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# Qualitative Analysis of Children with Down Syndrome using the Xbox 360® Console

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## Abstract

Down syndrome is characterized by a delay in the development of motor function. Games with interactive technology are shown as a new type of therapy that assists motor learning and postural control.

**Objective:** To evaluate the variables of gross motor coordination, balance and postural reaction of children with Down syndrome during the performance of virtual games through the X-Box 360® console.

**Methodology:** The study was approved by the Ethics Committee in Human Beings (795,905). Nine children with Down syndrome based on inclusion and exclusion criteria were selected. After signing the consent form Clarified, general data were collected from children such as anthropometry, vital data, among others. After this procedure the children were directed to a room and positioned within a rectangle demarcated to execute the games, being disregarded the actions when the child leaves the rectangle. The "leaks" and "rapids" games of X-Box 360® were selected, where children should play at the levels, basic, intermediate and advanced. After this procedure the variables gross motor coordination, balance and postural reaction were qualitatively analysed by the images captured from three cameras arranged in the place.

**Results:** Parametric Student's T test (<0.05) and the Kruskal Walls test was used. When comparing the variables coordination, balance and postural reaction, there was significant difference between coordination and balance (t: 3.11, p: 0.04) and coordination and postural reaction (t3, 17, p: 0.04), identifying greater difficulty in gross motor coordination of children during the Xbox games. Regarding difficulty levels, there was no significant difference.

**Conclusion:** We suggest that children with Down syndrome present difficulties of gross motor coordination when compared to the balance and postural reaction during the execution of virtual games by the independent X-box in the difficulty level of the games.

**Keywords:** Virtual reality games; Coordinating disability; Postural balance; Down's syndrome

## Introduction

The Down syndrome (DS) is characterized by a delay in the development of motor function as a result of associated disabilities, including muscular hypotonia, joint hyperextensibility, delay in acquisition of postural control, poor motor control and balance [1,2].

Shumway-Cook and Woollacott-3 when analyzing automatic postural responses in children with SD of four to six years for external disturbances generated by mobile platform noted a delay in onset of response, resulting in increased body sway and in some instances, loss of balance. In addition, adaptation to changing environmental were poorly developed and difficulty to use anticipatory reactions [3,4].

Motor Physical Therapy for children with Down syndrome aims to reduce delays in gross and fine motor skills in order to encourage and facilitate postural reactions necessary for the performance of activities and tasks [5-7]. The balance training provides to the patient with DS increasing muscle recruitment for maintaining the standing posture, thus promoting better posture adjustment [8,9].

Games with interactive technology are used in therapeutic treatment due to the playful encouragement in motivating patients to carry out the rehabilitation exercises, coming to present relevant results, such as increasing the level of attention and increased joint movement without pain reports during game execution [10-12]. This reality provides visual, auditory sensory and at the same time [13,14].

Video games that use physical interaction devices with the players are called exergames (in association with games that simulate a form of exercise) and exergaming, a junction of video games that use or are based on a form of physical exercise [15-18].

A case study developed by Peacock et al. [19], in which virtual reality has been used as an intervention for a child with cerebral palsy; it was found that there were gains on the motor performance, functional balance and mobility of this child based in Motor Development Scale (MDS) with gains in all areas evaluated, except in spatial organization. There was also an increase in the child's scores on the Pediatric Balance Scale (PBS) reaching maximum score after the intervention.

In the literature there are few studies related to the use of the console XBOX 360® associated with individuals with Down syndrome.

Because of the above reason, this study can provide information about the possible benefits of Kinect use to promote motor development leading to greater autonomy of these children. Therefore, the objective of this study was to evaluate the gross motor coordination, balance and postural response in patients with Down syndrome through X-Box 360® console. Hypotheses for this study are that:

1. Individuals with Down syndrome have more difficulty to perform movements that require balance and coordination.
2. The use of virtual games may assist in therapy of children with DS.

## Methods

This prospective, cross-sectional and observational study was conducted after approval by the Research Ethics Committee with the number of the opinion 795, 905.

### Population

The sample for this survey was convenience composed of patients with Down syndrome of both sexes who received treatment at the Clinical Hospital of the Federal University of Uberlândia HC/UFU and aged seven to twelve years. The sample size calculation was based on HC/UFU data for the years 2012 to 2013. The total size of the population was made up of 23 individuals, with sample corrected 14 individuals with DS.

