL and self-efficacy. Furthermore, the study compares the effects of using a stable surface for exergame balance training and a wobble board for balance training on these outcomes.

Methods

The current study was a single-blinded, prospective, randomized controlled trial, which adhered to Consolidated Standards of Reporting Trials (CONSORT) guidelines (Figure 1). The experimental group performed on a modified wobble board and the control group performed on a wobble board that was placed on a stable surface of the Nintendo Wii Fit system. This trial is registered and the study protocol can be accessed. The study was carried out according to the ethical principles of the Declaration of Helsinki. The study was conducted after getting ethical approval from the Ethics Committee of Riphah International University. All trial participants gave written informed consent prior to participating in the trial.

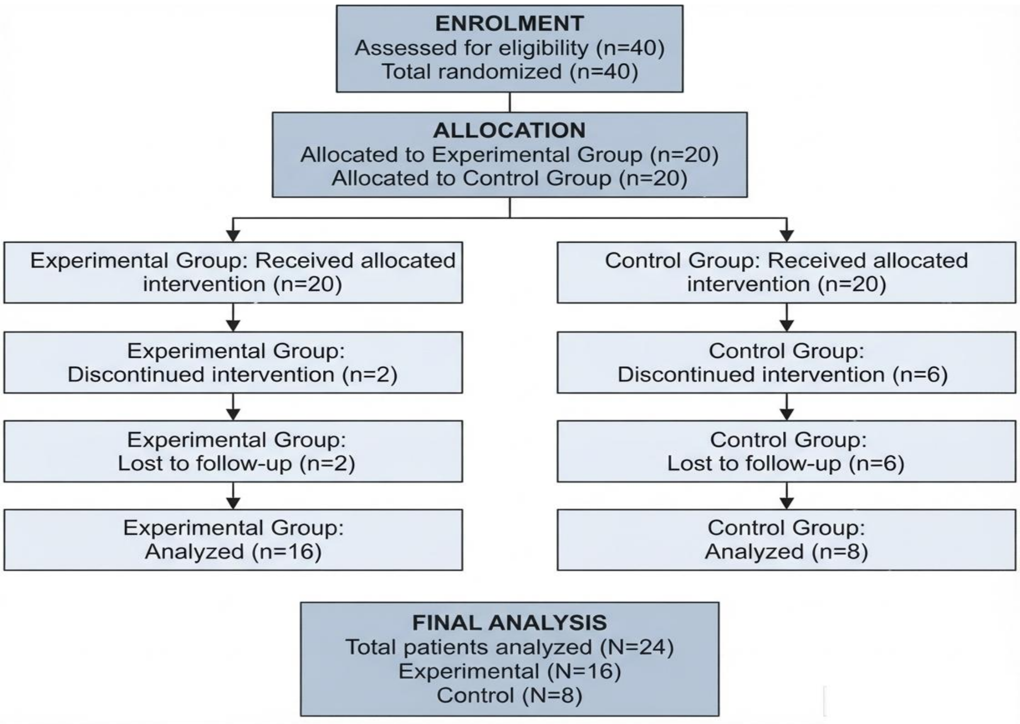

Figure 1: Consort Diagram

After getting approval from the Board of Advanced Studies and Research, participants were selected from Physiotherapy Department, Railway General Hospital, Rawalpindi Pakistan for a 9 month study duration. Inclusion criteria were: Adults older than 55 years; Montreal Cognitive Assessment (MoCA) between 18 and 24 (1,2); Clinical Dementia Rating (CDR) score ≤1.0 (21); and normal ability to stand for 30 seconds with eyes open and closed and vision and hearing sufficient to participate in the planned physical and computer-based cognitive training. Children who were not ambulatory and had a major mobility disorder, or had other neurological conditions that could be associated with cognitive impairment (e.g., stroke, Parkinson disease, head injury), or any clinically significant psychiatric disorder or current drug/drink abuse that would affect participation, or severe visual impairment, or who refused to participate were excluded.

The participants were informed of the study in writing and signed a consent form back. Participants were asked to fill in a questionnaire and 40 were enrolled, randomly divided into two groups of 20 by an independent statistician, using a sealed envelope method. The sample size was determined by using the GPower software (22) with a power of 80% and a significance of 0.05. The allocation of the groups was not revealed to the assessors or the participants until the first intervention session, serving as a baseline.

