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

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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 livingolder adults.

1.2. Methods

The study enrolled 62 participants aged 65 and over. Twenty-four wereassigned 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 socialfrailty indicators.

1.3. Results

The intervention cohort demonstrated marked enhancement in wordmemory ($p < 0.01$), Symbol Digit Substitution Task performance ($p < 0.01$), and depressive symptomatology (GDS-15; $p < 0.05$). Meanwhile, control participants experienced a significant declinein GDS-15 scores ($p < 0.05$). Although the control group's social frailty status remained static, theintervention 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 agerelated 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 impairmentparticularly memory loss, decreasedexecutive function, and attention deficitsposes a major risk to autonomy in old age [3]. Likewise, social isolation and loneliness are increasingly recognized as critical publichealth issues. These social factors are associated not only with depression and reducedquality 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 incommunity settings [6]. Cognitive training programs have been studied for decades as tools for maintainingor enhancing mental function in older populations. Meta-analyses have confirmed thattargeted 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 andvideo 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 andimmersive qualities [8]. In addition, the variety of games available on the market makesit possible to set the difficulty level based on the subject's experience.Certain genres of gamessuch as action games, rhythm games, or racing simulationsrequire 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 targetedcognitive rehabilitation [10]. In addition to cognitive effects, video games may providepsychosocial 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 activitieshas recently emerged as a key predictor of physical frailty and disability. Studies haveshown that socially frail older adults are at higher risk of cognitive decline and institutionalization [12]. Therefore, preventive measures that promote social participation areessential for healthy aging. Incorporating interactive video games into group-based settings may represent a novel and effective strategy in this domain. Research on gamebased 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 weeksshowed significant improvements in executive function and processing speed comparedto 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 find-ings indicated moderate increases in heart rate without adverse blood pressure effects,along with improvements in mood-especially among female participants [15]. Theseresults 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 isneeded 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-gameintervention in improving physical and cognitive function, as well as reducing socialfrailty among community-dwelling older adults.

3.Materials and Methods

3.1.Study Population

This quasi-experimental project was executed from October 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 di-agnoses such as dementia, major depression, serious visual or auditory deficits, cerebro-vascular disease, Parkinson’s, other neurological conditions, intellectual disabilities, and enrollment in the national long-term care support program. Inability to complete base-line 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, 40 intervention) 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 re-viewed and approved by the Ethics Committee of Akita University’s Department of Health Sciences (Approval No. 274).

3.2.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 pointsand areas for improvement.

3.3.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), andmental health indexed by the Geriatric Depression Scale-15 (GDS-15). Cognitive measurescomprised four tablet-based modules from the National Center for Geriatrics and Gerontology Functional Assessment Tool (NCGG-FAT) [20].

3.4. 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].

3.5. Statistical Analysis

The participants who lacked data either at the baseline or after the intervention, wereexcluded 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 statusFor 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 forWindows (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 participantsin the control group and 24 the intervention group. The basic characteristics of participants of the statistical analysis showed that there was no significant difference betweenthe 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 controlgroup 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, whereasthe 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 thetwo groups. Participants in the intervention group significantly improved their SDSTscores from pre-test to post-test, compared to no significant improvement observed in thecontrol 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 depressivesymptoms significantly worsened over the same period ($p < 0.01$).

