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Effects of a Video Game–Based Intervention on Cognitive Function and Social Frailty in Community-Dwelling Older Adults

Ayuto Kodama[1,2], Ryota Matsuhisa[3], Takako Ohnuma[1], Toshinobu Wakasa[4], Hisako Shindo[5], Yuka Sasaki[5], KeikoKudo[5], Hiroshi Suzuki[4] and Hidetaka Ota[1*]

[1]Advanced Research Center for Geriatric and Gerontology, Akita University, Akitacity, 010-8543, Japan

[2]Department of Occupational Therapy, Graduate school of Medicine, Akita University, Akita city, 010-8543, Japan

[3]Akita University School of Medicine, Akita city, 010-8543, Japan

[4]Social Cue Co., Ltd., Akita city,010-0001, Japan

[5]Akita Prefecture Council of Social Welfare, Akita city, 010-0922, Japan

[*]Corresponding author:

Hidetaka Ota,
Advanced Research Center for Geriatric and Gerontology, Akita University, Akitacity, 010-8543, Japan

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Video Game; Cognitive Function; Depression Symptoms; Social Frailty

1. Abstract

1.1. Background

This investigation examined how an interactive training regimen using videogames might influence cognitive, physical, and social health outcomes in independently living older adults.

1.2. Methods

The study enrolled 62 participants aged 65 and over. Twenty-four were assigned to the experimental cohort and 25 to a non-intervention control cohort. A range of assessments captured cognitive capacity, physical condition, emotional well-being, and social frailty indicators.

1.3. Results

The intervention cohort demonstrated marked enhancement in word memory ($p < 0.01$), Symbol Digit Substitution Task performance ($p < 0.01$), and depressive symptomatology (GDS-15; $p < 0.05$). Meanwhile, control participants experienced a significant decline in GDS-15 scores ($p < 0.05$). Although the control group’s social frailty status remained static, the intervention ting cognitive decline, reducing depressive symptoms, and supporting social engagement in aging populations.

2. Introduction

The global population is aging rapidly, and by 2050, those aged 65 and older are expected to account for nearly 16% of the world's population, nearly doubling from 9% in2019 [1]. This demographic shift is especially prominent in countries like Japan, whereover 28% of the population is already 65 or older [2]. With aging comes a rise in age related challenges such as cognitive decline, reduced physical capacity, and social disconnection, all of which threaten the well-being and independence of older adults. Among these concerns, cognitive impairment particularly memory loss, decreased executive function, and attention deficits poses a major risk to autonomy in old age [3]. Likewise, social isolation and loneliness are increasingly recognized as critical public health issues. These social factors are associated not only with depression and reduced quality of life, but also with increased mortality [4,5].To address these multifaceted challenges, researchers and healthcare professionals are increasingly calling for integrative and preventive approaches that target both cognitive and social dimensions of aging. However, there remains a pressing need for accessible, engaging, and evidence-based interventions that can be feasibly implemented in community settings [6]. Cognitive training programs have been studied for decades as tools for maintaining or enhancing mental function in older populations. Meta-analyses have confirmed that targeted cognitive interventions can improve specific domains such as memory, processing speed, and executive function [7]. However, these programs have many dropouts because it is difficult to maintain motivation. Against this backdrop, digital and video game-based interventions have attracted much attention in recent years. Videogames can offer rich, stimulating environments that challenge multiple cognitive systems, including attention, working memory, and decision-making. Compared with conventional approaches, games may better sustain motivation due to their interactive and immersive qualities [8]. In addition, the variety of games available on the market makes it possible to set the difficulty level based on the subject's experience. Certain genres of games such as action games, rhythm games, or racing simulations require rapid responses, sustained focus, and spatial navigation. These characteristics make them particularly relevant for enhancing cognitive flexibility and perceptual speed, which tend to decline with age [9]. Moreover, some games are explicitly designed to train memory or problem-solving abilities, creating opportunities for targeted cognitive rehabilitation [10]. In addition to cognitive effects, video games may provide psychosocial benefits. Participating in game-based activities, especially in group settings, offers opportunities for communication, cooperation, and shared experiences. These social interactions can combat loneliness, increase self-efficacy, and strengthen a sense of belonging, particularly for older individuals living alone or with limited mobility [11]. The concept of social frailty-a reduction in social roles, connections, and activities has recently emerged as a key predictor of physical frailty and disability. Studies have shown that socially frail older adults are at higher risk of cognitive decline and institutionalization [12]. Therefore, preventive measures that promote social participation are essential for healthy aging. Incorporating interactive video games into group-based settings may represent a novel and effective strategy in this domain. Research on game based interventions for older adults is still in its early stages, but growing. Maillot et al.(2012) found that older adults who engaged in physically interactive games for 12 weeks showed significant improvements in executive function and processing speed compared to a control group [13].Similarly, Anguera et al. (2013) demonstrated that specially designed video games could reverse age-related cognitive decline by targeting multitasking skills [14].In Japan, where societal aging is most advanced, innovative approaches are being explored. Kuwahara et al. (2021) investigated the use of Gran Turismo Sport(PlayStation 4,Sony), a racing simulation game, among older adults in community centers. Their findings indicated moderate increases in heart rate without adverse blood pressure effects, along with improvements in mood-especially among female participants [15]. These results suggest that even commercially available games, when appropriately supervised, can serve as low-risk tools for promoting well-being. Furthermore, Nishiguchi et al. (2020) conducted a randomized trial comparing cognitive training, aerobic cycling, and a combined approach among older adults. The combined group exhibited the most substantial gains in mnemonic discrimination and hippocampal plasticity, implying synergistic effects of physical and cognitive engagement[16]. Despite growing evidence supporting multi-domain interventions, further research is needed to assess the specific impacts of video game-based programs comprehensively. To this end, our study aimed to evaluate the effectiveness of a structured video game intervention in improving physical and cognitive function, as well as reducing social frailty among community-dwelling older adults.