The main outcome was dementia-related quality of life (QOL) assessed by the Dementia Quality of Life (DEMQOL). A valid and reliable questionnaire of 29 statements with a Likert scale from 1 - 5 for people with mild to moderate dementia. The reliability of DEMQOL ranges from 0.71 to 0.76 and validity from 0.01 to 0.75 (22). Secondary outcomes comprised self-efficacy measured with the General Self-Efficacy Scale (GSE), a scale of 10 items, with responses ranging from 1 (hardly true) to 4 (exactly true) (total scores ranging from 10–40) with acceptable reliability and validity (23). The Clinical Dementia Rating Scale (CDR) assessed dementia, with each of six domains (memory, orientation, judgement/problem solving, community affairs, home/hobbies, and personal care) rated on a 5 point scale (0 = no impairment to 3 = severe impairment). The CDR has proven to be reliable at 0.84 and valid at 0.44 (21). The Montreal Cognitive Assessment (MoCA) was also administered to assess and monitor cognitive status (cut-off 18-24 for MCI).
The experimental group was given exercises on a modified wobble board (40 cm diameter and 10 cm from the top surface to the apex) that enabled multidirectional rocking and weight transfer. A mobile device was mounted in the middle of the board and linked to an LED display; the actions of the wobble board were coupled with the action of a ball in a game. A virtual goalkeeper tried to block the ball into the goal and participants had to guide the ball into the goal (24). To ensure that the intensity of the game was low, the size of the goal was large throughout the 8-week intervention.

The Exer-game balance training group used the Nintendo Wii Fit system with the standard balance board that has four strain-gauge load sensors, which estimate center of gravity and monitor weight-shifting movements (25). Immediate feedback was given to practice postural adaptations as they were occurring. For weeks 1-4, participants played the Soccer Heading and Penguin Slide games, and for weeks 5-8, they played Ski Jump and Balance Bubble games (24). The 2 groups received the same amount of supervised training (24 minutes, 3x per week for 8 weeks, 24 sessions, 26) (26). A trained instructor systematically observed all sessions throughout the intervention. Minimal upper body stabilization was encouraged by having the participants maintain their hands on their iliac crests throughout all exercises. Since the aim of the study was to compare the two types of balance training exercise, no additional exercise to challenge postural stability was added. The baseline and the end of the 8th week assessments were conducted.

SPSS version 21 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. The Shapiro-Wilk test was used to determine normality of the data. Parametric tests were used for normally-distributed data ($p > 0.05$): independent sample t-test was used for inter-group comparisons and paired t-test was used for intra-group comparisons. Non-normally distributed data ($p < 0.05$) were analyzed using non-parametric tests used to compare two groups (Mann-Whitney U test) or a group compared to itself (Wilcoxon signed-rank test) (27). A significance level of 0.05 was used for all tests. Data were presented descriptively as mean, SD, median and interquartile range (IQR) as appropriate. All variables were found as baseline equivalents between groups. All analyses were based on intention-to-treat, there was no drop-out of participants from the intervention groups and no transfers between groups.

Result

There were 40 participants in all, 20 of which were enrolled in the Experimental group and 20 in the Control group. There was a 20% drop out rate at the end of the 8 week intervention, with 32 completing the study (18 in the Experimental group, 14 in the Control group). There were no significant differences in baseline demographic data (Table 1). Experimental and Control group age was 59.33 ± 8.46 years and 60.02 ± 6.03 years, respectively. This gender difference was significant with 72% male students and 27% female in the Experimental group, and 21% male students and 79% female in the Control group.

Table 1: Baseline Demographic Characteristics Of Participants

Variable	Experimental Group (N = 18)	Control Group (N = 14)
Age (years), Mean (SD)	59.33 (8.46)	60.02 (6.03)
BMI (kg/m^2), Mean (SD	25.91 (5.57)	28.10 (4.30)
Gender – Male, n (%)	13 (72.0%)	3 (21.4%)
Gender – Female, n (%)	5 (27.3%)	11 (78.6%)

The results for both groups showed significant gains from pre- to post-test on all measures (Table 2). For the Montreal Cognitive Assessment, the Experimental group improved from 20.25 ± 2.89 to 25.22 ± 2.10 (mean difference 4.90), while the Control group improved from 19.07 ± 2.65 to 23.51 ± 4.45 (mean difference 4.44). The Clinical Dementia Rating Scale total score improved from 4.01 ± 0.70 to 5.38 ± 0.81 in the Experimental group and from 3.64 ± 1.64 to 5.46 ± 0.57 in the Control group. The latter group (Experimental) showed a 14.11 point increase in their DEMQOL scores, while the Control group showed a 17.54 point increase. The scores for the General Self-Efficacy Scale in the Experimental and Control groups increased by 13.11 and 13.01 points, respectively.

