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ORIGINAL ARTICLE

# Effect of an intervention based on virtual reality on motor development and postural control in children with Down Syndrome

## Efecto de una intervención basada en realidad virtual sobre las habilidades motrices básicas y control postural de niños con Síndrome de Down

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## Abstract

There are few studies on the effect of a virtual reality-based intervention on motor development and postural control in children with Down Syndrome (DS). **Objective**: To determine the effect of a virtual reality-based intervention on motor development and postural control in children with DS. **Patients and Method:** Study with a quantitative approach, with a quasi-experimental design, which included 16 children with DS randomly assigned to an experimental group (Wii Balance Bord Group, WBBG, n = 9) and control group (CG, n = 7). Postural control was evaluated by the center of pressure displacement and motor development with TGMD-2. The intervention program was carried out for five weeks, two times per week. The data were subjected to statistical analysis, the Shapiro Wilk test for the sample distribution, and the Student's T-test for the comparison of group means. **Results**: Significant changes were observed in the TGMD-2 Test and its manipulation subtest ($p < 0.01$) respectively. In the rest of the tests, there was an improvement, but no significant differences were observed. **Conclusion**: A virtual reality-based intervention was effective in GWBB, providing low-impact exercises to improve postural control and thus leading to improved motor skills in children with DS.

**Keywords:**
Down Syndrome;
Motor Development;
Balance;
Postural control

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## Introduction

Down Syndrome (DS) is a chromosomal disorder caused by an additional copy of the chromosome 21, presenting particular physiological and anatomical characteristics such as hypotonia, joint hypermobility, and sensory deficits that contribute to a delay in the motor development[1]. These alterations have been explained fundamentally by changes in the neuron shape and quantity, changes in the brain size, central nervous system maturation disorder, and by physiopathological processes of the nervous system such as disorders in the regulation of neuronal apoptosis, gens overexpression that encode the beta-amyloid precursor protein, and processes that lead to a decrease in the neurotransmitters release[2]. Therefore, children with DS must undergo a process adapted to their characteristics in such a way that their insertion in social activities leads to an improvement in their quality of life[3].

According to Barr & Shields[3], the population with DS presents certain barriers that limit the practice of physical activity and favor sedentarism, characterized by features associated with DS, family responsibilities, reduced physical or behavioral abilities, and the lack of accessible programs. These barriers pose a great risk in a population that has been associated with high prevalence of obesity and overweight, risk of cardiovascular disease, osteoporosis, among others[4, 5]. In addition, the sole DS condition brings with it an increased risk of dyslipidemias, independent of the presence of comorbidities classically related to abnormal lipid profile, such as overweight, obesity, and hypothyroidism[6].

These characteristics along with others present in children with DS would influence the delay in the acquisition of motor skills and postural control, which brings with it problems in their daily life, affecting their inclusion and quality of life. The hypermobility present in people with DS affects stability and the ability to effectively control posture, significantly altering their adequate development in daily life, especially in actions such as standing, walking, or for support during voluntary movements of the extremities, trunk, and head[7, 8]. In the same way, motor skills are a very important component of most physical activities. In the case of children with DS, they show the same motor development patterns as children with normal development, but it takes longer to acquire them and gives way to improvement with practice[2,9]. Different investigations have found that the postural control differences are accentuated as the age of the people with DS increases[7, 10], in addition, in the children when the postural control is evaluated oriented to a motor task, also significant differences have been found compared with children with typical development[8], this reflects a limitation in terms of common activities of children, such as games and recreational activities, therefore to carry out interventions in the childhood could have an important impact for their global development[11, 12]. Different strategies have been used to improve motor skills and postural control in children with DS ranging from specific strategies for the fundamental skills development, neuromuscular training to even whole-body vibration training[13-15], however, one of the problems observed in practice is the low motivation and commitment to the interventions to be applied, thus, in recent years, the use of technology and video games has been proposed to make it more attractive for children. A systematic review carried out by Page, Barrington, Edwards and Barnett[16] determined the active video games (AVG) effectiveness or also called 'exergame' in the development of motor skills in children and adolescents of atypical development, finding that the interventions that used the Nintendo Wii console, could benefit the motor development, with promising effects on the balance, however, more research is needed due to the different biases that present the analyzed interventions. At present, there are few studies that have used the Nintendo Wii console in people with DS, we can only mention the study of Silva[17] conducted with adult population and its results showed that it can be an effective tool to improve physical condition, functional mobility, and motor competence, but we have not yet found studies in children with DS using the Nintendo Wii console. The objective of this research is to assess the effects of a virtual reality-based intervention on motor development and postural control in children aged six to 12 with Down syndrome.