3. Materials and Methods

3.1. Study Population

This quasi-experimental project was executed from Oc group experienced statistically significant improvements ($p < 0.05$). Analysis of variance revealed notable interaction effects for WM, SDST, and GDS-15 ($F = 7.54$, $p <0.01$).

3.2. Conclusion

Results underscore the potential value of video game-enhanced programming for mitigator 2024 through March 2025. Recruitment was carried out across Akita Prefecture using public notices and community outreach. Inclusion criteria required participants to ambulate unaided and maintain independent living without assistance. Exclusion criteria included clinical diagnoses such as dementia, major depression, serious visual or auditory deficits, cerebrovascular disease, Parkinson's, other neurological conditions, intellectual disabilities, and enrolment in the national long-term care support program. Inability to complete baseline cognitive screening also led to exclusion. Power analysis conducted via G*Power 3.1.9.4 estimated a total sample size of 200(160 control, 40intervention) to detect medium-sized effects with 80% power and a 5%significance threshold under a 4:1 group ratio. Only individuals fulfilling eligibility conditions and providing informed consent were admitted. The study's overarching goal was to evaluate the capacity of a structured gaming-based intervention to enhance cognitive, emotional, and physical resilience in older adults. The protocol was reviewed and approved by the Ethics Committee of Akita University's Department of Health Sciences (Ap- 122 proval No. 274,2018.10.1).

3.3. Intervention

Of the 62 participants who gave informed consent, they were assigned to either the control group or the video game-based intervention group. The control group was assessed twice, before and after the study period, but no interventions were performed during this time. The intervention group received 60 minutes of instruction from longtime video game professionals and welfare staff every 1 weeks for three months. The participants played a game racing game (Gran Turismo Sport, PlayStation 4,Sony)and rhythm game (Taiko no Tatsujin, Switch, Nintendo), as shown in Figure 1, 2.The screen was projected so that audience in the venue could see it. During intervention, participants were made aware that they were to improve their own performance ratherthan compete with others for grades. In addition, the instructors were conscious of praising participants not only for their grades, but also by explaining specific technical points and areas for improvement.

3.4. Assessment Domains

Demographic variables (e.g., age, sex, educational history, medication intake) and social participation were recorded at baseline via the Kihon Checklist (KCL) [19]. Evaluation points were established pre-intervention and after 3 months. Physical outcomes included grip strength (kg), habitual walking speed (m/s), and mental health indexed by the Geriatric Depression Scale-15 (GDS-15). Cognitive measures comprised four tablet-based modules from the National Center for Geriatrics and Gerontology Functional Assessment Tool (NCGG-FAT) [20].