Based on inclusion criteria, there was a total of 147 records with 18 deaths and 23 inactive, leaving 106 active and available for analysis. Out of this total 106, 70 were residing in Uberlândia and were contacted. However, 40 were not found due to the downgrading of the provided phone numbers and four had no interest to participate. An appointment was scheduled for 17 children, but eight of them did not show up on the day and time stipulated. Then the study was performed with nine children.

For analysis of the results the children were divided into five groups related to the ages of seven to 12 years, which were turned into months in order to avoid the conflict of different motor performance in each age.

### Data collection

A structured evaluation form was used containing educational and anthropometric data and vital data such as heart rate, oxygen saturation which were measured by the pulse oximeter and finger Geraratherm. The respiratory rate was measured by the researcher and the blood pressure was measured with stethoscope (Rappaport Premium) and sphygmomanometer (Aneroid Premium).

To carry out the game, a unit of H LED TV (-Buster 42-inch model), console Xbox 360® (TM Sensor with Kinect) and the game Kinect Adventures game - X360® were used. The records of the games were held by three Sony digital cameras (DCR-Sx22 Black) positioned one on each side and front of the participant.

Data collection was performed in the Physicl Therapy clinic of the Federal University of Uberlândia (UFU). On the assessment day, the whole procedure was explained to those responsible for these children and signed the Written Informed Consent Form (WICF) authorizing the child's participation in the study.

Upon arriving, the child and the guardian were instructed verbally about all evaluation procedures and the child was directed to a room with equipment. She was placed in a chair to rest for five minutes and at the same time, the evaluation form was applied. After applying it, followed by five minutes of rest, blood pressure was measured (BP), heart rate (HR), respiratory rate (RR) and peripheral oxygen saturation (Spo2%). With the result of normal vital signs, the children were placed in orthostatic position in a rectangle previously marked with tape, in front of the TV set and Xbox 360 console by performing the test with the game "Kinect Adventures" -X-Box 360® having the opportunity to train three times. After training, the collection began.

The child should play the games within the rectangle bounded by masking tape (the length between the X- Box and the child's placement was 2.75 m and the rectangle had the measure of 1 m by 3 m) for evaluation of motor coordination, balance and postural reaction. If the child leaves the marked rectangle, this was computed as difficulty to perform the activity.

The images captured by the three cameras positioned at the front and the right diagonal and left were used for qualitative analysis of the variables gross motor variables, balance and postural reaction.

### Variable analysis

After capturing the images, they were transferred to a computer where the researcher did the qualitative analysis of movement, through the definitions of the variables, observing the child's reactions. It is worth mentioning that the score generated by the game itself was not used as a means of analysis, but rather the movements and actions performed by the children with down syndrome during the execution of the game, being these gross motor coordination, balance and postural reaction, based on the following characteristics. For Carr, the balance is the ability to neutralize forces that could disrupt its initial state and keep a certain position, which requires coordination and postural control. Motor coordination results from the activation of various parts of the body to perform movements that have relation to each other, executed in a certain order, amplitude and speed. As a strategy for maintaining posture, anticipatory (Feed forward) and compensatory (Sensory feedback) mechanisms are used, activating the postural muscles before and after the disruption to the recovery of postural balance. First, the analysis of the children was made to remain within the rectangle during times of jumps, shifts and imbalance situations caused by the game for the testing of static and dynamic balance and postural reactions; motor coordination was evaluated primarily through the child's ability to be able to reach the target and complete the action to plug the holes. Then, holding the match was scored, as follows: 1) Has not performed, 2) Performed and 3) Performed with difficulty. The analysis was done by two researchers previously trained and interobserver concordance index greater than 80%.

A manual of the games was written for the study, where the games were tested and evaluated in relation to the difficulty to perform, difficulty understanding, discomfort and fatigue using the Borg scale; the action of each set was also determined with regard to the balance activities, coordination and posture reaction and the major muscles used and functions worked during the execution of the game.

The games used were "River Rush" and "Leaks" with its subdivisions in basic, intermediate and advanced levels.

In the game "Leaks", there was a glass cube on the seabed where the player remains locked. Fish and sharks begin to beat to drill holes in

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the glass cube. The player must plug the leaks using the arms, legs and head. As the options advance, the difficulty level increases, rising more than 5 leaks at the same time. The main functions worked were gross motor coordination, body control and feed forward (anticipation).

In the game "River Rush" the player remains in orthostatic position on a boat where it should go down the rapids. The movements to the sides, right and left, drive the boat to the ramps and bypass obstacles like rocks and plants. It is necessary to jump on the ramps to get to go over rocks and caves and the goal of the game to get the most possible coins. The main functions worked in this game were the balance, proprioception and global coordination.