## Patients and Method

### Study design

Quasi-experimental study with pre- and post-test and control group[18], which includes students with DS, aged between six and 12 years, from three special schools in the city of Chillán, Chile during the 2017 school year.

### Subjects of the study

19 children from three special schools in the city of Chillán were invited to participate in this study. The following inclusion criteria were defined: diagnosed DS, authorization signed by their guardian and being able to comply with orders assigned by the researchers. Children with DS who had a diagnosis of heart diseases, another diagnosed disability, or failed to meet 85% of planned sessions were excluded from the study. Finally, 16 children with

DS met these criteria. Of these, nine were randomly assigned to an experimental group that received an exercise program based on the use of the Nintendo Wii (WBBG) and seven were assigned to the control group (CG).

**Ethical aspects**

Once the authorizations were requested to the three special schools, the parents were informed about the investigation. Participation was voluntary. All participants were guided on the procedures to be carried out for the application of the tests and received information about the aims, objectives, and methods of the study before the beginning of the evaluations. Each tutor or guardian had to sign an informed consent for their son to participate in the study, and the research project was approved by the bioethics committee of the Universidad Adventista de Chile under No. 2018-1, thus, the Helsinki regulations on research involving human beings were respected.

**Procedures**

Before starting the intervention, a group of researchers, four Physical Education teachers specializing in special physical education, were trained and familiarized for two weeks with working with children with DS, where they were able to conduct practical evaluations to a pilot group, which would then be conducted before and after the intervention. The training and supervision of the intervention were carried out by a specialist in sports medicine and science. The duration of the intervention was five weeks with two weekly sessions and a 20-minute duration each one, using the Wi Fit software version along with the Wii Balance Board, selecting those games related to the investigation objective (Snowboard, Penguin slide, Super Hula Hoop, Heading Soccer, and Ski Jumping). The CG did not perform the intervention and just as WBBG completed its normal daily activities, including its psycho-educational therapies included in the school.

**Instruments**

Gross motor development was evaluated through the Test of Gross Development (TGMD-2) previously validated in Chilean population by Cano-Cappellacci, Leyton, & Carreño (2015)[19] and used in population with DS[11-13]. The TGMD-2 is used to identify deficits in gross motor development in children aged three to ten years, evaluating 12 skills grouped into two areas: locomotor skills and object control skills[20]. Children with DS have shown a motor delay of up to two years compared with children with typical development, therefore its application is justified in the age range of this sample[9].

Postural control was evaluated in standing on a Wii Balance Board using the RombergLab software previously validated by Rey-Martinez and Pérez-Fernández[21], which records the movement of the Pressure Center (PC) and calculates the PC area. During the evaluation, the child was asked to stand at an angle of approximately 45° to the feet, holding this position for 30 seconds trying to not move during that period. The PC registration was carried out with eyes open (PC EO) and eyes closed (PC EC) repeating a total of three attempts for each test registering the best of them[7].

**Statistical analysis**

SPSS 20.0 software (SPSS Inc., IL, USA) was used for statistical analysis. The normal distribution was checked with the Shapiro-Wilk test. The mean and standard deviation and percentages (p-value) were calculated to describe the variables of motor skills and postural control of the sample. The Student's T-test was used to compare group means. All $p < 0.05$ values were considered statistically significant.

## Results

Table 1 shows the descriptive characteristics of the children with Down syndrome who participated in the study. The group is made up of three girls and 13 boys who range in age from six to 12 years.