3.5. Social Frailty Status

Classification was based on Makizako's five-item checklist, covering solitary living, conversational frequency, perceived usefulness, social withdrawal, and visiting patterns. A score of 0 indicated robustness, 1 prefrailty, and 2 or higher denoted social frailty [21].

3.6. Statistical Analysis

The participants who lacked data either at the baseline or after the intervention, were excluded for analysis. The paired t-test was applied to compare the results of UWS, GS, WM, TMT-A & B, and SDST between pre-test and post-test of this program for participants. The chi-squared test was applied for gender and social frailty status for variables with significant differences yielded in the former comparison tests, the analysis of variance for split-plot factorial design was subsequently applied to examine interactions between the groups (control group and intervention group) and time (pretest/post-test) for main effects. The F-value and the effect size (η2) were calculated as statis-tics for the analysis of variance for split-plot factorial design. SPSS Version 27.0 for Windows (SPSS INC., Chicago. IL, USA) was used for the analysis, and the level of a significance was set at $p = 0.05$.

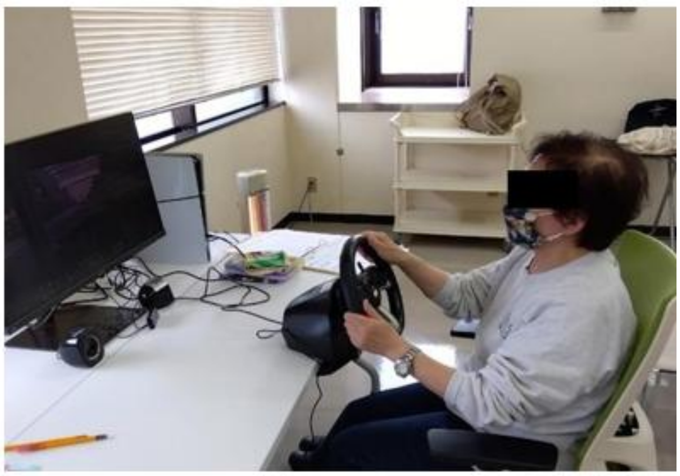

Figure 1: Playing a racing game.

Figure 2: Playing a rhythm game.

4. Results

As shown in Figure 3, the final samples used for analysis consisted of 25 participants in the control group and 24 the intervention group.

The basic characteristics of participants of the statistical analysis showed that there was no significant difference between the groups (Table 1). The paired t-test was used to analyze the differences between pretest and post-test and revealed for the control group a significant decrease in the GDS-15($p < 0.05$) (Table 2). On the other hand, the intervention group showed a significant improvement in the UWS ($p < 0.001$), WM ($p < 0.01$), SDST ($p < 0.01$), and GDS-15 ($p < 0.05$).In addition, the social frailty status did not have a significant difference for the control group but had a significant improvement for the intervention groups ($p < 0.05$) (Table 3).Next, figure 4 illustrates the significant interaction effect observed in Word Memory (WM)scores between the control and intervention groups from pre-test to post-test assessments. The intervention group demonstrated a significant improvement in WM scores, whereas the control group did not show significant change ($p < 0.01$). Figure 5 depicts the significant interaction effect for the Symbol Digit Substitution Task (SDST) scores between the two groups. Participants in the intervention group significantly improved their SDST scores from pre-test to post-test, compared to no significant improvement observed in the control group ($p < 0.01$). Figure 6 shows the significant interaction regarding scores on the Geriatric Depression Scale (GDS-15). The intervention group exhibited a notable reduction (improvement) in depressive symptoms, whereas the control group's depressive symptoms significantly worsened over the same period ($p < 0.01$).

