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A Comparative Analysis of the Impact of Two Distinct Virtual Reality Training Modalities on Gait and Balance in Individuals with Dementia: A Prospective Controlled Study

Demanslı Bireylerde İki Farklı Sanal Gerçeklik Eğitim Yönteminin Yürüme ve Denge Üzerindeki Etkisinin Karşılaştırmalı Analizi: Prospektif Kontrollü Çalışma

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ABSTRACT Objective: To compare the effects of different types of virtual reality training (VRT) given in conjunction with conventional exercises on the spatiotemporal parameters (STP) of gait and balance in individuals with dementia. **Material and Methods:** This study was designed as a nonrandomized controlled study. Thirty participants were divided into VRT1 (Xbox 360 Kinect®+exercise), VRT2 (ALDA Balance Gear®+exercise), and control groups (exercise only). All 3 groups underwent training on a biweekly basis for a period of 6 weeks. The study employed the BTS G-Walk® to evaluate the STP of the gait, while the Berg Balance Scale and the Time Up and Go Test were utilized to assess the participant's balance. **Results:** There were no significant differences between the groups following the intervention ($p>0.05$). Significant intragroup improvements were observed in gait speed, and gait cycle time in both VRT1 and VRT2 groups ($p<0.05$). **Conclusion:** As a result, no statistically significant differences were found between the groups. Moreover, different VRTs were not statistically superior to each other in individuals with dementia. Considering our findings, although there were small differences between the virtual reality groups, it was found that there were positive within-group improvements on speed and gait cycle duration in both virtual reality groups. In this context, VRT can be considered clinically useful in improving gait in individuals with dementia. However, long-term and comprehensive studies are needed to determine the effects of VRT on gait and balance in this patient group.

Keywords: : Dementia; exercise; geriatrics; rehabilitation; virtual reality

ÖZET Amaç: Demanslı bireylerde geleneksel egzersizlerle birlikte verilen farklı sanal gerçeklik eğitimlerinin [virtual reality training (VRT)] yürüyüşün zaman mesafe parametreleri [spatiotemporal parameters (STP)] ve denge üzerindeki etkilerini karşılaştırmaktır. **Gereç ve Yöntemler:** Bu çalışma, randomize olmayan kontrollü bir çalışma olarak tasarlandı. Otuz katılımcı VRT1 (Xbox 360 Kinect®+egzersiz), VRT2 (ALDA Balance Gear®+egzersiz) ve kontrol gruplarına (sadece egzersiz) ayrıldı. Her 3 gruba da 6 haftalık bir süre boyunca 2 haftada 1 eğitim verildi. Çalışmada yürüyüşün STP'yi değerlendirmek için BTS G-Walk® kullanılırken, katılımcıların dengesini değerlendirmek için Berg Denge Ölçeği ve Zamanlı Kalk Yürü Testi kullanıldı. **Bulgular:** Müdahale sonrasında gruplar arasında anlamlı bir fark bulunmadı ($p>0,05$). Hem VRT1 hem de VRT2'de yürüyüş hızı, ve yürüyüş döngüsü süresinde anlamlı grup içi iyileşmeler gözlendi ($p<0,05$). **Sonuç:** Sonuç olarak, gruplar arasında istatistiksel olarak anlamlı farklılıklar bulunmadığı tespit edildi. Üstelik, demanslı bireylerde farklı VRT'nin birbirlerine istatistiksel olarak üstün olmadığı da görüldü. Bulgularımız göz önüne alındığında VRT arasında küçük farklılıklar bulunmasına rağmen, her iki sanal gerçeklik grubunda da hız ve yürüyüş döngüsü süresi üzerinde grup içi olumlu gelişmeler bulunduğu tespit edildi. Bu kapsamda, demanslı bireylerde VRT'nin yürüyüşün geliştirilmesinde klinik açıdan faydalı olduğu düşünülebilir. Ancak, demanslı bireylerde VRT'nin yürüyüş ve denge üzerindeki etkilerinin belirlenmesi için uzun vadeli ve kapsamlı çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Demans; egzersiz; geriatri; rehabilitasyon; sanal gerçeklik