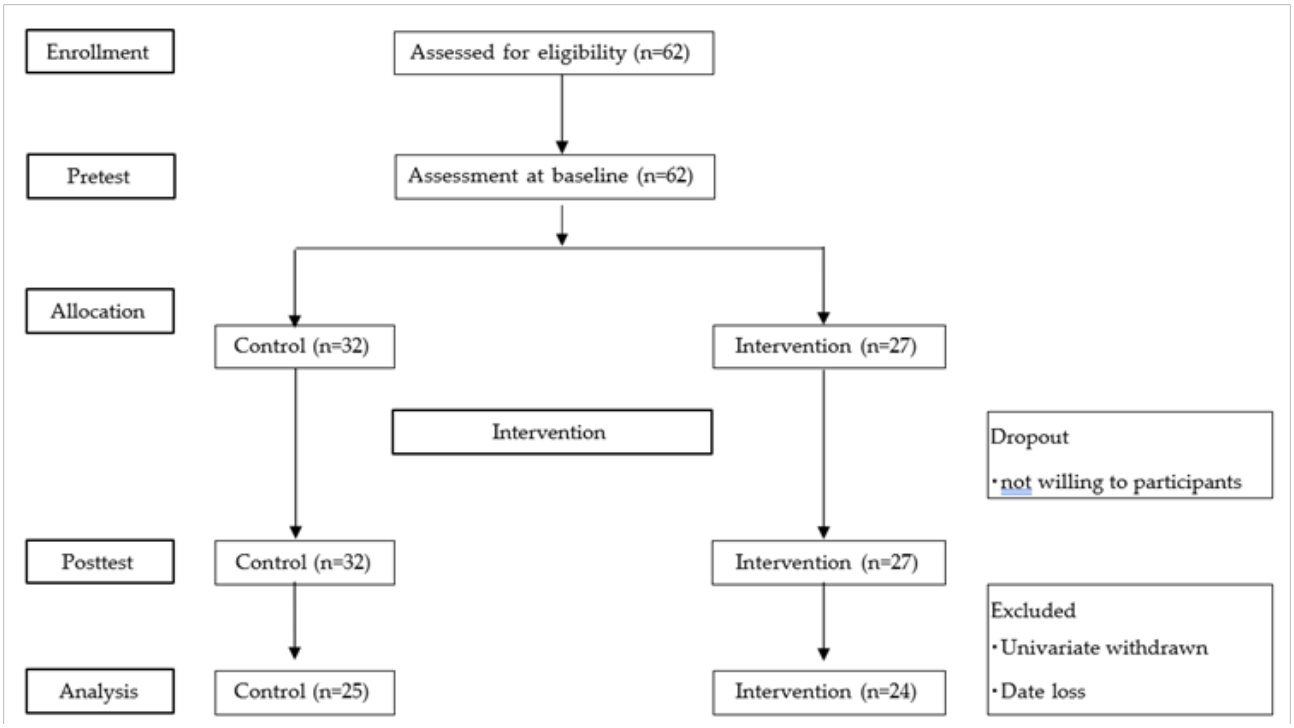

Figure 3:Flow diagram of screening.

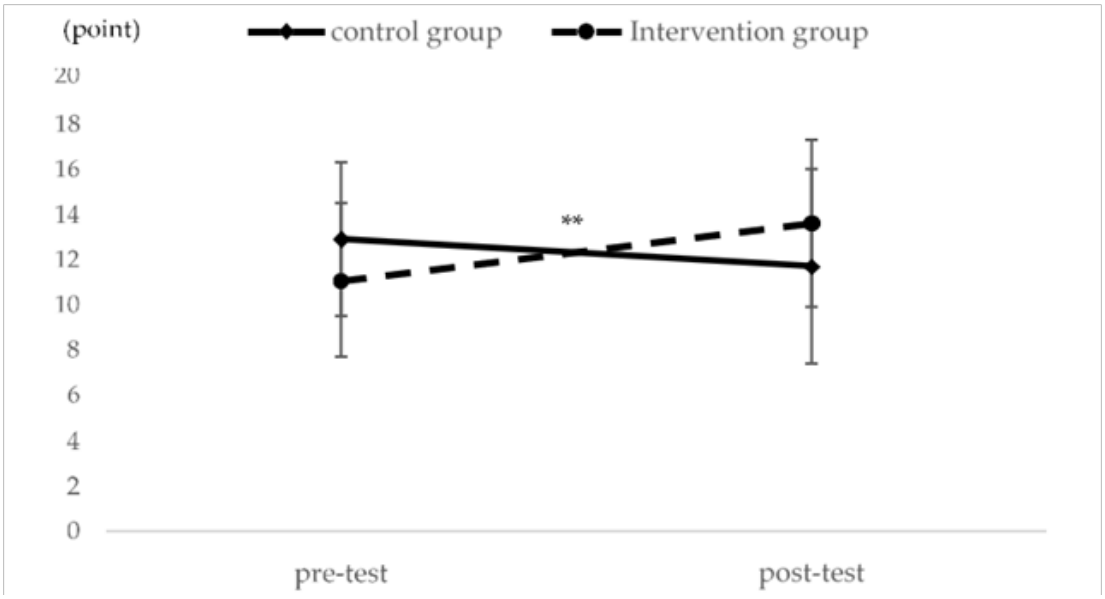

Figure 4:Main effect analysis of interaction regarding WM between the control group and the intervention group.**p<0.01.