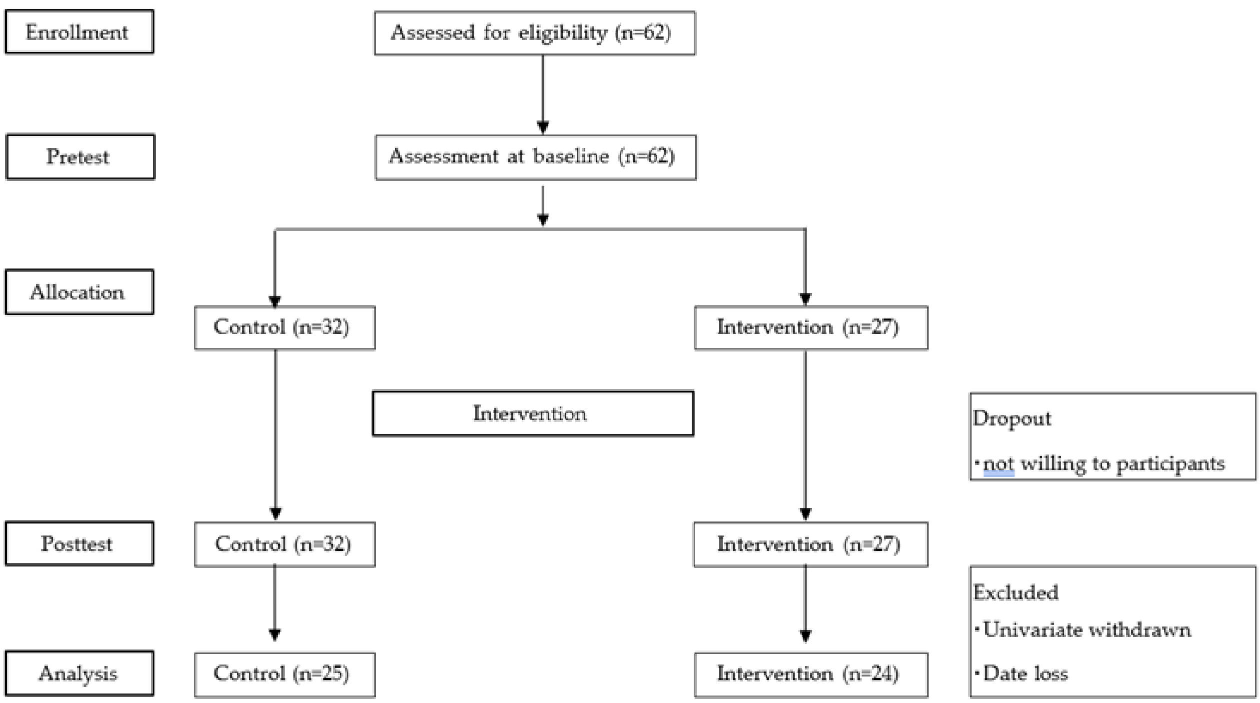

Figure 3:Flow diagram of screening.

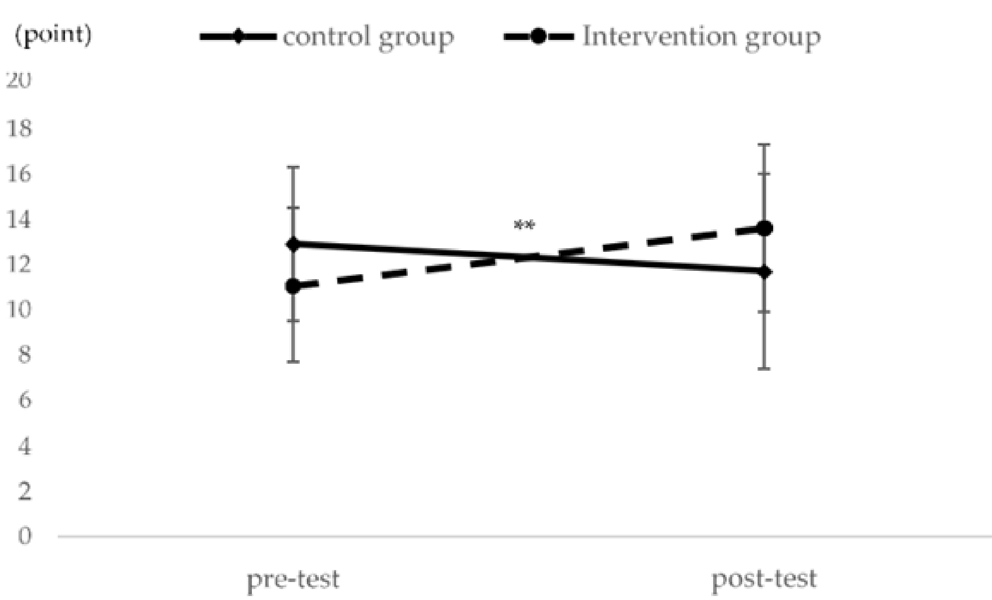

Figure 4:Main effect analysis of interaction regarding WM between the control group and the intervention group.**p<0.01.