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Dementia represents a significant challenge for the geriatric population, affecting an estimated 9.9 million individuals annually and influencing mobility parameters such as gait and balance, in addition to cognitive functions.[1,2] Although the gradual loss of safe and independent gait and balance is a common feature of the advanced stages of dementia that affects every day function, there is evidence to suggest that this process may begin in the early stages of the disease.[3]

It has been demonstrated that regular exercise has a beneficial impact on mobility issues, including gait and balance disorders.[4,5] Virtual reality training (VRT) encompasses a wide variety of computer-aided exercise forms, ranging from commercially available systems, including the Wii Balance Board™ (Nintendo, Japan), Microsoft Xbox Kinect 360™ (Microsoft Corp., USA) and PlayStation EyeToy™ (Sony Corp., USA), to systems designed for the purpose of academic research or rehabilitation, including Physiomat (EPL, Germany) and Bike labyrinth (BikeLabyrinth, Netherlands).[6-10] The extant evidence indicates that VRT has a beneficial impact on balance, mobility, and gait in older adults.[10] Some studies have indicated that commercial virtual reality (VR) systems have greater positive effects than VR systems for rehabilitation purposes.[11]

There is some evidence to suggest that VR may be an effective intervention for improving mobility and balance in individuals with dementia.[12] A recent metaanalysis found that in people with dementia or mild cognitive impairment, VR training using commercial or rehabilitation-specific VR systems had a positive effect on gait speed, balance, and lower limb strength.[13-16] Nevertheless, the remaining spatiotemporal parameters (STP) of gait, aside from speed, have not been subjected to analysis in the aforementioned studies. Moreover, no study has yet been conducted to compare the effects of different VRT methods on dementia. It is therefore unclear to what extent different types of VRT methods are superior in influencing gait and balance. The present study aimed to compare the effects of 2 distinct VRT methods on balance and STP of gait in individuals with dementia, thereby contributing to the existing literature on this topic. We hypothesized that VRT administered in conjunction with the conventional exercise program would prove superior to the conventional exercise program alone in terms of balance and gait. Furthermore, another objective was to ascertain which VRT exhibits this superiority.

MATERIAL AND METHODS

TRIAL DESIGN

The present study was designed as a 6-week nonrandomized controlled interventional trial using a parallel design. The study was approved by the ethics committee of the Ankara Yıldırım Beyazıt University (date: March 15 2019; no: 2019-65) and was registered in the Clinical Trials database (NCT04377191). The procedures used in this study are in accordance with the principles of the Declaration of Helsinki.

PARTICIPANTS

The aim and content of the study were explained to the participants and professional caregivers, and signed written informed consent was obtained from all parties. The study population consisted of individuals diagnosed with dementia and residing in nursing homes in the city of Ankara, Türkiye. Recruitment took place between March-November 2019. To obtain the medical records of the individuals in question, the nursing home staff was consulted. The authors then determined which participants were eligible based on their review of the medical records and the study criteria. The participants were selected if they met the following criteria: age 65 or above, diagnosis of dementia, Mini-Mental State Examination (MMSE) score between 18 and 23, the ability to speak and understand Turkish, the ability to comply with basic commands, graduation from at least primary school, and willingness to participate.[17,18] The participants were excluded if they met one of the following criteria: severe visual or hearing problems, history of acute retinal hemorrhage or ophthalmic surgery, neurologic or vestibular problems and/or use of medication to treat these problems, uncontrolled cardiovascular disease, congestive heart failure, acute myocarditis, the presence of pulmonary hypertension or a pacemaker, history of malignancy, or history of orthopedic or neurological surgery in the previous 6 months.

The participants were assigned into the 3 groups comprising the 2 different VRT groups (VRT group 1: VRT1 and VRT group 2: VRT2) and a control group. Given the distinctive technical characteristics of VR devices, a random assignment of individuals to VRT groups was not feasible. Appropriate nursing homes were selected for VR applications. For the VRT1 group, nursing homes that possessed a television or a projector, a spacious hall with a depth of 1.5-2 meters and an area that enabled the participant to be the only individual in front of the Kinect sensor were selected. For the VRT2 group, nursing homes that did not meet the VRT1 criteria were selected because the ALDA sensor (Alexandave Industries, Taiwan) is a more practical option.

