The Effect of Wii-Based Interactive Virtual Games on Spasticity, Gait, Balance, and Trunk Control of Children with Mild Cerebral Palsy: A Randomized Controlled Trial

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Abstract

Aim: The purpose of this study was to examine the impact of Nintendo Wii treatment (NWT) on spasticity, balance, gait, and trunk control in individuals with mild cerebral palsy (CP).

Method: This randomized controlled trial included a total of 35 individuals with mild CP: the Nintendo Wii therapy group (WiiG, n:17) and the control group (CG, n:18). The individuals in both groups received conventional physiotherapy (CPT) for 40 minutes in two sessions per week for 8 consecutive weeks. The WiiG received Nintendo Wii Treatment (NWT) for 20 minutes in two sessions per week for 8 consecutive weeks using the Nintendo Wii Fit gaming console in addition to CPT. The Modified Ashworth Scale (MAS), Functional Forward Reach Test (FFRT), Functional Sideways Reach Test (FSRT), 10-meter walking test (10-mWT), and Trunk Impairment Scale (TIS) were evaluated before and after the intervention. Group x time interaction was demonstrated using the ANOVA (2×2 factorial Analysis of Variance).

Results: Right elbow flexor MAS decreased only in the WiiG ($p=0.035$) but did not differ between both groups ($p>0.05$). Furthermore, FFRT, FSRT, 10-mWT, and all sub-tests of TIS scores improved in the WiiG ($p<0.05$), while only TIS-Trunk Coordination increased in the CG ($p=0.023$).

Conclusion: NWT in addition to conventional physiotherapy, has positive effects on balance, gait, and trunk control in the rehabilitation process of CP. More research is needed to better understand the effects of NWT on spasticity.

Keywords: Cerebral palsy, spasticity, balance, gait, trunk control, virtual reality, physiotherapy.

Hafif Serebral Palsili Çocuklarda Wii Tabanlı Etkileşimli Sanal Oyunların Spastisite, Yürüyüş, Denge ve Gövde Kontrolü Üzerindeki Etkisi: Randomize Kontrollü Çalışma

Öz

Amaç: Bu çalışmanın amacı hafif serebral palsili (SP) bireylerde Nintendo Wii tedavisinin (NWT) spastisite, denge, yürüyüş ve gövde kontrolü üzerine etkisini araştırmaktır.

Yöntem: Bu randomize kontrollü çalışmaya hafif SP'li toplam 35 kişi dahil edildi: Nintendo Wii teedavi grubu (WiiG, n:17) ve kontrol grubu (CG, n:18). Her iki gruptaki bireylere 8 hafta boyunca haftada iki seans olmak üzere 40 dakika süreyle Konvansiyonel Fizyoterapi (KFT) uygulandı. WiiG, CPT'ye ek olarak 8 hafta boyunca haftada iki seans 20 dakika Nintendo Wii Fit oyun konsolu kullanılarak NWT aldı. Modifiye Ashworth Ölçeği (MAS), Fonksiyonel İleri Uzama Testi (FİUT), Fonksiyonel Yan Uzama Testi (FYUT), 10 metre yürüme testi (10-mYT) ve Gövde Bozukluk Ölçeği (GBÖ) tedavi öncesi ve sonrasında değerlendirildi. Grup x zaman etkileşimi ANOVA (2×2 faktöriyel Varyans Analizi) kullanılarak gösterilmiştir.

Özgün Araştırma Makalesi (Original Research Article)
Geliş / Received: 16.08.2024 & **Kabul / Accepted:** 14.11.2024
DOI: https://doi.org/10.38079/igusabder.1534336
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ETHICAL STATEMENT: This randomized controlled trial was ethically approved by the Non-invasive Clinical Trials of Sivas University Ethics Committee (protocol no: 2024-02/08 date:22.02.2024). All procedures followed the Declaration of Helsinki and written informed consent was obtained from families of all individuals with CP.