### Statistical analysis

The tabulation of data was described in Microsoft Office Excel 2007 and data analysis was performed using the SPSS statistical software program.

Categorical variables coordination, balance and postural reactions were analyzed using Student's t parametric test with significant p value equal and/or below 0.05, while for the categorical variable: Level of complexity of the game Kruskal Wallis nonparametric test, with a significance level equal to or below 0.05.

## Results

Continuous variables height and weight will be presented as mean and standard deviation, while categorical variables: Ethnicity, gender, cognitive, knowledge of the game, age, education, interest in the game and participate in physical therapy, will be presented as a percentage (Figure 1). Among the nine children assessed there was an average of 150.65 (± 0.94) for height and average of 45.33 (± 2.35) in weight and the children classified, therefore, as normotonics (Table 1).

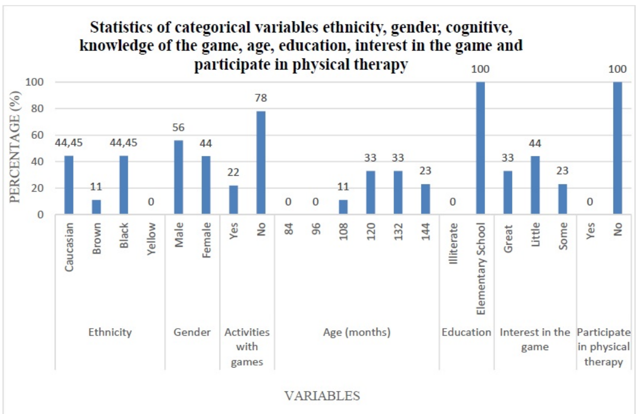


**Figure 1:** Statistics of categorical variables ethnicity, gender, cognitive, knowledge of the game, age, education, interest in the game and participate in physical therapy.

To compare categorical variables, coordination, balance and postural reaction, significant differences were observed between coordination and balance (t: 3.11, p: 0.04) (Figures 2 and 3) and coordination and postural reaction (t: 3, 17, p: 0.04) (Figure 4), thus identifying a greater difficulty in gross motor coordination of children with Down syndrome during the Xbox games. Regarding the game difficulty levels significant difference was not observed (H: 0.0351 p: 0.98) (Figure 5).

| Weight | | | Height | | |
|---|---|---|---|---|---|
| 20-30 kg | Ẋ=25.75 kg | Sd=2.77263 4 | 120-130 cm | Ẋ=126 cm | Sd=1 |
| 30-40 kg | Ẋ=32 kg | Sd=0 | 130-140 cm | Ẋ=133 cm | Sd=2.94392 0 |
| 40-50 kg | Ẋ=45.33 kg | Sd=2.35702 3 | 140-150 cm | Ẋ=149 cm | Sd=0 |
| 50-60 kg | Ẋ=55 kg | Sd=0 | 150-160 cm | Ẋ=150.65 cm | Sd=0.94280 9 |

