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Original Article

The use of interactive games by children with Down syndrome[1]

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Abstract: Introduction: Playing is fundamental for children's development and an important resource in working with children, but it is important to consider that toys and games have been transformed and the virtual games were included, which started to be used in Occupational Therapy. Objective: To analyze three platforms and six virtual games, to describe the participation of children with Down syndrome in the use of interactive games and to identify the most accessible platform, and the preference of the children. Method: This is an exploratory, descriptive study with a quantitative approach involving 13 children with Down syndrome, aged between 10 and 13 years old, using six interactive games from Leap Motion, Nintendo platforms Wii® and Timocco. Results: In the children's performance variables, the Timocco Platform reached the highest averages, with statistically significant differences in: "knowing what to do," "respecting the distance indicated for the platform," "playing with independence," and "players´ performance." The correlation between the "players´ performance" and the "demonstration of interest" variables presented significant results. In children's evaluation on the platform and the preferred game, Timocco was chosen, with the game called Falling fruits. The reasons for this choice included the fact that the game was fun, the child's good performance and is easy to play. Conclusion: The Timocco platform presented a higher average in all the variables studied, pointing to the importance of carrying out new studies in which the platform games can be used as an occupational therapy resource for children with Down syndrome, aiming to stimulate the development learning.

Keywords: *Occupational Therapy, Down Syndrome, Games and Toys*.

O uso de jogos interativos por crianças com síndrome de Down

Resumo: Introdução: O brincar é fundamental para o desenvolvimento infantil e um importante recurso no trabalho com crianças, mas é importante considerar que os brinquedos e brincadeiras vêm se transformando e incluíram os jogos virtuais, que passaram a ser utilizados nos atendimentos de terapia ocupacional. Objetivo: Analisar três plataformas e seis jogos virtuais, descrever a participação de crianças com Síndrome de Down no uso de jogos interativos, identificar a plataforma mais acessível e a preferência das crianças. Método: Trata-se de um estudo descritivo exploratório, com abordagem quantitativa, que contou com a participação de 13 crianças com síndrome de Down, com idades entre 10 e 13 anos, no uso de seis jogos interativos das plataformas *Leap Motion*, Nintendo Wii® e Timocco. Resultados: Verificou-se que, em relação às variáveis de desempenho das crianças, a Plataforma Timocco alcançou as maiores médias, com diferenças estatisticamente significativas em: "saber o que fazer", "respeitar a distância indicada para a plataforma", "jogar com independência" e "desempenho dos jogadores". A correlação entre as variáveis "desempenho dos jogadores" e a "demonstração de interesse" apresentou resultado significativo. Na avaliação das crianças sobre a plataforma e o jogo preferido, a escolhida foi a Timocco, com o jogo *Falling fruit*s. As razões para a escolha incluíram o fato de o jogo ser divertido, a criança ter tido bom desempenho

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e ser fácil de jogar. Conclusão: A plataforma Timocco apresentou maior média em todas as variáveis pesquisadas, apontando para a importância da realização de novos estudos em que os jogos da plataforma possam ser utilizados como recurso terapêutico ocupacional com crianças com síndrome de Down, com o objetivo de estimular o desenvolvimento da aprendizagem.

Palavras-chave: *Terapia Ocupacional, Síndrome de Down, Jogos e Brinquedos.*

1 Introduction

Playing is fundamental for the child´s development, but it has been changing with the advancement of technology.

Currently, in addition to conventional toys, interactive games have attracted the attention and interest of children. In this scenario, through the use of platforms and virtual games, the occupational therapist can combine a playful activity with the treatment process, guaranteeing the individual better performance. Thus, the activity encourages the active participation of the child, even with physical and/or cognitive disability; provides a motivating environment for learning; and facilitates the study of the characteristics of the individuals´ perceptual and motor skills and abilities (SCHIAVINATO et al., 2011).

Studies have shown that when working with children with disabilities, the use of playful tools increases interest and motivation to perform rehabilitation activities through games (REID, 2002), and virtual environments can contribute to therapeutic or rehabilitation intervention, and the evaluation process of these individuals (STANDEN; BROWN, 2005; DIAS et al., 2017). Children with Down syndrome are in this group of children with disabilities, in which the occupational therapist can increase their participation by adapting resources and strategies that provide opportunities for experimentation, learning, and interaction during games and playing (PELOSI, 2009).