INTERVENTIONS

The program spanned a period of 6 weeks, with 2 sessions conducted per week, resulting in a total of 12 sessions for all groups. Each session lasted between 40-60 minutes, including training and rest periods, and was supervised on an individual basis by a physiotherapist.

One of the VRT groups in this study received exercise and VRT with the Microsoft Xbox Kinect 360™ (VRT1), while the other VRT group received exercise and VRT with the ALDA™ system (VRT2). The control group received only exercise training without VRT. To facilitate comprehension and adaptation to the systems, VRT was administered for 10 minutes in the initial week, 20 minutes in the 2nd week, and 30 minutes in the subsequent 4 weeks. The exercise training regimen was incrementally increased from 8 to 12 repetitions for all groups, in consideration of the participants' exercise adaptations and fatigue levels. Each participant received individualized training from a physiotherapist, and all groups underwent training in person. All training sessions were carried out in one-to-one format with a physiotherapist. The exercises were conducted in accordance with the established safety protocols. Prior to the commencement of the exercise, a comprehensive review of the participants' daily vital signs was conducted, encompassing blood pressure, body temperature, and blood glucose levels. Furthermore, measures were implemented to address any potential imbalances that might emerge during the course of the exercise.

VR TRAINING

During the VRT in VRT1, participants were instructed to assume a standing position in front of a Kinect® camera. Subsequently, the participants were instructed to observe the game and to take note of the verbal and visual feedback provided by the physiotherapist. Kinect training progressed from simple tasks to complex ones. In the initial sessions, training was conducted through simple seated VR exercises [Fruit Ninja (Halfbrick Studios, Australia), Go the Distance (Minute to Win It) (Zoo Publishing, USA), Gold Rush Mountain (Carnival Games) (2011-2K Play, USA), and Extreme Hanky Panky (Minute to Win It) (Zoo Publishing, USA)] to allow participants to focus on the VR exercises and to realize that they were controlling the exercises "by their own movements". In the subsequent sessions, a VRT program was implemented that required weight transfer in the standing position and the use of the upper extremities. The concluding sessions comprised a VRT program incorporating more sophisticated movements in standing positions, including lunges and mini squats [Funnell Cake Falls (Carnival Games) (2011-2K Play, USA), Nervous Nelly (Herald Tribune, USA), Crossboard, and Bowling].

In VRT2, the VRT was performed using the ALDA® system. The system comprises a motion-detector sensor, a USB port for wireless transfer of sensor motion data to the computer, and the VRT, which was developed for balance evaluation and balance training. The sensor was secured between the L3-5 vertebrae to detect the participants' movements. The training regimen encompassed a series of exercises that could be regulated by movements of the trunk and weight transfer in either a sitting or standing position, with adjustable difficulty levels [Space Shooter (Alexandave Industries, Taiwan), Balance Surfing, and Balance Maze (Alexandave Industries, Taiwan)]. In the initial 3 sessions, the participants engaged in seated VR exercises, which progressively increased in difficulty. Subsequently, the exercises were performed in a standing position.

EXERCISE TRAINING

The exercise program included postural alignment exercises for the upper quadrant and postural exercises for spinal alignment, trunk and lower extremity strengthening, coordination, functional movements, balance, and gait. In addition, normal joint movement of the neck, trunk, and upper extremities and stretching exercises for the lower extremities were performed as warm-up and cooling exercises before and after the program.

ASSESSMENTS

The participant's clinical and sociodemographic data were recorded at baseline. The cognitive status was evaluated through the MMSE-Turkish version at the beginning of the study. The MMSE comprises questions within the following categories: orientation, registration, attention and calculation, recall and language, with a total score of 30 points.[17] A score of 24 or above was deemed to be within the normal range, while a score of 18 to 23 was indicative of mild cognitive impairment.[18,19] STP and balance were evaluated at baseline and after the 6-week training program. All assessments were performed by the same physiotherapist.