Table 2: Overall Pre- And Post-Intervention Values For All Outcome Measures

Outcome	Group	Pre Mean (SD)	Post Mean (SD)	Mean Difference
MoCA	Experimental	20.25 (2.89)	25.22 (2.10)	4.90
	Control	19.07 (2.65)	23.51 (4.45)	4.44
CDR	Experimental	4.01 (0.70)	5.38 (0.81)	1.37
	Control	3.64 (1.64)	5.46 (0.57)	1.82
DEMQOL	Experimental	56.44 (7.40)	70.55 (6.28)	14.11
	Control	51.53 (5.53)	69.07 (7.42)	17.54
GSE	Experimental	21.33 (2.89)	34.44 (4.11)	13.11
	Control	20.15 (3.18)	33.15 (5.12)	13.01
MoCA = Montreal Cognitive Assessment; CDR = Clinical Dementia Rating Scale; DEMQOL = Dementia Quality of Life Questionnaire; GSE = General Self-Efficacy Scale.				

There were no statistically significant differences in most of the primary outcomes between groups. However, there was a large advantage for the Experimental group on MoCA post intervention with $p = 0.02$. The Control group had a significant higher total score on CDR ($p = 0.05$); there were significant between group differences on subcomponent scores of orientation ($p = 0.04$), home and hobbies ($p < 0.001$), and personal care ($p = 0.01$). Figure 2 shows the comparison of the total score on the MoCA and CDR before and after the intervention in each group. Figure 3 shows the percentage of those who improved on subcomponents of CDR.