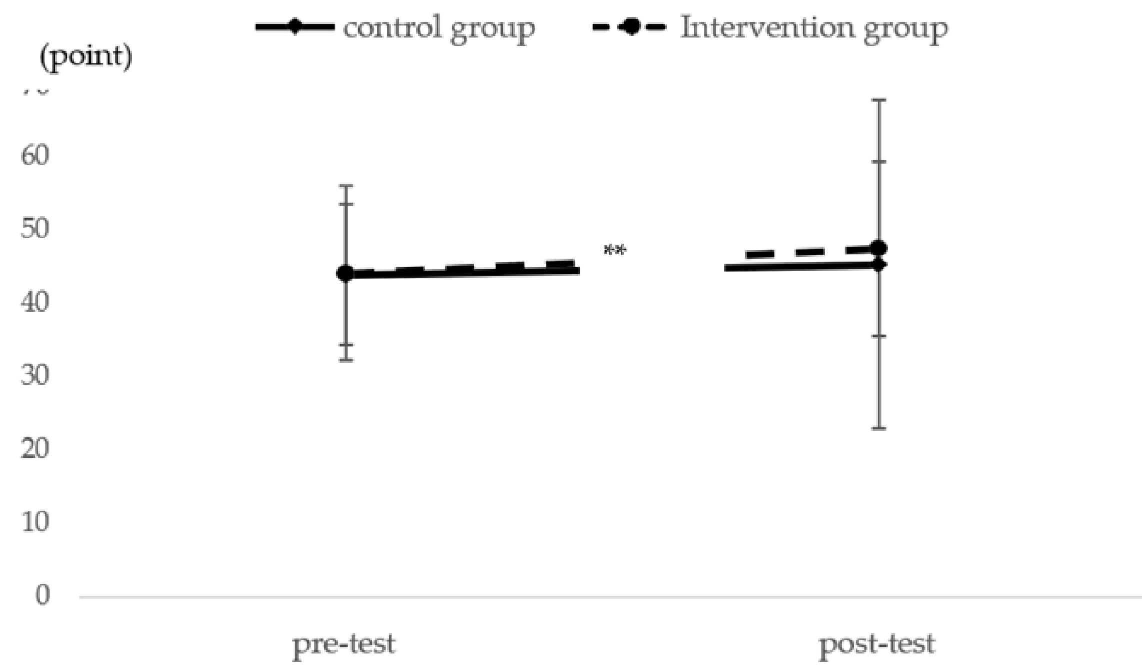

Figure 5: Main effect analysis of interaction regarding SDST between the control group and the intervention group.**p<0.01.