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Bulgular: WiiG sağ dirsek fleksör MAS azaldı (p=0,035) ancak her iki grup arasında farklılık göstermedi (p>0.05). Ayrıca, FFRT, FSRT, 10-mWT ve TIS'in tüm alt test puanları WiiG'de iyileşirken (p<0.05), CG'de sadece TIS-Gövde Koordinasyonu arttı (p=0.023).

Sonuç: Geleneksel fizyoterapiye ek olarak NWT'nin SP rehabilitasyonunda denge, yürüme ve gövde kontrolü üzerinde olumlu etkileri vardır. NWT'nin spastisite üzerindeki etkilerini daha iyi anlamak için daha fazla çalışma yapılmalıdır.

Anahtar Sözcükler: Serebral palsi, spastisite, denge, yürüme, gövde kontrolü, sanal gerçeklik, fizyoterapi.

Introduction

Cerebral palsy (CP) is described as a non-progressive neurological problem resulting from damage to the brain and is one of the most common causes of motor disability in childhood[1]. Spasticity seen in individuals with CP can be defined as excessive and inappropriate involuntary muscle activities caused by upper motor neuron paralysis or syndrome and musculoskeletal components[2]. Spasticity is one of the most important motor disorders affecting the motor skills of this individuals[3]. On the other hand, trunk control is vital in maintaining functionality in many tasks associated with daily living activities, including mobility and upper extremity functions[4]. The weakness of the trunk muscles, along with spasticity, potentially predisposes balance and gait issues in children with CP[5]. Based on these findings, it can be emphasized that reducing spasticity and improving trunk control and functionality should be considered in the rehabilitation approach to reduce balance and gait deficits in CP.

Conventional physiotherapy (CPT) is a commonly used rehabilitation approach to improve balance and gait in CP[6]. CPT generally consists of positioning, stretching, passive and active movements, strengthening, balance, and gait exercises. CPT has been known to be effective in improving balance and gait disorders in CP[7]. On the other hand, the development of new technology approaches such as virtual reality, which are preferred in rehabilitation, has recently started to become a frequently preferred application for balance and gait training in individuals with CP[8].

Nintendo Wii treatment (NWT) is a commonly used virtual reality tool in the rehabilitation of individuals with CP[9]. The NWT is an affordable non-immersion virtual reality platform that uses a handheld joystick and a screen, with or without a Wii Balance Board[10]. NWT is an effective rehabilitation tool that increases children's active participation in rehabilitation by adding motivation and fun to the exercises, especially when considering children who constitute the majority of the CP population[11]. Many studies have investigated the effect of NWT on gait and balance in individuals with CP[9,12-16]. On the other hand, meta-analyses and systematic reviews have reviewed the effect of NWT on balance and gait[9,12-15]. According to recent systematic reviews and meta-analysis studies in particular, it has been stated that the rehabilitation approaches using NWT show differences (e.g. with a Wii Balance Board or without a Wii Balance Board) and that further studies are needed to demonstrate its superiority over conventional treatments[9,12,15]. There are only two studies investigating the effect of NWT on trunk control and spasticity in individuals with CP[17]. Park et al.[18] applied NWT in a sitting position to individuals with CP who could not ambulate independently (GMFCS III and IV) and found that the training improved trunk stability. In another study, Gatica-Rojas

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et al.[17] conducted a pilot study. They found that NWT reduced spasticity. In summary, randomized controlled trials are needed to better understand the effects of the widely used NWT and to demonstrate improvements in balance and walking, especially trunk control and spasticity. In this context, this study purposed to investigate the effect of NWT on spasticity, balance, gait, and trunk control in individuals with mild CP.

Material and Methods

Ethical considerations

This randomized controlled trial was ethically approved by the Non-invasive Clinical Trials of Sivas University Ethics Committee (protocol no: 2024-02/08 date:22.02.2024). All procedures followed the Declaration of Helsinki and written informed consent was obtained from families of all individuals with CP.