**Table 1:** Values referring to mean and standard deviation of height and weight.

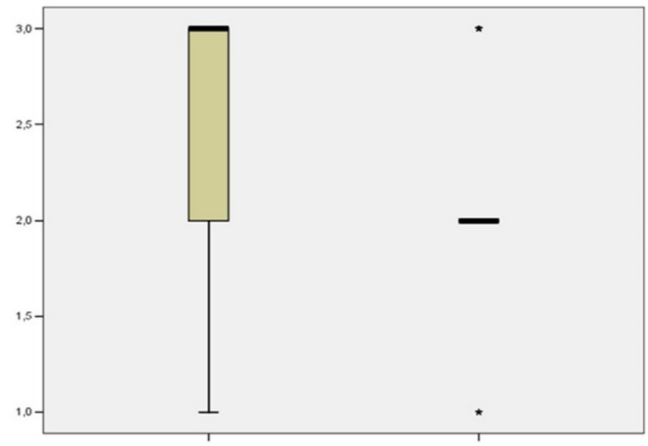

**Figure 2:** Comparison between categorical variables coordination and balance.

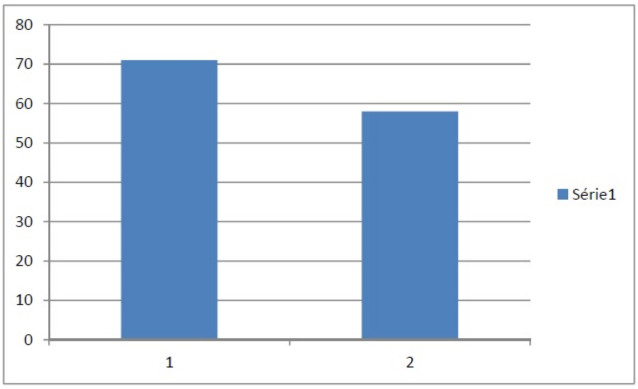


**Figure 3:** Comparison between categorical variables coordination and balance (Série1 referes to Series1).

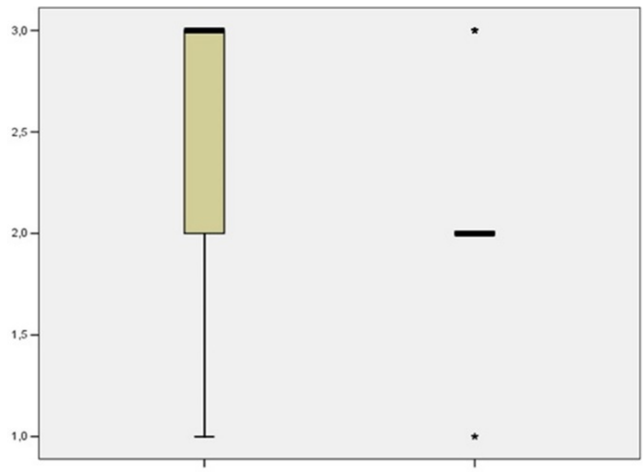


**Figure 4:** Comparison between categorical variables coordination and postural reaction.

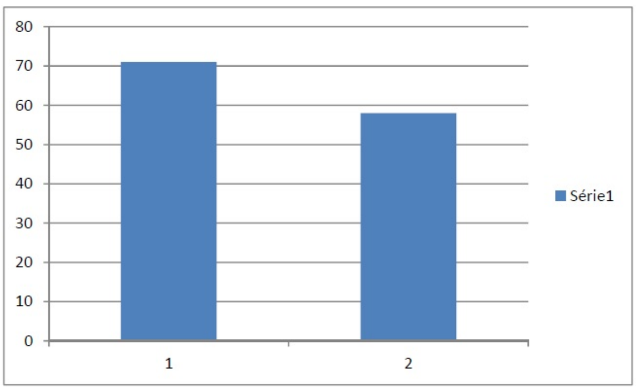


**Figure 5:** Comparison between categorical variables coordination and postural reaction (Série1 referes to Series1).

## Discussion

This study assessed the gross motor coordination, balance and postural reaction of children with Down syndrome through X-Box 360® console. When comparing the variables coordination and balance, coordination and postural reaction were observed in significant differences, identifying greater difficulty in gross motor coordination of these children [20].

It is known that these children have changes in the central nervous system, such as cellular changes in the hippocampus, reduction of synapses in the temporal cortex and lower total volume of cerebellum, causing changes in balance and coordination of movements, as well as generalized hypotonia [21-23].

We believe that the results obtained may be associated with a higher cerebellar deficit in the areas for the control of motor coordination when compared to controlling areas of balance and postural reaction. Based on visual analysis of game achievement, a score was assigned, so that: 1) Has not performed 2) Performed and 3) Performed with difficulty. It was observed that during the execution of the game when it was required the combination of balance variables, postural reaction and motor coordination, the children had a score of 2 and 3 for the first two variables, while for the coordination variable, many had scores 1 and 3.

For the maintenance of balance and posture, the specific areas of the cerebellum promote the proper contraction of axial and proximal muscles of the limbs when the body moves, whereas the control of voluntary movement through the cerebellum involves two steps: A movement planning and another of correction [24,25]. Planning is prepared and expressed as intention of the movement, the motor plan is then sent to the motor areas of the cerebral cortex and put into execution by activating the appropriate neurons. Through sensory afferents, the motion characteristics which is being executed are reported and the corrections of the motor areas are made [24,25]. Based on these findings, we believe that the complexity of the implementation of coordinated movements may be limited due to the speed of movement during games.

During the implementation of the protocol and qualitative analysis it was observed great dysmetry [25]. So that the participants had difficulty in positioning the members correctly during voluntary movements needed to perform the game. The dysdiadocokinesia that often disabled the participant to make alternate moves quickly to plug the leaks using arms, legs and head, also was observed.