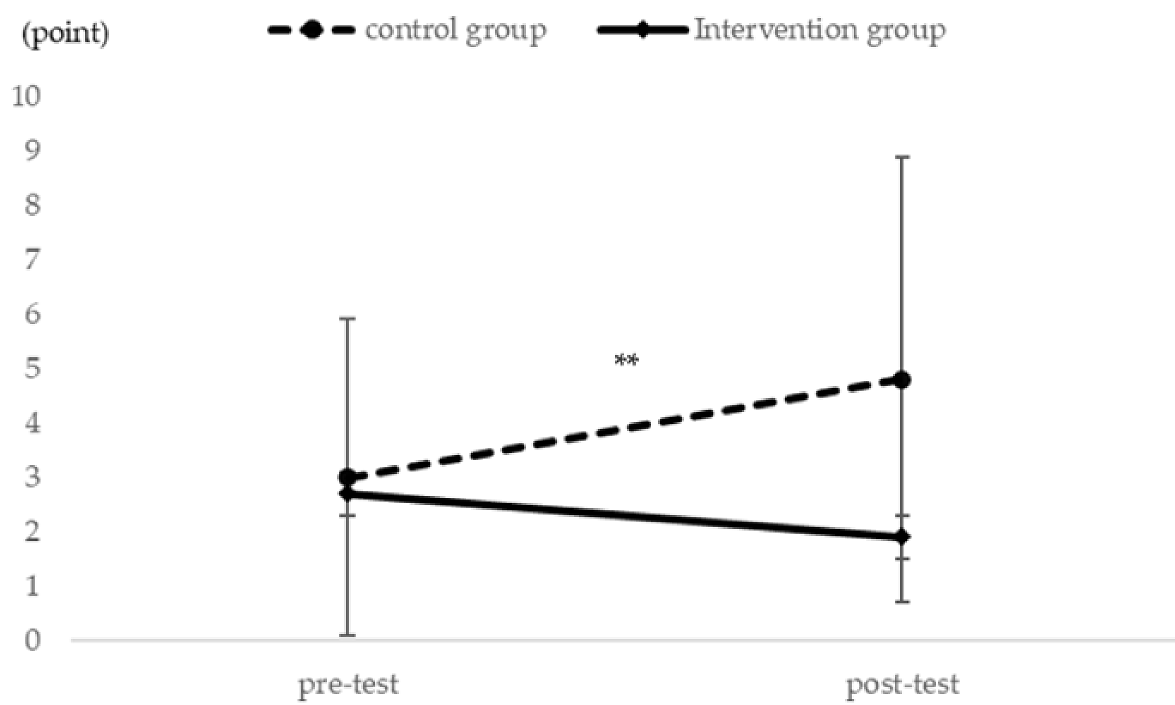

Figure 6: Main effect analysis of interaction regarding GDS-15 between the control group and the intervention group.**p<0.01.

Table 1: Base line characteristics and between group difference.

	Control group		Intervention group		
	n=25		n=24		p value
	Mean	SD	Mean	SD	
Age(years)	77.4	4.5	76.7	6.2	0.243
Gender(%female)	73.7		65.6		0.655
Height(cm)	156.2	6.5	155.4	9.3	0.421
Weight(kg)	55.6	9.4	56.5	12.3	0.922
BMI(kg/㎡)	22.4	3.2	22.7	3.8	0.894
Education(years)	12.4	1.9	12.0	1.9	0.132
Medication(n)	2.8	2.6	3	2.3	0.246
KCL(point)	5.0	3.2	4.5	3.2	0.386

The paired t-test (Age, Height, Weight, Medication, Education, KCL), the χ2 test (gender). Abbreviations: SD, standard deviation; KCL, Kihon Check List.

Table 2: Differences in dependent variables between groups over time, and interactions or main effects between the group.

	control group (n=25)					Intervention group (n=24)													
	pre-test		post-tesst			pre-test		post-tesst			Interaction (Group × Time)			Main effect (group)			Main effect (time)		
	Mean	SD	Mean	SD	p value	Mean	SD	Mean	SD	p value	F (7.54)	p value	η^2	F (7.54)	p value	η^2	F (7.54)	p value	η^2
GS (kg)	25.3	7.6	26.2	7.5	0.124	24.2	8.6	24.4	9.2	0.532	0.822	0.369	0.018	0.362	0.550	0.008	2.645	0.111	0.056
UWS (m/s)	1.32	0.29	1.34	0.28	0.640	1.37	0.23	1.44	0.25	0.010*	0.721	0.400	0.016	0.882	0.353	0.019	2.745	0.105	0.057
WM (point)	12.9	3.4	11.7	4.3	0.067	11.1	3.4	13.6	3.7	0.008**	12.689	0.001**	0.220	0.001	0.980	0.001	1.894	0.176	0.040
TMT-A (sec)	21.8	7.4	21.6	4.8	0.831	24.5	24.3	22.7	23.4	0.183	0.845	0.363	0.018	0.148	0.702	0.003	1.437	0.237	0.031
TMT-B (sec)	43.7	24.9	45.5	22.4	0.640	45.3	57.7	46.3	57.7	0.687	0.026	0.874	0.001	0.011	0.918	0.000	0.366	0.548	0.008
SDST (point)	44.0	9.6	45.4	22.4	0.449	44.2	11.9	47.5	11.9	0.002**	9.609	0.003**	0.176	0.458	0.502	0.010	4.301	0.044*	0.087
GDS-15 (point)	3.0	2.9	4.8	4.1	0.014*	2.7	1.8	1.9	1.8	0.035*	10.257	0.003**	0.186	5.290	0.026*	0.105	2.005	0.164	0.043

*p<0.05, **p<0.01 the paired t-test, the analysis of variance for split-plot factorial design. Abbreviations: GS, Grip Strength; UWS, Usual Walking Speed; WM, Word Recognition; TMT-A, Trail Making Test-Version A and B; SDST, Symbol Digit Substitution Task; GDS-15, Geriatric Depression Scale short-form.