Participants

This study included 35 individuals with CP aged 6-17 years with Gross Motor Function Classification System (GMFCS) levels I and II, who could use the game console with or without support on standing and who could follow verbal instructions. All evaluations were performed by a physiotherapist in a special education and rehabilitation center in Sivas. Individuals with CP who did not agree to participate in the study, who had lower extremity surgery within the last six months, or who received Botulinum toxin treatment were excluded from the study. Participants were divided into groups using the closed envelope randomization, with 17 individuals assigned to the Nintendo Wii therapy group (Wii Group; WiiG) and 18 individuals to the control group (Control Group; CG) (Figure 1).

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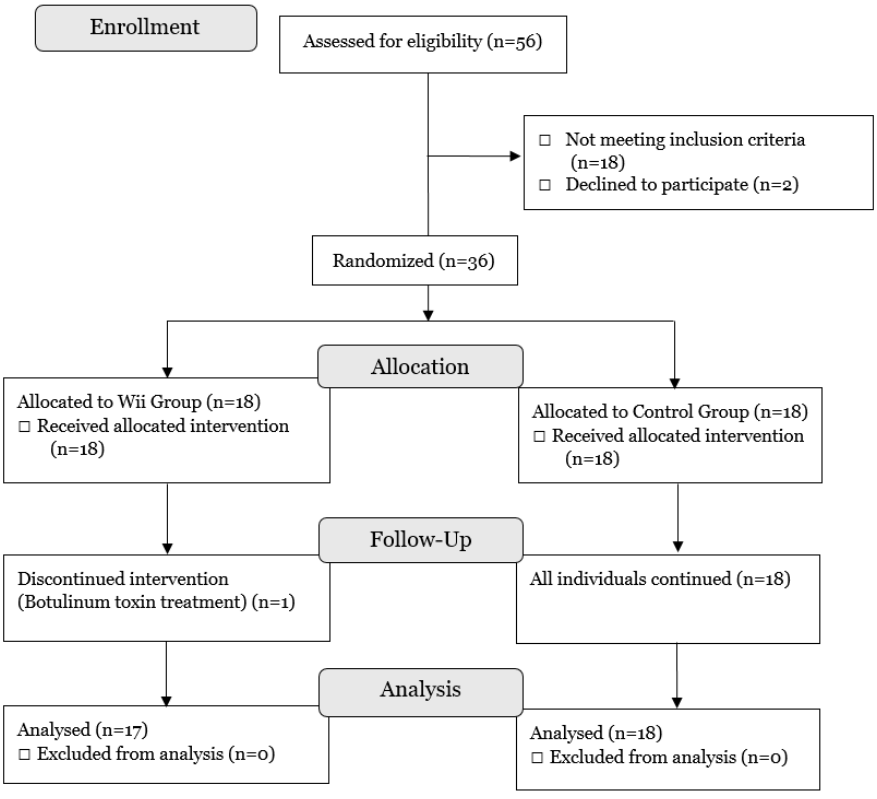
Figure 1. Participants flow through the study. Consolidated Standards of Reporting Trials (CONSORT) flow chart



Interventions

The individuals in both groups received CPT for 40 minutes in 2 sessions per week for 8 consecutive weeks (16 sessions). CPT included stretching, strengthening, balance, and gait exercises and was planned according to the needs of individuals in both groups. Additionally, WiiG received Nintendo Wii Treatment (NWT) for 20 minutes in 2 sessions per week for 8 consecutive weeks (16 sessions) using the Nintendo Wii Fit gaming console. Individuals played Bowling, Baseball, Tennis, Basketball, and Heading Nintendo Wii games in random order. To reduce potential bias, after and before treatment assessments were performed by the same assessor.

Outcome measures

GMFCS was used to classify gross motor function levels[19]. The GMFCS is scored between 1 (can walk without limitations) and 5 (transported by manual wheelchair).