Children with Down syndrome have neuropsychomotor developmental delay and some intellectual disability, expressed by significant limitations in both cognitive functioning and adaptive behavior in conceptual, social and practical skills, and in the physical aspects and clinical complications that influence the development of their motor and communication skills (BRASIL, 2013).

The use of virtual reality games is becoming more frequent in the rehabilitation programs for people with disabilities; however, the virtual reality games available in the market have many stimuli in general, requiring the speed and the use of multiple movements from the player, which may impair the rehabilitation process when it is used without supervision (TRESSER, 2012; REIFENBERG et al., 2017).

Games may be available on different platforms and in the literature there have been studies in which they were used for motor, cognitive or social rehabilitation (WUANG et al., 2011; MONTEIRO et al., 2011; TRESSER, 2012; TAVARES et al., 2013; COSTA, 2014; ROCHA et al., 2015; CRUZ; D'ALENCAR; MENUCHI, 2015; CAIANA; NOGUEIRA; LIMA, 2016; MEDEIROS et al., 2017; REIFENBERG et al., 2017; BENHAM; GIBBS, 2017).

Platforms may be different to access the games. On the *Leap Motion* platform, the player only moves his hands and fingers on a sensor attached to a computer to interact with the games without any intermediate objects. In the Timocco gaming system, the control is performed by ball-shaped sensors captured by the computer's webcam, and on the Nintendo Wii, the console is connected to the television and controlled by a motion-sensitive device that can be attached to other objects, like a racket and a steering wheel.

Rocha et al. (2015) used the *Leap Motion* platform to encourage children with motor disabilities to perform daily activities such as playing, feeding, and bathing a dinosaur created as a character for the game. The child, together with the occupational therapist moved his hand in front of the *Leap Motion* sensor to perform the activities proposed by the game. Costa (2014) together with an occupational therapist on the same platform, created a 3D game for the Windows, Mac OS X, and Linux platforms, controlled with the movements of the upper limbs, through a *Leap Motion* device. The main objective of the game was to help the development of global and fine motor skills in children between 5 and 9 years old who presented delays in this area, and without a defined diagnosis.

Several works on the use of video games with the Wii platform are frequent in the literature. A study with Parkinson's patients showed positive results in optimizing balance and reducing the motor symptoms of the disease. However, the complexity and speed of games were considered as negative aspects for rehabilitation (CRUZ; D'ALENCAR;

MENUCHI, 2015). This is a fundamental aspect to be considered when choosing the therapeutic resource for children since very difficult games can frustrate the user, reducing their motivation, and leading to a refusal to continue playing. In this sense, the game environment has a crucial effect on player participation (BUNDY, 1997). The Wii Sports game on the same platform consisting of tennis, bowling, boxing, golf, and baseball games was used with a GMFCS Level III spastic diparesis cerebral palsy patient in 11 sessions, ranged from 60 to 90 minutes, with training in standing and sitting position. These results improved visual perception, functional mobility and postural adjustment (TAVARES et al., 2013).

Nintendo Wii® was used in different studies with children and young people with Down syndrome. In one of them, 30 children aged 10 to 13 years old received traditional physical therapy associated with a 6-week videogame therapy program, and the results have improved balance compared to the control group that received only physical therapy (ABDEL-RAMAN, 2010). In another study, seven young people from 11 to 18 years old used the bowling game to verify the occurrence of motor learning in this task, and the data showed a good performance of the players, who were able to knock down 6 to 10 pins in all phases of the research on average (MONTEIRO et al., 2011). Another study compared children who received occupational therapy care with those who received occupational therapeutic care associated with the use of virtual reality, and the data revealed better motor performance, visual skills integration, and sensory integration functions of children in the second group (WUANG et al., 2011).

Other platforms, such as Timocco's are also being used. Research conducted by Tresser (2012) showed that working with 5 years and two months old child diagnosed with dyspraxia using the Timocco platform fruit game showed a significant improvement in his motor skills, with a decreased number of errors, better fruit picking, and basket performance, and increased child motivation to try new activities. Data were monitored by the records made by the program and generated graphs related to the variables number of errors, lost fruits, and efficiency.