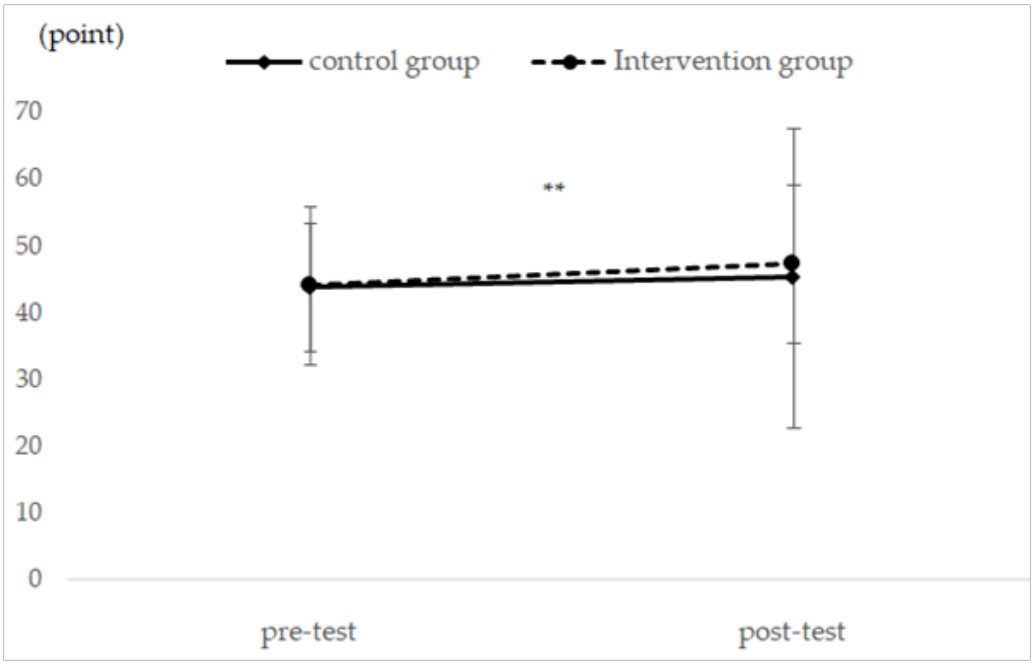

Figure 5: Main effect analysis of interaction regarding SDST between the control group and the intervention group.**p<0.01.

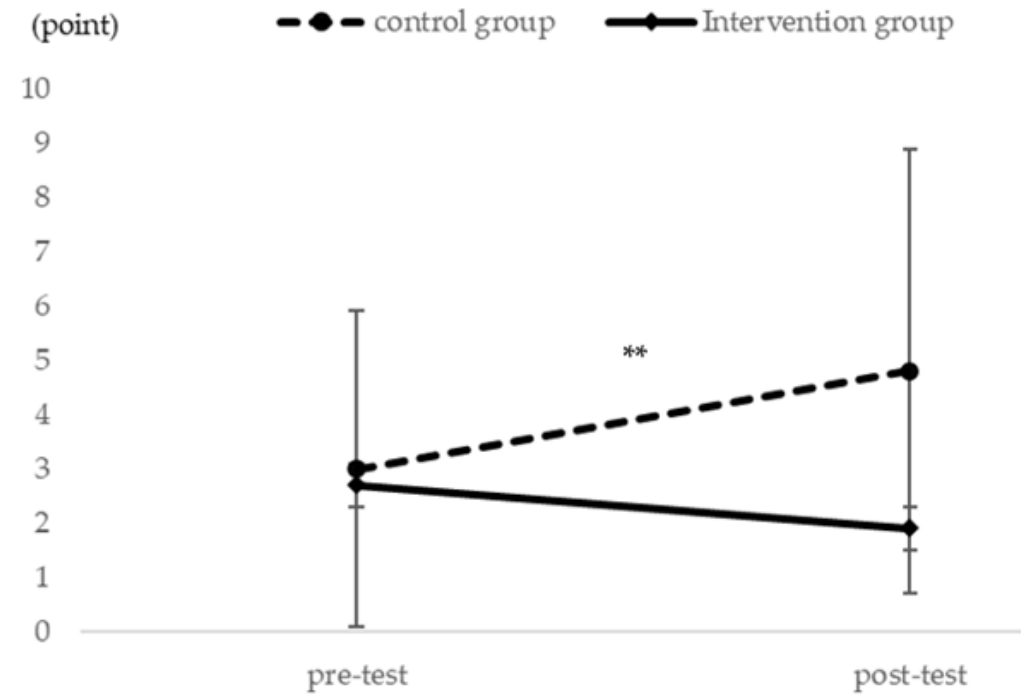

Figure 6: Main effect analysis of interaction regarding GDS-15 between the control group and the intervention group.**p<0.01.