Table 2 shows the results obtained in the pre- and post-test intragroup analysis. A significant increase is observed only in the WBBG, in the variables PC EC ($p < 0.039$), TGMD 2 ($p < 0.002$), and Manipulation ($p < 0.010$). No significant changes were observed in the CG and in the rest of the variables.

Table 3 shows the obtained results when performing the pre- and post-test intergroup analysis. A significant increase is observed only in the post-test in the TGMD 2 variable ($p < 0.04$). No significant changes were observed in the rest of the variables.

**Table 1. Descriptive data of the Sample**

| Total sample | CG (n = 7) $\bar{x} \pm DS$ | WBBG (n = 9) $\bar{x} \pm DS$ |
|---|---|---|
| Age (years) | 8.43 ± 1.62 | 8.30 ± 2.06 |
| BMI (kg/m$^2$) | 20.56 ± 3.74 | 17.54 ± 3.12 |
| Height (cm) | 127.57 ± 16.16 | 125.30 ± 11.45 |
| Weight (kg) | 34.29 ± 11.27 | 28.25 ± 9.48 |

CG=Control Group; WBBG=Wii Balance Board Group. SD= Standard Deviation.

**Table 2. Results of the Intragroups Comparison. Pre and Post Test**

| | CG (n = 7) | | | WBBG (n = 9) | | |
|---|---|---|---|---|---|---|
| | Pre test $\bar{x} \pm DS$ | Post test $\bar{x} \pm DS$ | p-Value | Pre test $\bar{x} \pm DS$ | Post test $\bar{x} \pm DS$ | p-Value |
| PC EO ($m^2$) | 0.06 ± 0.05 | 0.04 ± 0.03 | 0.36 | 0.06 ± 0.040 | 0.07 ± 0.005 | 0.52 |
| PC EC ($m^2$) | 0.05 ± 0.02 | 0.04 ± 0.02 | 0.31 | 0.05 ± 0.03 | 0.02 ± 0.019 | 0.039* |
| TGMD 2 | 63.86 ± 6.34 | 63.14 ± 7.99 | 0.60 | 63.00 ± 5.39 | 71.67 ± 7.75 | 0.002* |
| Locomotion | 33.71 ± 3.69 | 33.71 ± 4.82 | 1.00 | 34.56 ± 5.94 | 36.67 ± 3.39 | 0.30 |
| Manipulation | 30.14 ± 6.67 | 29.43 ± 5.86 | 0.09 | 28.44 ± 5.46 | 35.00 ± 5.50 | 0.010* |

CG = Control Group; WBBG =Wii Balance Board Group. SD = Standard Deviation; PC OE = Area of movement of the Pressure Center with Eyes Open; PC CE = Area of movement of the Pressure Center with Eyes Close.

**Table 3. Results of the Intragroups Comparison. Pre and Post Test**

| | Pre test | | | Post test | | |
|---|---|---|---|---|---|---|
| | CG (n = 7) $\bar{x} \pm DE$ | WBBG (n = 9) $\bar{x} \pm DE$ | p-Value | CG (n = 7) $\bar{x} \pm DE$ | WBBG (n = 9) $\bar{x} \pm DE$ | p-Value |
| PC EO ($m^2$) | 0.06 ± 0.05 | 0.06 ± 0.04 | 0.83 | 0.04 ± 0.03 | 0.07 ± 0.05 | 0.31 |
| PC EC ($m^2$) | 0.05 ± 0.19 | 0.05 ± 0.03 | 0.86 | 0.04 ± 0.02 | 0.02 ± 0.19 | 0.13 |
| TGMD 2 | 63.86 ± 6.34 | 63.00 ± 5.39 | 0.77 | 63.14 ± 7.99 | 71.67 ± 7.75 | 0.04* |
| Locomotion | 33.71 ± 3.69 | 34.56 ± 5.94 | 0.75 | 33.71 ± 4.82 | 36.67 ± 3.39 | 0.17 |
| Manipulation | 30.14 ± 6.67 | 28.44 ± 5.46 | 0.58 | 29.43 ± 5.86 | 35.00 ± 5.50 | 0.07 |

CG = Control Group; WBBG = Wii Balance Board Group. SD = Standard Desviation.