The Modified Ashworth Scale (MAS) is a manual test often preferred to determine the severity of spasticity in CP[20]. The scale is scored between 0 (no increase in muscle tone) and 4 (rigid in flexion or extension).

The Functional Sideways Reach Test (FSRT) and the Functional Forward Reach Test (FFRT) were used to assess balance. FFRT is measured by performing maximum forward reach while maintaining a stable base of support in a standing position and with the arm flexed to 90°. FSRT is measured by performing maximum sideways reach standing and

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with the arm abducted to 90°. FFRT has been reported to be a reliable measurement tool in neurological diseases and children with spasticity[21].

In the study, a 10-meter walking test (10-mWT) was used to evaluate gait performance. The 10 mWT is a reliable scale for assessing gait performance in children with neurological disorders[22].

The Trunk Impairment Scale (TIS) is a reliable scale for children with CP[23]. The TIS assesses static balance and dynamic balance and trunk coordination in a sitting position. The TIS is scored between 0 (minimal performance) and 23 (perfect performance).

Statistical analysis

The normality was tested with Shapiro–Wilk test. Demographic characteristics of individuals were compared between the groups using the Chi-square test (gender, dominant side, CP type, and GMFCS) or the Mann-Whitney U test (Age, BMI,).

For outcome variables, the ANOVA (2×2 factorial Analysis of Variance) was used with time (baseline vs. post) and group (Wii group vs. Control group). Post-hoc comparisons were assessed using Bonferroni corrections for the dependent variables. Non-normally distributed outcome variables were presented as median (interquartile range [IQR]), and normally distributed outcome variables were presented as mean ± standard deviation (SD). The significance level was set at $p<0.05$.

Results

Of the 35 individuals with mild CP included in this study, 17 (8 female, 9 male, median age: 12 (10.5-14.5) years) were included in WiiG, and 18 (10 female, 8 male, median age: 12.5 (7.5-15) years) were included in CG. Individuals in both groups had similar characteristics when compared in terms of age, body mass index, gender, dominant side, CP type, and GMFCS levels ($p>0.05$), (Figure 1 and Table 1).

Table 1. Characteristics of participants.

	WiiG (n=17)	**CG (n=18)**	**p**
Age (years)	12 (10.5-14.5)	12.5 (7.5-15)	0.642
BMI (kg/m²)	16.42 (14.16-18.42)	14.57 (12.98- 17.93)	0.391
Gender, Female/Male (Female %)	8/9 (47.1%)	10/8 (55.6%)	0.615
Dominant side, right/left (right %)	9/8 (52.9%)	13/5 (72.2%)	0.238
CP type, n (%)			
Bilateral	8 (47.1)	11 (61.1)	0.404
Unilateral	9 (52.9)	7 (38.9)	
GMFCS, n (%)			
1	8 (47.1)	11 (61.1)	0.404
2	9 (52.1)	7 (38.9)	

BMI: Body mass index, CG: Control group, CP: Cerebral Palsy, GMFCS: Gross Motor Function Classification System, WiiG: Wii Group, Values are Median (IQR) or percentile, $p<0.05$.

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There was no significant difference between the WiiG and the CG at the initial assessment in terms of outcome measures (p>0.05). Additionally, there was no difference between the WiiG and the CG groups in terms of MAS scores (Elbow flexor spasticity showed group improvement on the WiiG only) (Table 2). The changes in FFRT, FSRT, 10-mWT, and all TIS measures were significant, in favor of the WiiG (Table 2).