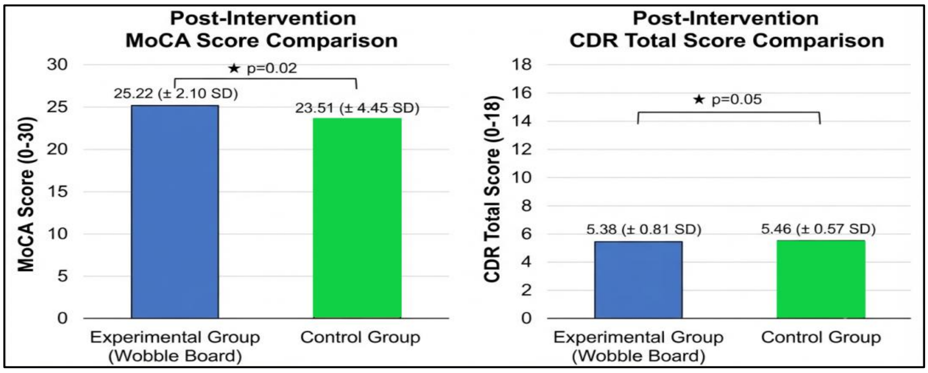

Figure 2: Post-Intervention MOCA And CDR Total Score Comparisons Between Groups

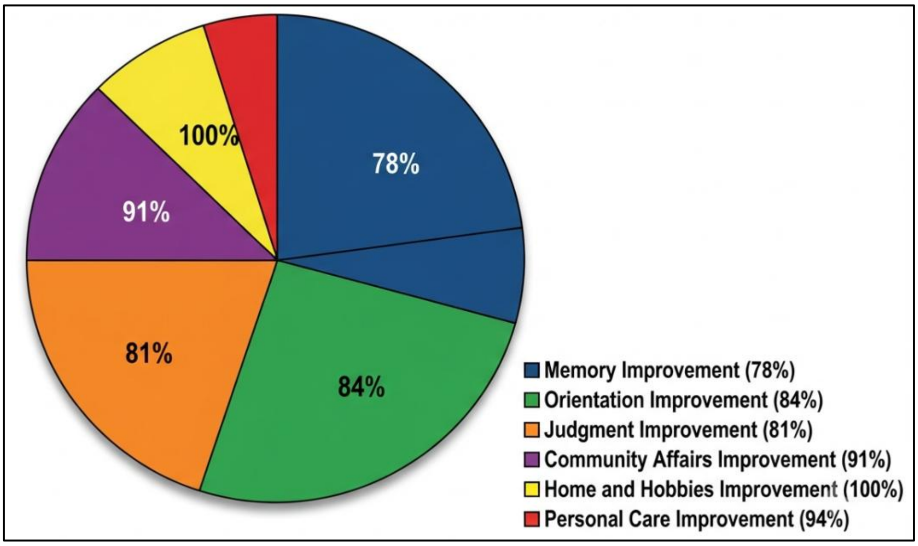

Figure 3: Proportion Of Participants Showing Improvements Across CDR Subcomponents (N= 32)

No difference was found between groups for total score (p = 0.42) in the DEMQOL. Subcomponent analyses showed that there were significant differences in favor of the Experimental group for the items, enjoying life (p = 0.02) and irritable (p = 0.02). The results of these analyses are summarized in Figure 4. There were no significant differences between the groups in the General Self-Efficacy Scale post intervention (p = 0.56).

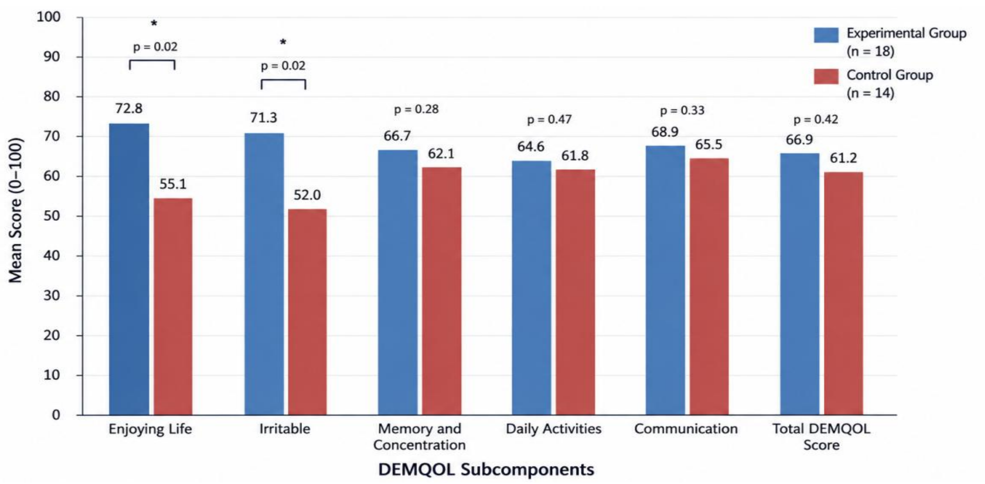

Figure 4: Between-Group Comparison Of DEMQOL Subcomponents Scores

Both within-group analyses and between-group analyses indicated that both groups had significant gains for all primary outcomes from baseline to post intervention. Both groups showed a significant improvement in MoCA scores ($p < 0.001$, for both). All sub-components of CDR total score had significant improvement in the Experimental ($p<0.05$) and Control ($p<0.001$) groups. There were significant improvements in DEMQOL scores and GSE scores in both groups ($p<0.001$ for both).

In general, both exergame balance training regimens (Wii Fit stable floor and wobble board based) successfully enhanced cognition, dementia-related quality of life and self-efficacy in the participants of this study, who were older adults with MCI. No clear between-group advantage was found for either intervention although some between-group differences were found at subcomponent levels. There was also a lot of individual variation within each group, reflecting variability in the effects of the treatments.

Discussion

This RCT compared the effectiveness of the modified wobble board with the conventional exergame balance training performed on a stable surface (Wii Fit) on mild cognitively impaired individuals. Post intervention results revealed that there was no significant difference between the Experimental group and the Control group on the dementia-related quality of life (DEMQOL) and self-efficacy (General Self-Efficacy Scale). There were significant within-group improvements in cognition (MoCA) and level of dementia (CDR), quality of life (DEMQOL), and self-efficacy from baseline to post-intervention for both groups. There were no advantages for either treatment in most of the outcomes.