## Discussion

The objective of this study was to assess the effects of a virtual reality-based intervention on motor development and postural control in children with DS. The results show that children who participated in a five-week virtual reality intervention using the Nintendo Wii along with the Wii Balance Board significantly improved postural control with eyes closed ($p < 0.039$), overall TGMD-2 motor development score ($p < 0.04$), and in subtests of manipulation skills ($p < 0.010$).

However, the results found during the pre-test (table 2) shows that both CG and WBBG have a lower postural control and motor development than expected for age[7,11]. According to Deprá, Bisconsini, & Vieira[22], late motor development in children with DS may be conditioned by the strength and balance that develop late in this population. Other studies, such as that of Capio et al.[13] have analyzed the influence of balance on basic motor skills, finding that those subjects who have better balance tend to have better motor development. Our intervention was based on exercises using a Nintendo Wii along with the Wii Balance Board over an experimental group while the control group continued their normal daily activities. The games applied on the Wii balance board challenge the stability of the child through the body weight balance, as requested by the game, causing a sensory and motor stimulus that led the experimental group after the intervention improved both their postural control and motor performance, while the control group did not show significant changes after five weeks. Previous studies have shown that environments that offer a variety of experiences and motor practice are favorable for children with DS to achieve the main motor milestones early[2,23].

The Nintendo Wii has been used for therapeutic purposes on young people with cerebral palsy, during the burns treatment, after a stroke, cancer, in people with limb limitations or amputations, Parkinson's disease or spinal cord injuries, demonstrating its effect on balance, motor function, energy efficiency, and postural control, reduction of stress associated with diseases, among others[24]. In turn, Wuang, Chiang, Su & Wang[8] compared the effect of traditional occupational therapy with those of a virtual reality software using Nintendo Wii sports games played for 24 weeks in children with DS, the results of the study show that the group that used the Nintendo Wii significantly improved the gross

motor function and to a wider extent than that achieved by traditional therapy. Similar results are presented by Berg, Martian, Primrose & Wingen[25] using the case study methodology with a 12-year-old boy, who for eight weeks received an exercise program based on Nintendo Wii games, finding improvements in gross motor functions and postural control, but also showed to be a fun and social strategy when it is implemented at home with the family. From a methodological point of view, this type of intervention could take on great value by favoring adherence from an early age to programs that favor the motor development of children with DS, with physical work in accordance with their particular characteristics, with the potential to significantly reduce problems associated with muscular hypotonia in addition to obesity[26]. In this sense, the implementation of virtual reality games has great potential since they can be effective by incorporating them both in the educational and therapeutic context, as well as inside the home, favoring the development of motor skills and the development of executive functions in children with DS.

This study was not without limitations, a reduced and convenience sample was used and the obtained results could not be generalized to the children with DS of Chillán. Another aspect was the limited possibility of comparing the data obtained from the sample with other studies, due to the few studies conducted with children with DS using the Wii balance board. However, within the strengths of our study, and to our knowledge, we can mention that this would be the first study using the Wii balance board in children with DS conducted in Chile which evaluates the effects of this type of intervention. Second, it provides data on a population exclusively of children with DS, while the few previous studies focus mainly on adults and other pathologies. Finally, the data provided in this study allow future research with children with DS and using an intervention based on the Wii balance board in order to make a proper comparison.

We recommend that in future research that performs this type of intervention with the Wii balance board to use a larger number of children with DS that is representative of the city or region, presenting the data separated by gender, age, and intellectual capacity. In terms of intervention, consideration should be given to increasing hours and working time in order to make these results generalizable and also to recognize the appropriate environments for special education schools to conduct this type of intervention.

In conclusion, a virtual reality-based intervention was effective for the WBBG as it provides low-impact exercises to improve postural control and thereby leading to better performance in TGMD 2 in children with DS.

## Ethical Responsibilities

**Human Beings and animals protection:** Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

**Data confidentiality:** The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

**Rights to privacy and informed consent:** The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

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Authors state that no economic support has been associated with the present study.

## Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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