Table 2. Treatment effects on spasticity, gait, balance, and trunk control for the Wii group and control group at baseline and 8-week follow-up

		Pre-test mean±SD	Post-test mean±SD	Mean difference (95% CI)	p (within group)	Interaction (time × group)		
						F	p	ηp ²
MAS								
Elbow Flexors RS	WiiG	0.82±1.18	0.47±1.06	-0.35 (-0.68- (-0.02))	**0.035***	0.696	0.410	0.021
	CG	0.55±1.04	0.38±0.91	-0.16 (-0.48- 0.15)	0.292			
Elbow Flexors LS	WiiG	0.29±0.77	0.23±0.56	-0.06 (-0.37- 0.25)	0.706	1.091	0.304	0.032
	CG	0.22±0.54	0.38±0.84	0.16 (-0.14- 0.47)	0.276			
Ankle plantar flexors RS	WiiG	1.94±1.78	1.23±1.60	-0.70 (-1.47- 0.63)	0.071	1.048	0.313	0.031
	CG	1.55±1.75	1.38±1.57	-0.16 (-0.91- 0.58)	0.653			
Ankle plantar flexors LS	WiiG	0.88±1.40	0.70±1.21	-0.17 (-0.89- 0.54)	0.621	0.340	0.564	0.010
	CG	1.11±1.53	1.22±1.21	0.11 (-0.58- 0.81)	0.749			
FFRT	WiiG	22.61±6.33	26.64±7.42	4.03 (1.68- 6.37)	**0.001***	4.917	**0.034***	0.130
	CG	23.56±6.63	24.03±6.22	0.47 (-1.80- 2.74)	0.675			
FSRT	WiiG	17.47±6.65	20.32±6.80	2.84 (-5.48- (-0.19))	**0.036***	0.032	0.859	0.001
	CG	17.66±4.46	20.18±5.42	2.51 (-0.05- 5.08)	0.054			
10-mWT	WiiG	9.48±2.46	8.27±1.64	-1.21 (-1.87- (-0.54))	**0.001***	1.608	0.214	0.046
	CG	9.17±1.79	8.54±1.90	-0.63 (-1.27- 0.02)	0.057			
TIS								
Static Sitting Balance	WiiG	6.17±0.80	6.64±0.60	0.47 (0.20- 0.73)	**0.001***	1.904	0.177	0.055
	CG	6.72±0.46	6.94±0.23	0.22 (-0.03- 0.47)	0.086			
Dynamic Sitting Balance	WiiG	5.94±3.17	9.29±1.15	3.35 (2.05- 4.65)	**<0.001***	6.038	**0.019***	0.155
	CG	7.83±2.70	9.00±1.60	1.16 (-0.09- 2.42)	0.069			
Trunk Coordination	WiiG	2.82±1.38	4.11±1.57	1.29 (0.56- 2.02)	**0.001***	0.850	0.363	0.025
	CG	2.94±1.76	3.77±1.47	0.83 (0.12- 1.54)	**0.023***			
Total	WiiG	14.94±4.68	20.05±2.72	5.11 (3.31- 6.91)	**<0.001***	5.733	**0.022***	0.148
	CG	17.50±4.19	19.66±2.40	2.16 (0.41- 3.91)	**0.017***			

CG: Control Group, FFRT: Functional Forward Reach Test, MAS: Modified Ashworth Scale, TIS: Trunk Impairment Scale, FSRT: Functional Sideways Reach Test, LS: Left Side, RS: Right Side, 10-mWT: 10-meter walking test, WiiG: Wii Group.

* p<0.05 for interaction (time × group) by analysis of variance (ANOVA).

Discussion

This study investigated the effects of NWT and conventional physiotherapy on spasticity, gait, balance, and trunk control in individuals with CP. The study's findings showed that NWT positively improved the spasticity of elbow flexors, gait, balance, and trunk control in CP compared to the control group. To the best of our knowledge, this is the first study to examine the effect of NWT on spasticity and trunk control individuals in CP.