Table 3: Comparison of the social frailty for the control group and the Intervention group at the pretest and the post-test.

Control group			Intervention group	
			p value	p value
	pre-test	post-test	pre-test	post-test
Social frailty (%)				
robust	54.0	52.0	50.0	54.5
			0.723	0.018*
pre-frailty	21.2	20.8	22.7	18.2
frailty	24.8	27.2	27.3	27.3

*p<0.05,the χ^2 test.

5. Discussion

This study demonstrated that a video game-based intervention program for community dwelling older adults significantly improved cognitive function and social frailty. Participants in the intervention group showed significant improvements in WM, SDST, andGDS-15 scores, whereas the control group exhibited a significant deterioration in GDS-15. These findings suggest that the intervention positively influenced both cognitive and psychological domains. Recently video game-based interventions aimed at enhancing cognitive function among older adults have gained international attention. For instance, Maillot et al. (2012) reported improvements in executive function and processing speed among older adults following a 12-week video game intervention [22]. Additionally, Anguera et al. (2013) showed significant cognitive improvements through multitasking game-based training in older adults [23]. Games such as racing and rhythm games, used in the current study, require reflexes and timing skills, making them particularly effective in enhancing cognitive flexibility and visual processing speed, crucial for maintaining cognitive function in older adults [24,25].The observed improvement in social frailty in this study is also significant. Social frailty is deeply associated with health outcomes among older adults, with loneliness and social isolation contributing to declines in physical and cognitive health, as demonstrated multiple studies [26,27,28]. Video games provided opportunities for social interaction among participants, fostering group cohesion and reducing feelings of loneliness. Importantly, video games can facilitate interactions not only for those actively playing but also for observers. Observers can participate by praising players' skills, offering advice, or sharing in the emotional experiences of success or challenges, thereby fostering mutual communication and a sense of community belonging. Such opportunities for social interactions may significantly alleviate feelings of isolation, enhancing social roles and com- 283 munity participation [29].The improvement of depressive symptoms (measured by GDS-15) is another critical fining. Depressive symptoms significantly affect older adults' quality of life (QOL) and are known to exacerbate physical and cognitive declines. While exercise and cognitive inter- 287 ventions are well-documented methods to alleviate depression [30,31,32], the effective- 288 ness of video game interventions in achieving similar outcomes presents an additional, valuable option for older adult care. Kuwahara et al. (2021) reported increased heart rate and improved mood among older adults playing Gran Turismo Sport, particularly noting substantial psychological improvements among female participants. Their findings suggest the feasibility and effectiveness of commercial video game interventions at the community level [33]. The practical implementation of the intervention within community-based settings is another notable strength of this study. Unlike many tightly controlled laboratory studies, this study was conducted in community centers, enhancing its generalizability. Futurestudies with broader geographic implementation and larger sample sizes could further confirm the intervention's effectiveness. Nevertheless, the current study has several limitations. Firstly, the relatively small sample size necessitates replication with larger samples. Additionally, the short follow-up period limits our understanding of the long-term sustainability of observed effects, necessitating longer-term evaluations. Investigating the impact of varying intervention parameters, such as game types, difficulty levels, and frequency, is also essential for optimizing cognitive and social frailty outcomes.

In conclusion, the current findings support the effectiveness of multi-faceted video game interventions in enhancing cognitive functions, promoting social connections, and reducing depressive symptoms among older adults. With rapid global population aging, demonstrating the effectiveness of such low-cost and easily implementable programs is crucial for improving older adults' quality of life. Future research should focus on elucidating detailed mechanisms and optimizing video game interventions for broader application.

6. Conclusions

This study supports the effectiveness of video game-based interventions for enhancing cognitive function, reducing social frailty, and alleviating depressive symptoms among community dwelling older adults. Such interventions offer an accessible, cost-effective, and enjoyable method for promoting healthy aging and maintaining quality of life. Given the rapid aging of populations globally, adopting innovative, engaging strategies like video game interventions can significantly contribute to public health efforts targeting older adults. Future research should aim to further explore long-term effects, optimal intervention parameters, and mechanisms underlying the observed benefits to maximize the utility and effectiveness of video game interventions in diverse community settings.

7. Conflicts of Interest:

The authors declare no conflict of interest in the study.

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