Several explanations are possible why the two interventions would have an equivalent effect. The two different groups were presented with a structured exergame balance training focusing on weight-shifting and postural control exercises. The wobble board in the Experimental group and the Wii Fit balance board in the Control group both gave immediate feedback and involved active motor learning – factors which could have triggered similar changes in the brain compared to the other experimental groups. Exergaming has been demonstrated to positively impact cognitive function, balance and quality of life in older adults with MCI (15, 28). Another reason for the lack of group differences to emerge is the heterogeneity of the MCI population; different people have different cognitive profiles across the spectrum, and employ cognitive function at different levels, and react differently to interventions.

In Korea, geun-Ho Lee conducted a research on the effectiveness of a virtual reality program training of MCI patients in 2021. Forty senior citizens were randomly assigned to the VR game group and a control group.Older adults (40) were randomly split into a VR game group or a control group. Our study confirmed that both VR and activities of daily living scores were significantly lower for the geriatric depression group (28); similar results were found by comparing geriatric depression scale and ADL scores (29). However, another study by Lee Geun Ho was conducted in 2016 to assess the impact of virtual reality exercise on balance, quality of life and depression among the cognitive decline population without showing significant results in the control group and significant results in the experimental group (26). From our results, we can see that we both had a performance gain and neither one outperformed the other.

In Australia, Nathan M D'Cunha et al (2019) reportedly found that VR interventions could help enhance QOL in persons with dementia and MCI (30). We also compared the results of our study with those from a VR-based childhood psychotherapy intervention for mental wellbeing in older people with MCI by Waleed Riaz et al. (31), in which mental wellbeing measures were measured using the MoCA. The results obtained were similar to those that were reported by Puleio (2019) who noted that there were significant effects between the experimental group and verbal memory within group for the experimental group but not for the control group, and similar to our results (140). In MCI, we found that exergame training improved cognition (MoCA, $p < 0.05$) and quality of life (DEMQOL, $p < 0.05$) (32) in line with findings by Nathalie Swinnen et al. in the study of major neurocognitive disorders.

There are certain constraints of this study. The patient sample size used was relatively small ($n = 32$ completers) which could have limited the power to detect between-group differences. Gender numbers were also noted as there was a higher proportion in the Experimental group (72% males) than the Control group (78.6% females), which could affect the results of this study as gender been shown to have an impact on progression of MCI and response to intervention (6). The dropout rate was 20%, though eight participants dropped out of the follow up, which could have caused attrition bias. The absence of a true control group (no intervention) poses the risk that the improvements observed in the pre-test and post-test for the intervention groups can be mixed with natural recovery, social interaction impacts during sessions, and/or learning effects from performance on the exergame. Assessment instruments included were validated on dementia and cognitive impairment, but not on MCI specifically for responsive of exergame intervention in MCI. In addition, the observational period (8 weeks) may be too short to allow differential responses to the two types of exergame, and longer follow-up periods may be necessary to reveal differences.

Study Limitations

This study has several limitations, including the small sample size and 20% dropout rate, which may have reduced statistical power and introduced attrition bias. The marked gender imbalance between groups may also have influenced the results. In addition, the absence of a no intervention control group limits the ability to distinguish treatment effects from learning, social interaction, or natural changes. The relatively short 8 week intervention and lack of long term follow up also limit conclusions regarding sustained effects. Finally, the findings may have limited generalizability because participants were recruited from a single hospital.

Conclusion

Results indicated that both exergame balance training on the customized wobble board and exergame balance training on the stable surface with Wii Fit were effective in enhancing cognition, dementia-related quality of life and self-efficacy in older adults with mild cognitive impairment. There was no difference found between the two interventions that was statistically significant. Future studies should be conducted in larger samples and with longer intervention times and control groups in which no balance training is provided in order to identify the best balance training type and dose for this population.

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Conflicts of Interest:

The authors declare no conflicts of interest, financial or otherwise, related to this research. All authors have no competing interests to declare.

Ethical Approval and Informed Consent:

The study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Ethics Committee of Riphah International University. Written informed consent was obtained from all participants before enrollment.

Clinical Trial Registration:

ClinicalTrials.gov Identifier: NCT05158595. The study protocol is available through ClinicalTrials.gov.

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