Benham and Gibbs (2017) also used telerehabilitation to monitor the work of two children, aged 5 and 7 years old, with difficulties in fine motor coordination at school. Both children participated in 20 sessions, conducted by previously trained occupational therapists, using the Timocco platform, with a minimum duration of 30 minutes, for six weeks. The results showed that both children advanced in fine motor coordination skills. The therapists and the assistants reported positive experiences with camera motion capture.

The use of interactive games may favor playing and be a source of stimulation for the acquisition or improvement of a motor, sensory, cognitive, language, and social skills.

The objectives of this paper were to analyze three platforms and six virtual games, to describe the participation of Down syndrome children when using interactive games, to identify the most accessible platform to contribute to the advancement of knowledge about the virtual reality games available in the market, and, identify which game the children most enjoyed playing. The dissemination of the findings may broaden the knowledge about the platforms and, consequently, their use as a therapeutic resource during the occupational therapy intervention process with children with intellectual disabilities, contributing to the development of their autonomy and independence.

2 Method

This is a descriptive exploratory study with a quantitative approach.

The sample had 13 children with Down syndrome, aged 10 to 13 years old, who were seen once a week at the outpatient occupational therapy service, located in a therapeutic toy library. All children of this age group attended at the toy library during the data collection period participated in the study.

Six different games from 3 platforms were used, totaling on 78 games sets. The games of *Mario Kart Wii*® and *Nintendo Wii Sports*® *- Tennis* were used from Nintendo; the *Caterpillar count* and *Balloon buzz* games were used from the *Leap Motion* Platform; the games *Buble bath* and *Falling fruit* were used from the Timocco platform.

2.1 Platforms and games

Leap Motion Platform – It is a computer hardware sensor device that captures hand and finger movement. No manual or touch contact is required. The *controller* has a technology that shows a world beyond the screen when feeling the movement of the hands as augmented reality. In this study, no 3D glasses were used.

Balloon buzz game - In this game, a bee appears on the screen that will pop balloons from the movement of the player's hands. The one with more points wins the game.

Caterpillar count game - This is a 1 to 100 number sequence game, divided into levels organized by dozens. The centipede's head and a hand with the index finger helping to signal the direction the player's hand movement is making is shown on the screen. The centipede does not catch wrong numbers, making the player rethink the number sequence.

Timocco Platform - This is a computer-based gaming system using the webcam to control players' hand movements, holding two-colored ball-shaped sensors to interact with the platform.

Buble bath Game - In this game, Timocco the monkey is in a bathtub and the game is to pop the soap bubbles. The game has multiple levels, no error signaling, and the player's evolution is shown by a monkey climbing a ladder on the left side of the screen. When the player reaches the top of the ladder, he gains a set of coins, with monkey music and dance, and going to the next level of the game.

Falling fruit Game - In this game, the monkey Timocco raises his arms to catch fruits that appear on the screen and then takes a basket at the bottom of the screen. There is the same evolution control as Buble bath with the monkey climbing the ladder. After completing the first stage, the game will work with two fruits for classification in different baskets.

Nintendo Wii® Platform - This is a Nintendo video game connected to a TV. With the remote control, it is possible to have an interactive experience. The motion-sensitive Wii Remote can be used as a direct pointing device or attached to other objects such as a racket and a steering wheel.

Mario Kart Wii® Game - This is a racing game in which the player must overtake his opponents without hitting them or leaving the track. The game was used in the demo version, and the remote control was attached to the Wii Wheel. The player had to press the button 2 to accelerate and to press the button 1 to brake and move the steering wheel. If the player hits another car or the sides of the track, he should try to get back to it. The position of the player in the circuit is visible in the right corner of the screen.

Nintendo Wii Sports® Game - Tennis - This is a tennis game with players of Nintendo® characters in which the player must hit the ball with the racket and throw it across the court. The game was used in the demo version, and the remote control was attached to a racket. Information about the player server, a replay, if the game was 40 x 40 if two points were required to set the game, if the game needed deuce or if there was a match point were needed to be translated by the researcher during the experiment.

2.2 Instruments

The data collection instruments included: 1) Esar Protocol for game analysis (GARON, 1998); 2) Child assessment script during the experience of the game; 3) Communication board for the child's choice of the favorite game by the platform, considering all games; 4) Video recording of the games.