The primary outcome was gait speed, assessed using the BTS G-Walk® (BTS Bioengineering S.p.A., Garbagnate Milanese, Italy), a reliable and valid inertial sensor. During the gait, data are transferred through a Bluetooth® 3.0 connection (G-Studio® software) (BTS Bioengineering S.p.A., Garbagnate Milanese, Italy), and the STP are determined.[20] The sensor was affixed to the L4-L5 spinal segment with a semi-elastic belt. The participants were asked to walk along an 8-meter corridor at their usual gait speed, which was defined as the maximum distance that individuals could walk without encountering any obstacles in each nursing home included in the study.[21]

The secondary outcomes were the other STP, including cadence, stride length, right and left step length, percentage of stride length/width, and gait cycle time, which were assessed by the BTS G-Walk® sensor. The BTS G-Walk has been shown to possess excellent reliability and validity.[20] The Berg Balance Scale (BBS) Turkish version was used to evaluate participants' static balance. There are 14 tasks commonly performed in daily life, such as transfers, turning, and picking up objects from the ground. Each task is scored between 0 and 4, with higher scores indicating good balance ability.[22,23] The BBS Turkish version has been shown to have good inter-rater reliability and validity.[23] The Time up and go test (TUGT) was used to evaluate dynamic balance. During the TUGT, participants were asked to rise from a chair, walk 3 meters, then turn around, return, and sit back in the chair. The performance time was recorded in seconds.[24,25]

SAMPLE SIZE

The requisite sample size was calculated using G*Power 3.1 (University of Düsseldorf, Düsseldorf, Germany) with the F test family [analysis of variance (ANOVA) repeated measures within-between interaction]. The following variables were considered: power size (1-β)=0.80, effect size (f)=0.30, type-1 error (α)=0.05, number of groups=3, number of measurements=2, correlation among repeated measures=0.5, correction ε=1, and critical F=3.354. A power analysis conducted as a result of the study indicated that an effect size of 0.30 could be obtained between the 3 groups. This would require a sample size of at least 30 individuals, with at least 10 individuals per group. The analysis was conducted at a 95% confidence level with a 0.05 margin of error, resulting in an 80% power.

STATISTICAL METHODS

The distributions of continuous variables were examined using the Shapiro-Wilk test and normality graphs. Variables with normal distribution are expressed as mean±standard deviation, variables without normal distribution are expressed as median (range, minimum-maximum), and categorical variables are expressed as frequency (%). Demographic characteristics were compared between the groups using one-way ANOVA, the Kruskal-Wallis test, and the Fisher-Freeman-Halton test, depending on the type and distribution of variables. Changes in balance and STP before and after treatment were evaluated using the two-way mixed ANOVA test if assumptions were met. In the absence of these assumptions, the F1-LD-F1 design was used. In the two-way mixed ANOVA test, group*time interaction and within-group and between-group differences were examined simultaneously. Group*time interaction and within-group changes were examined in the F1-LD-F1 design. The effect size was calculated with partial eta squared (ηp^2). The values usually range between 0 and 1. Furthermore, at the 95% confidence level, the $p \leq 0.05$ was considered statistically significant. The F1-LD-F1 design was implemented with the nparLD package using the R programming language (ver.3.5.1) and the RStudio (Posit PBC, USA) software (ver.1.2.1335). Other statistical analyses, calculations, and graphic drawings were performed using the IBM SPSS Statistics 22.0 (SPSS Inc, USA) software.

RESULTS

Fifty-three participants were recruited for this study. During the study, 23 participants withdrew, with 8 from the VRT1 group, 8 from the VRT2 group, and 7 from the control group. Thirty participants completed the 6-week training program. Figure 1 shows the flow diagram of the study. Twenty-two participants (73.3%) were female, and 9 (30%) used a single-point cane. No significant differences were found between the groups in terms of sociodemographic or clinical characteristics (Table 1).