Another neuromuscular disease that can lead to incoordination is muscle hypotonia, which causes a ligamentous laxity that can be seen in the whole body, causing hyperflexibility joints and inability to stabilize a member in a position without support, leading to incoordination during voluntary movement [25], observed during the performance of the game.

The balance and postural reaction may also suffer deficits in children with hypotonia. Shumway-Cook and Woollacott-3, previously mentioned, observed a significant delay in performance in static and dynamic balance tests proposed, besides characterizing children as hypotonic, which is consistent with the existing literature. In another study by the same authors, the balance was evaluated by a mobile platform and a considerable difference in the organization of postural patterns in young children in different age groups with DS was found when compared to typical children. It was observed that typical children under 3 years old had a reasonable control and some muscle synergy, while children with DS had oscillations inconsistent responses, poorly organized and slow. The authors suggested that children's inability to modulate postural responses result in instability and body sway. They concluded that possibly balance problems in children with DS are not only a result of delayed motor development, but also represents a delay in the evolution and ontogenetic development of postural control [26]. Thus, our results confirm our first hypothesis that individuals with DS have more difficulty to perform movements that require balance and coordination.

Based on the fact that children with DS have motor changes due to genetic mutation that leads to a delay in motor development and neuromuscular disorders, motor rehabilitation is essential and to make it attractive, the Virtual Reality shows as an effective tool and accepted by children favoring the playful [27]. Despite being new in the therapeutic environment, Virtual Reality has been studied by some researchers to scientifically present its activities in motor improvement. Rahman [28] in his study examined the effect that the Wii-Fit would have on the balance of children with DS, compared to the control group that received only conventional therapy. The results indicated that therapy based on virtual reality significantly improved the children's balance compared to those in the control group. In another study that aimed to evaluate the intervention with Virtual Reality on psychomotor needs of a child with DS using Xbox 360 with Kinect sensor resulted in an improvement in overall motor skills, balance and spatial organization [29].

Virtual reality has some advantages for therapy, such as the video game can be used for different populations not being used for SD only, but also children with cerebral palsy and adults who have suffered stroke as well as for different types of exercises. Another advantage is interactivity and motivation, because video game provides visual and auditory rewards to the patient during the games. We can also point out that the patient data is stored in databases not suffering subjective interference by the therapist or the patient, as in other evaluation and rehabilitation means and thus real [30]. Based on scientific evidence and consulted by the findings in this study, we accept our second hypothesis, that the use of virtual games can help children's therapy with SD. However, we reinforce that the purpose of this study was to evaluate the intrinsic variables of the child during the game and not the benefits of the games as therapy.

## Conclusion

Based on the results of this study, we believe that the complexity of movements to be performed during games, regardless of the level of difficulty of the game, makes it impossible for the child with Down syndrome to perform the coordination movements due to their intrinsic alterations compared to the equilibrium and postural reaction variables. In spite of the limited number of subjects, the study directs us to the need to work with the gross motor co-ordination of the child with Down's syndrome, since this variable is more altered.

## Study Limitations

The study was based on a new activity being implemented in the conventional physiotherapy. Despite the effectiveness of the activity, few scientific studies show the characteristics of the child and postural adjustments relating to exergames activity in children with DS. To answer these questions, the project was created, but we faced the difficulty of selecting individuals with DS to participate in the study, limiting our sample and making it impossible for the authors to present an effective conclusion. However, it should be emphasized that this is a previous study presenting the characteristics of the variables coordination, balance and postural reaction during virtual games, which are scarce in the literature suggesting the need for further studies on the subject.

In addition, we report that children with DS may present difficulties in recognizing and responding to the demands of virtual games, thus necessitating adjustments of the games, but we emphasize that the two games used "River Rush" and "Leaks", did not need adaptations and that the children with DS who participated in the study responded adequately to the games.

## Clinical Implications

The results of this study favour, despite the limited number of participants, to understand the variables coordination, balance and postural reaction of children with DS through virtual games. We emphasize that in addition to identifying the components of the variables mentioned above; the games also help in concentration and interest, which was observed during collections. For this purpose, the use of virtual games would be effective as an evaluation tool and could positively aid therapies.

## Key-Points

- Children with Down syndrome have changes in coordination and balance.
- The evaluation seeks to recognize the balance conditions and coordination of these children. The use of video games presents relevant results in therapeutic treatment.
- In the literature, there are just a few studies exercise game and Down syndrome. Greater difficulty in gross motor coordination has been identified in these children.

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