1) **Esar –** The protocol of classification and analysis of playful materials called Esar system evaluates the game in 6 stages: a) Playful activities; b) cognitive behaviors; c) functional skills; d) Social activities; e) Language skills; and f) Affective behaviors.

Stage A - Playful activities: 1) Exercise game module (sound, visual, tactile, olfactory, taste, motor and manipulation sensory); 2) Symbolic game module (make-believe, role play, representations); 3) Building module (building set, ordering, mechanical assembly, electromechanical, electronic assembly, scientific building, artistic building); 4) Simple rules game module (lotto, dominoes, sequence, circuit, dexterity, elemental sport, luck, elemental question and answer, vocabulary, math, theater); 5) Complex rules game module (reflection game, complex sport, complex strategy, luck, question and answer complex, complex vocabulary, mathematical analysis, complex building set, complex representation, scene); Stage B - Cognitive behaviors: 1) Sensorimotor behavior module (repetition, sensorimotor recognition, sensorimotor generalization, practical reasoning); 2) Symbolic behavior module (symbolic evocation, image-word connection, verbal expression, representative thoughts); 3) Intuitive behavior module (screening, pairing, color differentiation, dimensions, shapes, textures, temporal, spatial, idea association, intuitive reasoning); 4) Module concrete operational behavior (classification, ranking, correspondence, image-word relationship, numbering, numerical operation, conservation of physical quantities, spatial relationship, temporal relationship, simple coordination, concrete reasoning); 5) Formal operative behavior module (hypothetical, deductive, inductive, combined reasoning, complex system/representations); Stage C - Functional Skills: 1) Exploration module (visual perception, hearing, tactile, taste, olfactory, visual referencing, hearing, holidng, displacement, dynamic movement in space); 2) Imitation module

(reproduction of actions, objects, events, roles, models, words, sounds, rules enforcement, visual attention, hearing, visual discrimination, hearing, tactile, taste, olfactory, visual memory, hearing, tactile, taste, olfactory, hand-eye coordination, eye-foot, spatial, temporal orientation, spatial, temporal organization); 3) Performance module (visual acuity, hearing, dexterity, lightness, agility, endurance, strength, speed, accuracy, patience, concentration, logical memory); 4) Creation module (creative expression, productive, inventive); Stage D - Social Activities: 1) Individual activity module (solitary activity, parallel activity); 2) Collective participation module (associative, competitive, cooperative activity); 3) Variable participation module (solitary or parallel activity, solitary or associative activity, solitary or competitive activity, solitary or cooperative activity); Stage E - Language Skills: 1) Oral receptive language module (verbal discrimination, verbal matching, verbal decoding); 2) Oral productive language module (pre-verbal expression, verbal reproduction of sounds, verbal naming, verbal sequence, verbal expression, phonetic, semantic, lexical memory, language awareness, reflection on language); 3) Written receptive language module (letter discrimination, letter-sound correspondence, syllable decoding, words, phrases, messages); 4) Written productive language module (spelling, graphical, grammatical, syntactic, written expression); Stage F - Affective behaviors: 1) Confidence module (non-differentiation, smile as social response, attachment to a transitional object, distress towards the unknown); 2) Autonomy module (no consciousness, body, self-recognition); 3) Initiative module (gender differentiation, paternal identification, learning of social roles); 4) Work module (intellectual curiosity, social recognition, extra-family identification); 5) Identity module (personality search, learning the forms of social organization) (GARON, 1998). The games were evaluated by four consultant occupational therapists and childhood researchers and, in case of discrepancy, the most frequent classification was considered.

2) **Child assessment script during game experimentation** - The script contained 17 topics to be considered. Initial data included the child's medical record number, age, platform, and game name if the child had the platform and the game at home, and the number of times the child had played each game before starting data collection. The variables were: 1) Understanding the rules of the game; 2) Attention in the demo period; 3) Interest; 4) Initiative; 5) Quality of visual-manual coordination; 6) Spatial orientation; 7) Rhythm during the game; 8) Temporal organization; 9) Global motor coordination; 10) Level of independence to use the game; 11) Ability to oral or alternative communication during the game; 12) Concentration level; 13) Know what to do in his turn to play; 13) Respect for the distance of the sensor; 14) Behavior during the game; 15) Respect for the rules; 16) Level of satisfaction; and 17) Acceptance when the game ends. The occupational therapist scored on a Likert Scale, ranging from no participation to excellent participation. The scoring had a ruler from 0 to 10 to assign the score to each mark, and an average of participation of the child was generated. The authors built the protocol from observations recorded by occupational therapists in the observation process of children with Down syndrome, with age close to those of this study, while trying out virtual games. The protocol was evaluated by four consultant occupational therapists and early childhood researchers to make the necessary adjustments.