The baseline BBS scores of all participants were higher than 40. After the training, BBS scores increased significantly only in VRT1. The inter- and intra-group analysis revealed no statistical differences in pre- and post-training TUGT performance. Furthermore, no significant difference was observed in the TUGT performance group*time interaction (Table 2).

Inter-group analysis revealed similar speeds and cadence before and after training. However, the speed and cadence increased significantly in both VRT groups after the training period. A statistical difference was observed in the group*time interaction for speed, but not for cadence. A significant difference was observed between pre- and post-training gait cycle time values. The intra-group analysis showed a significant decrease in gait cycle time in the VRT groups, but no significant change in the control group. The group*time interaction for the time of the gait cycle was statistically significant (Table 3).

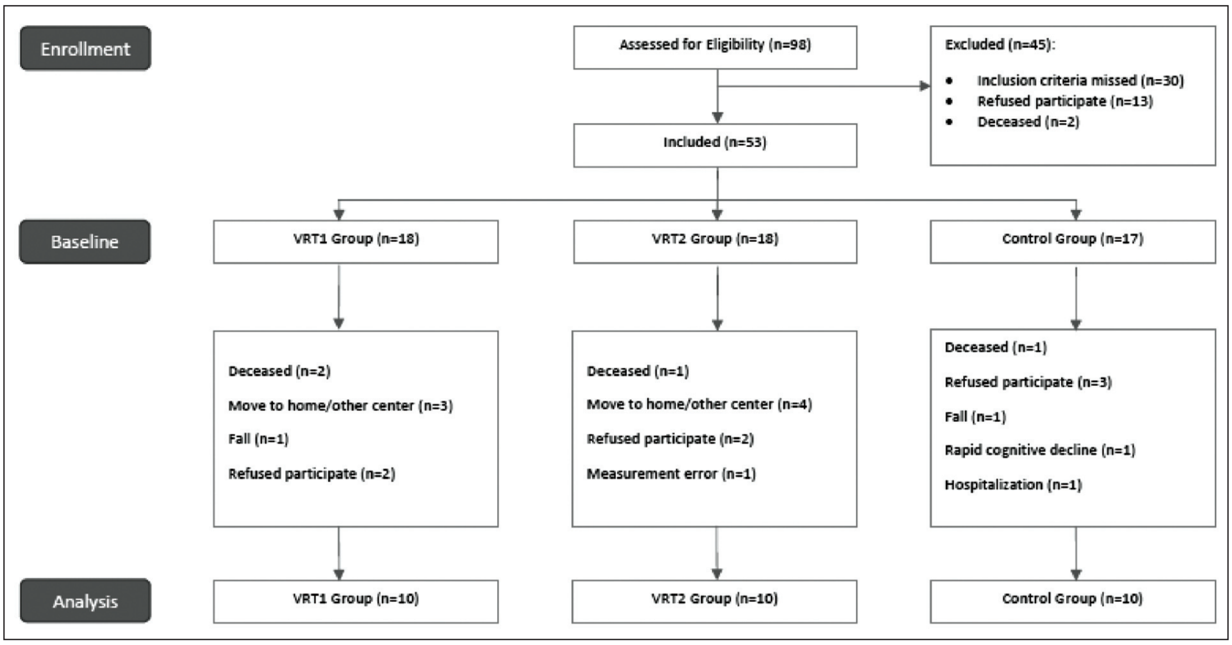

FIGURE 1: Flow diagram

TABLE 1: Characteristics of participants

	VRT1 group n=10	VRT2 group n=10	Control group n=10	Between groups p value
Age (years), X̅±SD	80.40±6.75	79.90±8.19	79.10±8.60	0.93
Gender (women), n (%)	8 (80.0)	8 (80.0)	6 (60.0)	0.66
Height (m), X̅±SD	1.56±0.11	1.63±0.11	1.59±0.08	0.36
Weight (kg), X̅±SD	60.00±9.19	65.10±10.84	60.55±9.20	0.45
BMI (kg/m^2), X̅±SD	24.59±3.25	24.75±4.23	24.01±3.99	0.90
Level of education, n (%)				0.95
Primary education	2 (20.0)	2 (20.0)	2 (20.0)	
Secondary school	1 (10.0)	3 (30.0)	2 (20.0)	
High school	3 (30.0)	3 (30.0)	2 (20.0)	
Bachelor's degree or higher	4 (40.0)	2 (20.0)	4 (40.0)	
MMSE, X̅±SD	20.70±2.00	20.90±2.56	20.40±2.37	0.88
Comorbidities, n (%)				
Diabetes	2 (20.0)	4 (40.0)	4 (40.0)	0.69
Hypertension	6 (60.0)	8 (80.0)	6 (60.0)	0.69
Cardiovascular disease	3 (30.0)	1 (10.0)	1 (10.0)	0.57
Others	3 (30.0)	2 (20.0)	4 (40.0)	0.87