Table 1: Base line characteristics and between group difference.

	controlgroup		Interventiongroup		
	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 $\chi 2$ test (gender). Abbreviations: SD, standard deviation; KCL, Kihon Check List.

Table 2: Differences in dependent variables between groups over time, and interactionsor 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 factorialdesign. Abbreviations: GS, Grip Strength; UWS, Usual Walking Speed; WM, WordRecognition; TMT-A, Trail Making Test-Version A and B; SDST, Symbol DigitSubstitution Task; GDS-15, Geriatric Depression Scale short-form.

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

controlgroup			Interventiongroup	
			p value	p value
	pre-test	post-test	pre-test	post-test
socialfrailty(%)				
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,theχ^2test.

5. Discussion

This study demonstrated that a video game-based intervention program for communitydwelling 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 amongolder adults have

gained international attention. For instance, Maillot et al. (2012) reported improvements in executive function and processing speed among older adults followinga 12-week video game intervention [22]. Additionally, Anguera et al. (2013) showed significant cognitive improvements through multitasking game-based training in olderadults [23]. Games such as racing and rhythm games, used in the current study, requirereflexes and timing skills, making them particularly effective in enhancing cognitive flexibility and visual processing speed, crucial for maintaining cognitive function in olderadults [24,25].The observed improvement in social frailty in this study is also significant. Social frailtyis deeply associated with health outcomes among older adults, with loneliness and socialisolation contributing to declines in physical and cognitive health, as demonstrated multiple studies [26,27,28]. Video games provided opportunities for social interactionamong participants, fostering group cohesion and reducing feelings of loneliness. Importantly, video games can facilitate interactions not only for those actively playing butalso for observers. Observers can participate by praising players' skills, offering advice, orsharing in the emotional experiences of success or challenges, thereby fostering mutualcommunication 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 areknown 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 furtherconfirm 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 optimizingcognitive and social frailty outcomes.

In conclusion, the current findings support the effectiveness of multi-faceted video gameinterventions 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 iscrucial 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 enhancingcognitive function, reducing social frailty, and alleviating depressive symptoms amongcommunitydwelling older adults. Such interventions offer an accessible, cost-effective,and enjoyable method for promoting healthy aging and maintaining quality of life. Giventhe rapid aging of populations globally, adopting innovative, engaging strategies likevideo game interventions can significantly contribute to public health efforts targetingolder adults. Future research should aim to further explore long-term effects, optimal intervention parameters, and mechanisms underlying the observed benefits to maximizethe 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.

References

1. United Nations, Department of Economic and Social Affairs, Population Division. World population ageing 2019.
2. Cabinet Office, Government of Japan. (2023). Annual report on the ageing society. 2023.
3. Harada CN, Natelson Love, MC, Triebel KL. Normal cognitive aging. Clinics in Geriatric Medicine. 2013; 29(4):737-752.
4. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: A meta-analytic review. PLoSMedicine. 2010; 7(7): e1000316.
5. Cacioppo JT, CacioppoS. Social relationships and health: The toxic effects of perceived social isolation. Socialand Personality Psychology Compass. 2014; 8(2): 58-72.
6. Park DC, Bischof GN. The aging mind: Neuroplasticity in response to cognitive training. Dialogues in ClinicalNeuroscience. 2013; 15(1): 109-119.
7. Reijnders JS, van Heugten CM, van Boxtel MP. Cognitive interventions in healthy older adults and peoplewith mild cognitive impairment: A systematic review. Ageing Research Reviews. 2013; 12(1): 263-275.
8. Anguera JA,Gazzaley A. Video games, cognitive training, and the aging brain. Dialogues in Clinical Neuroscience. 2015; 17(2): 361-368.