3) **Communication Boards -** The child's preferred game evaluation instrument on each platform and the preferred game among all games. For this evaluation, two communication boards were used. The first board had the picture cards of the six games. The second board had positive and negative characteristics such as: liked; did not like; easy; difficult; funny; and tiring. The communication boards were used to help the children remember the games they had experienced during the collection period and help them to express an opinion about the games because despite talking, without the support of the communication board, the children showed great difficulty in expressing their opinions.

4) **Video Recordings –** The video recordings were used by two tripod-supported cameras, and the material was analyzed complemented the data from the "Child Assessment Guide During Game Experimentation" that provided observations on how children played.

2.3 Procedures

The initial stages of the game configuration were performed by the researcher.

One of the games was tested at each meeting from the following procedures: 1) The child observed the therapist playing and was instructed on how

to proceed; 2) The child tested the game with the therapist's physical and verbal help, when necessary, for 15 minutes; 3) The child played three games without assistance, considering the data from the last game for the analysis. Data collection time was six weeks for non-missing children, and the maximum period required was eight weeks. Data collection was performed by two occupational therapists with experience in the use of interactive games in their clinical practice, who were trained to use the protocol and who received in-service supervision.

Each platform had a simple game and a more complex game. The experiments started with the simplest games of each platform: 1) *Leap Motion* platform, with the *Balloon buzz* and *Caterpillar count* games; 2) *Timocco* platform with the games *Buble bath* and *Falling fruit*; and 3) *Nintendo Wii*® with *Mario Kart Wii*® and *Nintendo Wii Sports*® - *Tennis* games.

After experimenting the two games on the same platform, the child would choose the picture of the game he liked most on that platform, and his choice was fastened with velcro on a card with his name. Each child had a card and collected their favorite games there. The final choice of the game he liked the most came at the end of the test of all games from his card data.

2.4 Data analysis

A spreadsheet was created to store the data through the Microsoft Excel® 2013 program. The data were entered by two people, with double entry, for subsequent verification of inconsistencies. In the divergences, the researcher resumed the data to make the relevant corrections.

The database was imported into the Statistical Package for Social Science (SPSS) software, version 19.0 for analysis. The measures of central tendency and variability were performed to meet the objectives. Multiple Comparison Test (Anova) and Pearson Correlation Coefficient were used. The magnitude of this correlation was classified as weak ($0 < |r| < 0.3$), moderate ($0.3 \leq |r| < 0.5$), strong ($0.5 \leq |r| \leq 1.0$). For this study, the significance level $p < 0.05$ was considered.

The Research Ethics Committee approved the project under the opinion 49028415.8.0000.5264. The families signed the Informed Consent Form, and the children got explanations of what the game would be like and agreed to participate. The Assent Form was not made due to the difficulty in understanding the term by the children with Down syndrome who participated in the study, even written in plain language.

3 Results

Data is presented in four topics: 1) Game analysis; 2) Considerations about games and children from video analysis; 3) Performance of children during the experimentation of games recorded in the observation protocol; and 4) Choice of preferred game.

3.1 Games analysis

The study analyzed six games: *Balloon buzz* and *Caterpillar count* from the *Leap Motion* platform; *Buble bath* and *Falling fruits* from the Timocco platform; and *Mario Kart*® and *Nintendo Wii Sports Tennis*® from the Wii platform. Table 1 shows the Esar assessment items in which at least one of the games had one of the listed skills.