# of Medications, median (R)	8 (3-18)	9 (1-11)	8 (3-11)	0.98
Use of Walking Aid at Baseline, n (%)	3 (30.0)	4 (40.0)	2 (20.0)	0.87

VRT: Virtual reality training; SD: Standard deviation; BMI: Body mass index; MMSE: Mini Mental State Examination; R: Range; m: min-max; m^2: meter; kg: kilogram

TABLE 2: Intervention effects on balance and posture

		VRT1 group n=10	VRT2 group n=10	Control group n=10	Between groups p value	GTI p value
BBS score, X̅±SD (95% CI)	Baseline	47.60±5.70 (44.1, 51.1)	48.50±3.92 (46.1, 50.9)	48.50±5.42 (45.1, 51.9)	0.90	0.27
	6 weeks	49.70±4.90 (46.7, 52.7)	48.70±4.27 (46.1, 51.4)	50.20±3.58 (48.0, 52.4)	0.73	
	Intragroup p value	**0.022**	0.81	0.06		
	Partial eta squared =0,992					
TUGT (s.), median (R) (95% CI)	Baseline	15.1 (10.0-82.9) (7.37, 38.21)	18.1 (12.0-40.8) (12.72, 27.03)	18.6 (8.1-26.0) (12.72, 21.46)	0.61	0.72
	6 weeks	17.5 (10.9-59.3) (10.51, 31.16)	17.8 (13.4-24.6) (15.4, 20.79)	18.4 (10.7-23.7) (14.52, 20.88)	0.86	
	Intragroup p value	0.90	0.54	0.58		
	Partial eta squared=0,771					

VRT: Virtual reality training; GTI: Group*time interaction effect; BBS: Berg Balance Scale; SD: standard deviation; CI: Confidence interval; TUGT: Time up and go test; R: range, s.: second.

DISCUSSION

The primary objective of this study was to compare the effects of 2 different types of virtual reality training, combined with conventional exercise training, to conventional exercise training alone, on a set of predetermined STP related to gait and balance in individuals with dementia. A secondary aim of the study was to determine if one of the VRT methods was more effective than the other in improving the targeted parameters. The results of the study demonstrated that there were no significant differences in the STP of gait, as assessed by the BTS G-Walk®, BBS, and the TUGT, between the groups receiving different types of training.

There is strong evidence that exercise has a positive effect on gait disorders in dementia.[26,27] A number of study examining the effects of various types of