Nintendo Wii treatment offers a more fun and motivating exercise opportunity compared to conventional physiotherapy in the rehabilitation of individuals with CP, the majority

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of whom are children. A randomized controlled trial has shown that NWT administered in addition to CPT provided greater improvement in postural control and gait performance than CPT alone, although this was not statistically significant[24]. In another study, Tarakcı et al. found that NWT applied in addition to CPT improved static and performance-related balance more than the group that received only CPT[25]. Jha et al. showed in their randomized controlled trial that virtual reality gaming combined with CPT may be more effective in improving balance compared to the group receiving CPT alone[16]. Montoro-Cárdenas et al.[9] reviewed 11 randomized controlled trials with 270 individuals with CP in their systematic review and meta-analysis studies. The study's results showed that NWT may be a good way to help people with CP improve their functional and dynamic balance. This is especially true when combined with CPT in 30-minute sessions that last longer than 3 weeks. Recently, Warnier et al.[12] conducted a systematic review of 26 articles investigating the effects of virtual reality therapy, the majority of which were NWT, on balance and gait. According to the results of the study, virtual reality therapy was indicated as an effective treatment, but it was pointed out that new studies were needed due to the differences in the interventions used, the lack of randomized controlled trials, and relatively small groups. Based on the results, it is understood that NWT can be an effective treatment for balance and gait, but further studies are needed. In our study, there was an improvement in the NWT group in the 10-mWT and the FSRT balance test, while there was no significant improvement in the control group. However, this improvement did not create a difference between the two groups. On the other hand, the NWT group showed a significant improvement in the FFRT balance test than the CG. Our results support the existing literature and provide new evidence.

For effective movement production, there must be sufficient stability in the spine, and the trunk muscles play an important role in achieving sufficient strength, endurance, and power[26]. These movements become more important, especially in extremity movements where the trunk muscles provide the basis[27]. Therefore, the trunk muscles should be an important heading in the evaluation and rehabilitation. Park et al.[18] performed exercises on a Nintendo Wii balance board while sitting in individuals with CP who were unable to ambulate independently (GMFCS III and IV) and found that NWT provided greater sitting balance and trunk stability than arm reach training during the sitting position. Unlike the previous study, this study included individuals with mild (GMFCS I and II) CP, and NWT training was given while standing. In addition, the control group in our study received CPT. Despite these differences, in line with the previous study, the group that received NWT training showed significantly more improvement compared to the control group in this study. This study is the first to investigate the effects of NWT on trunk control in individuals with mild CP.

Spasticity can cause premature or exaggerated muscle contractions during movements. Therefore, spasticity can directly affect the control of movements and the maintenance of balance. To our knowledge, there is only one study investigating the effect of NWT on spasticity[17]. Gatica-Rojas et al.[17] applied NWT training to only 10 individuals with mild CP in their pilot study. According to the results of the study, they found that NWT training reduced spasticity. Unlike the previous study, our study is a randomized

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controlled trial in which the CG received CPT. According to our study results, there was no significant change in the CG, while a significant decrease was found only in the spasticity of right elbow flexors in the treatment group. The fact that spasticity did not change in other parameters may be due to the low level of spasticity seen in individuals with CP in this study. We believe that future studies that include individuals with CP with high spasticity and use more objective assessment methods may provide a better understanding of the effect of the NWT in individuals with CP.

The current study had several limitations. First, the assessor was not blinded. Second, follow-up studies are needed to determine how long the effects of Wii training last. Third, this study included individuals with mildly affected CP. Therefore, the results cannot be generalized to all levels of CP. Studies are needed for different levels of CP types.

Conclusion

This study showed that the Nintendo Wii treatment received in addition to conventional physiotherapy provided significant gains in balance, gait, and trunk control in individuals with mild CP compared to conventional physiotherapy alone. On the other hand, it was found that the Nintendo Wii treatment applied in addition to conventional physiotherapy in improving spasticity did not provide a significant improvement. Based on this, we suggest that Nintendo Wii treatment can be preferred as an additional option to conventional physiotherapy in improving balance, gait, and trunk control. More research is needed for its effects on spasticity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors are grateful to all participants in this study.

Funding

None.

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