9. Green CS,BavelierD. Action video game modifies visual selective attention. Nature. 2003; 423(6939): 534-537.
10. Basak C, Boot WR, Voss MW, Kramer AF. Can training in a real-time strategy video game attenuatecognitive decline in older adults? Psychology and Aging. 2008; 23(4): 765-777.
11. De SchutterB. Never too old to play: The appeal of digital games to an older audience. Games and Culture. 2011; 6(2): 155-170.
12. Makizako H, Shimada H, Tsutsumimoto K, Lee S. Social frailty in community-dwelling olderadults as a risk factor for disability. Journal of the American Medical Directors Association. 2015; 16(11): 1003.e7-1003.e11.
13. MaillotP, Perrot A,Hartley A. Effects of interactive physical-activity video-game training on physical andcognitive function in older adults. Psychology and Aging. 2012; 27(3): 589-600.
14. Anguera JA, Boccanfuso J, Rintoul JL, Al-Hashimi O, Faraji F. Video game training enhances cognitive 366 control in older adults. Nature. 2013; 501(7465): 97-101.
15. Raz N, Kennedy KM. A systems approach to the aging brain: neuroanatomic changes, their modifiers and cognitivecorrelates," in Imaging the Aging Brain, eds W. Jagust, and M. D'Esposito (New York, NY: Oxford University Press). 2009; 43-70.
16. Nishiguchi S, Yamada M, Higuchi T, Tanimoto K. Synergistic effects of aerobic exercise and cognitive training on mnemonic discrimination. Frontiers in Aging Neuroscience. 2020; 12: 563855.
17. Faul F,Erdfelder E, Buchner A. Statistical power ana lyses using g*power 3.1: tests for correlation and regression analyses. Behav Res Methods. 2009; 41: 1149-1160.
18. Faul F,Erdfelder E, Lang AG. G*power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007; 39: 175-191.
19. Satake S, Senda K, Hong YJ, Miura H. Validity of the Kihon Checklist for assessing frailtystatus. GeriatrGerontol Int. 2016; 16(6): 709-715.
20. Makizako H, Shimada H, Park H, Doi T, Uemura K,Tsutumimoto K. Evaluation of multidimensional neurocognitive function using a tablet personal computer: Test-retest reliability and validity in community-dwelling olderadults. Geriatr. Gerontol. 2013; 13: 860-866.
21. Makizako H, Shimada H,Tsutumimoto K, Lee S. Social Frailty in Community-Dwelling Older Adults as a Risk Factor for Disability, J Am Med Dir Assoc 2015: 16: 1003 e1007-1011.
22. Maillot P, Perrot A, Hartley A. Effects of interactive physical-activity video-game training on physical andcognitive function in older adults. Psychology and Aging. 2012; 27(3): 589-600.
23. Anguera JA, Boccanfuso J, Rintoul JL, Al-Hashimi O, Faraji F. Video game training enhances cognitivecontrol in older adults. Nature. 2013; 501(7465): 97-101.
24. Stern Y, Arenaza-Urquijo EM, Bartrés-Faz D, Belleville S. Defining and investigating cognitive reserve, brain reserve, and brain maintenance. Alzheimer's & Dementia. 2018; 14(9): 1305-1314.
25. Nishiguchi S, Yamada M, Tanigawa T, Sekiyama K. Cognitive training and aerobic exercisein older adults: A randomized controlled trial. Frontiers in Aging Neuroscience. 2020; 12: 234.
26. Holt-Lunstad J, Smith TB, BakerM, HarrisT. Loneliness and social isolation as risk factorsfor mortality: A meta-analytic review. Perspectives on Psychological Science. 2015; 10(2): 227-237.
27. Cacioppo JT,Cacioppo S. The growing problem of loneliness. The Lancet. 2018; 391(10119): 426.
28. Makizako H, Shimada H, Tsutsumimoto K. Social frailty in community-dwelling older adults as a riskfactor for disability. Journal of the American Medical Directors Association. 2015; 16(11): 1003.e7-1003.
29. Noice T, Noice H,Kramer AF. Participatory arts for older adults: A review of benefits and challenges. TheGerontologist. 2014; 54(5): 741-753.
30. Catalan-Matamoros D, Gomez-ConesaA, Stubbs B, Vancampfort D. Exercise improves depressive symptomsin older adults: an umbrella review. Psychiatry Research. 2016; 244: 202-209.
31. Schuch FB, Vancampfort D, Firth J, Rosenbaum S, Ward PB. Physical activity and incident depression:a meta-analysis of prospective cohort studies. American Journal of Psychiatry. 2018; 175(7): 631-648.
32. Morres ID, Hatzigeorgiadis A, Stathi A. Aerobic exercise for adult patients with major depressive disorder:a systematic review and meta-analysis. Depression and Anxiety. 2019; 36: 39-53.
33. Kuwahara A, Nishida Y, Yamamoto H. Effects of playing Gran Turismo Sport on older adults' cardiovascular and psychological health. Journal of Aging and Physical Activity. 2021; 29(6): 921-929.