TABLE 3: Intervention effects on spatiotemporal characteristics of gait

		VRT1 Group n=10	VRT2 Group n=10	Control Group n=10	Between groups p value	GTI p value
Speed (m/s), X̄±SD (95% CI)	Baseline	0.708±0.143 (0,619, 0.797)	0.649±0.191 (0.531, 0.767)	0.799±0.179 (0.688, 0.91)	0.16	**0.029**[1]
	6 weeks	0.874±0.128 (0.795, 0.953)	0.755±0.171 (0.649, 0.861)	0.782±0.217 (0.648, 0.916)	0.30	
	Intragroup p value	**0.001**	**0.031**	0.71		
	Partial eta squared=0,962					
Cadence, X̄±SD (95% CI)	Baseline	41.76±9.12 (36.1, 47.4)	41.26±11.51 (34.1, 48.4)	46.06±8.98 (40.5, 51.6)	0.50	0.056
	6 weeks	50.48±7.75 (45.7, 55.3)	48.32±7.21 (43.9, 52.8)	44.39±10.97 (37.6, 51.2)	0.30	
	Intragroup p value	0.009	0.032	0.59		
	Partial eta squared=0,973					
Stride length (m), X̄±SD (95% CI)	Baseline	1.03±0.18 (0.918, 1.14)	0.96±0.13 (0.879, 1.04)	1.06±0.20 (0.936, 1.18)	0.46	0.62
	6 weeks	1.06±0.18 (0.948, 1.17)	0.94±0.17 (0.835, 1.04)	1.09±0.22 (0.954, 1.23)	0.19	
	Intragroup p value	0.48	0.63	0.47		
	Partial eta squared =0,976					
Left step length (m), X̄±SD (95% CI)	Baseline	0.541±0.091 (0.485, 0.597)	0.463±0.056 (0.428, 0.498)	0.526±0.122 (0.45, 0.602)	0.16	0.98
	6 weeks	0.537±0.092 (0.48, 0.594)	0.464±0.093 (0.406, 0.522)	0.528±0.100 (0.466, 0.59)		
	Intragroup p value	0.89	0.97	0.94		
	Partial eta squared=0,977					
Right step length (m), X̄±SD (95% CI)	Baseline	0.490±0.100 (0.428, 0.552)	0.499±0.079 (0.45, 0.548)	0.533±0.090 (0.477, 0.589)	0.53	0.20
	6 weeks	0.524±0.096 (0.465, 0.584)	0.477±0.072 (0.432, 0.522)	0.561±0.130 (0.48, 0.642)	0.20	
	Intragroup p value	0.16	0.36	0.24		
	Partial eta squared=0,974					
%Stride length/height, X̄±SD (95% CI)	Baseline	66.00±11.12 (59.1, 72.9)	59.30±7.78 (54.5, 64.1)	66.46±11.32 (59.4, 73.5)	0.23	0.67
	6 weeks	67.89±9.65 (61.9, 73.9)	57.93±9.93 (51.8, 64.1)	67.74±12.11 (60.2, 75.3)	0.07	
	Intragroup p value	0.49	0.62	0.64		
	Partial eta squared=0,981					
Gait cycle time (s), median (min-max) (R) (95% CI)	Baseline	1.38 (1.12-2.80) (1.18, 1.88)	1.40 (1.11-4.42) (0.98, 2.39)	1.30 (0.96-2.13) (1.13, 1.58)	0.50	**0.035**[1]
	6 weeks	1.19 (0.98-1.71) (1.07, 1.37)	1.21 (1.00-1.73) (1.12. 1.42)	1.31 (0.94-2.62) (1.12, 1.78)	0.29	
	Intragroup p value	**0.001**	**0.013**	0.70		
	Partial eta squared =0.932					

[1]The change in VRT1 group is significantly higher than those in the control group. No significant difference was found between other pairs of groups. VRT: Virtual reality training; GTI: Group*time interaction effect; SD: Standard deviation; CI: Confidence interval; R: range: min-max; m: meter; s: second

exercise on dementia reported that exercise had positive effects on gait speed, cadence, stride length, stride time, and double support time.[26,28,29,30] However, there is insufficient evidence regarding the effects of VRT on these parameters. A study compared VRT to walking exercise in individuals with dementia and concluded that overall gait performance in both groups had improved after 8 weeks.[10] Another study compared VRT to conventional exercise in individuals with memory complaints. At the end of the 12-week study, researchers reported that the 6-Minute Walk Test scores improved in the VRT group.[14] However, in those studies, the data obtained on gait performance were obtained via scales that are not sufficiently objective and detailed.[10,14] In the present study, gait was objectively examined using the STP. To the best of our knowledge, this research represents a pioneering investigation into the effects of VRT on STP in dementia. A number of studies have demonstrated significant improvements using the VRT in healthy older adults.[29,30] However, this research expands upon the existing understanding of the effects of different types of VRT methods (Kinect or ALDA) on the STP of gait in elder adults with dementia, and possible improvements in these parameters. The results of our study demonstrated that the experimental groups exhibited no significant advantage over one another. However, the observed improvements in gait and gait cycle time in the virtual reality groups suggest that VRT may offer clinical utility for individuals with dementia. Our study aligns with numerous existing studies in the literature, which have also documented improvements in gait and gait cycle time in virtual reality groups.

Although some studies have suggested that VRT may improve balance, the evidence remains inconclusive. In previous studies, VRT increased BBS scores when VRT was compared to walking exercise alone, and this improvement in balance was sustained following the conclusion of the training period.[9,10] Uğur and Sertel reported that VRT significantly improved TUGT times compared to routine medical care.[31] Karssemeijer et al.reported no significant difference in TUGT times between VRT and aerobic and flexibility exercises.[8] In a feasibility study of a single case, it was found that 2 weeks of VRT did not improve BBS scores or TUGT times.[12] Ramnath et al. found that a 12-week interactive video game training program was effective in reducing TUGT times.[14] Reviews and systematic analyses have reported that VR training has a positive effect on balance in individuals with memory problems or cognitive impairment.[13,32] While numerous prior studies have employed the Wii-fit to enhance balance in individuals with dementia, no investigation to date has utilized Kinect or ALDA to assess the impact of diverse VRT systems on balance.[9,10,31] The present study is distinguished from previous research in 2 key respects: firstly, in its use of a range of different virtual reality (VR) systems; and secondly, in its provision of exercise training for all groups. No notable differences were identified in BBS scores between the groups. BBS scores improved significantly only in the VRT1 post-treatment values. However, this significance was identified solely within the group, and no statistically significant group-time interaction was observed. The results of this study indicate that the activities in VRT1, which were comparable to those in the BBS assessment, may have been a contributing factor to the observed improvements. These activities included the simultaneous use of the bilateral upper extremities while standing (Fruit Ninja, Gold Rush Mountain, and Nervous Nelly), narrowing the base of support (Cross board), and trunk flexion (Bowling).

No harmful or undesirable effects were reported in any of the 3 groups during our study. Neither of the 2 VRT groups reported experiencing the cybersickness symptoms that have been previously associated with VRT application, as documented in the relevant literature.[33] Throughout the course of the study, all participants engaged in the prescribed exercises in accordance with the established safety protocols.

The current study is subject to certain limitations. Chief among these is the lack of information about the specific dementia subtypes of the participants. Consequently, the findings cannot be generalized to all dementia patients, given the differences in neurological and functional characteristics among the various subtypes. Additionally, in some nursing homes, residents had only one common area for activities such as watching television, attending events, or socializing. The absence of a designated area for exergame training occasionally resulted in participants experiencing challenges in maintaining concentration and motivation, due to the influence of negative attitudes and behaviors exhibited by other residents. As a consequence, a number of participants withdrew from the study. This is a crucial factor in determining the acceptability of VR interventions by participants and the preferability of such interventions by clinicians. This study has several notable strengths, including the use of 2 distinct VRT systems. Furthermore, it represents a pioneering effort in the field of research to investigate the impact of VRT on STP in individuals with dementia. Another noteworthy aspect is the utilization and comparison of diverse VR systems with varying features.

CONCLUSION

In conclusion, the findings of this study provide new insights into the effects of 2 distinct VRT techniques on STP and balance in individuals with dementia. No significant differences were observed between the various VRT applications and exercise programs. The statistically significant change observed in the groups during the study suggests that VRT may be a clinically useful intervention in improving gait parameters in individuals with dementia. The VRT types used in VRT1 were more specific for the participants' disorders, suggesting that this may be a more effective option in improving gait and balance in older adults with dementia. In comparison to the greater assortment of exercises and the more substantial and readily comprehensible movements in VRT1, the system in VRT2 presents a more limited range of exercises and necessitates the performance of more intricate and less readily grasped movements. This could potentially present challenges with regard to patient participation and the effectiveness of the treatment. It is now necessary to conduct a comprehensive examination of the long-term effects of VRT methods on gait and balance in patients with dementia in further studies.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

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