Based on the Esar protocol, the analysis of the games in the stage of playful activities showed that all the games required physical exercises and manual dexterity. Only the games on the *Leap Motion* platform did not determine the holding of any object in their hands. They were simple rule games, symbolic games, except for the *Leap Motion* platform, in which *Balloon buzz* was a dexterity game, and *Caterpillar count* was a math game that required building, sorting, and sequencing skills. There were two sports and elemental strategy games on the Nintendo Wii platform. As for cognitive behaviors, all games demanded sensory-motor, intuitive or concrete operative behaviors, and only Nintendo platform games required hypothetical reasoning. Regarding functional abilities, the games established exploration, imitation and performance actions, except for the *Leap Motion* platform games, which did not require tactile perception or holding objects skills. Regarding social activities, Wii platform games were tried individually and in the demo version, not allowing group or competitive activities.

Leap Motion games could also provide solitary and competitive activities with the scoring of each player, not addressed in this study. None of the games required language skills, and as for affective behaviors, all required body awareness, and three of them required the "No" consciousness.

3.2 Considerations about the games and the children

The games were analyzed considering the positive and negative aspects of each one, as shown in Table 2.

The analysis of the videos revealed that in the Wii platform tennis game, the children had a hard time with the proper time to hit the ball.

Table 1. Esar Game Classification – Variables of each game.

Variables	Leap		Tim		Wii		Variables	Leap		Tim		Wii	
	A	B	C	D	E	F		A	B	C	D	E	F
STAGE A – PLAYFUL ACTIVITIES							*Stage C – Exploration Module*						
Stage A – Exercise game							Tactile perception						
Sound sensory game							Visual referencing						
Visual sensory game							Hearing referencing						
Tactile sensory game							Holding						
Motor sensory game							Dynamic movement in space						
Manipulation Sensory							*Stage C – Imitation Module*						
Stage A – Symbolic game							Action reproduction						
Make-believe game							Rules reproduction						
Stage A – Building game							Visual attention						
Construction							Hearing attention						
Ordering							Visual discrimination						
Etapa A – Simple Rule							Hearing discrimination						
Sequence game							Tactile Discrimination						
Circuit game							Visual memory						
Dexterity game							Hand-eye coordination						
Elemental sports game							Spatial orientation						
Elemental strategy game							Temporal orientation						
Math game							Spatial organization						
Stage A – Complex Rules							*Stage C – Performance module*						
STAGE B – COGNITIVE BEHAVIOR							Visual acuity						
Stage B – Sensorimotor							Hearing acuity						
Repetition							Dexterity						
Recognition							Lightness						
Generalization							Agility						
Practical reasoning							Resistance						
Stage B – Symbolic							Speed						
Stage B – Intuitive													
Precision													
Screening							Patience						
Pairing							Concentration						
Color differentiation							*Stage C – Creation Module*						
Dimension Differentiation							**STAGE D – SOCIAL ACTIVITIES**						
Shape Differentiation							*Stage D – Individual Activity*						
Temporal differentiation							Solitary activity						
Spatial differentiation							*Stage D – Collective Participation*						
Idea Association							Competitive activity						
Intuitive reasoning							*Stage D – Variable Shareholding*						
Stage B – Concrete Operative							Solitary or competitive						
Classification							**STAGE E – LANGUAGE SKILL**						
Serialization							*Stage E – Language*						
Numbering							**STAGE F – AFFECTIVE BEHAVIORS**						
Space relationship							*Stage F – Confidence*						
Temporal relationship							Distress of the unknown						
Simple coordination							*Stage F – Autonomy*						
Concrete reasoning							"No" awareness						
Stage B – Formal Operative							Body awareness						
Hypothetical reasoning							Self-Recognition						
STAGE C – FUNCTIONAL SKILLS							*Stage F – Initiative*						
Stage C – Exploration Module													
Stage C – Exploration Module							*Stage F – Work Module*						
Visual perception							Intellectual curiosity						
Hearing perception													

A – *Balloon buzz – Leap Motion (Leap)* / B – *Caterpillar count – Leap Motion* / C – *Buble bath* – Timocco (Tim) / D – *Falling fruits* – Timocco / E – *Mario Kart*® – Wii / F – *Nintendo Wii Sports – Tennis*® – Wii.

Table 2. Analysis of the positive and negative aspects of the games.

Games	Positive Aspects	Negative Aspects
Leap Motion ***Balloon buzz***	No joystick needed Simple and intuitive No setup needed to start It is necessary to move the hand to bring the bee to the balloon.	Difficulty for the child to put the hand at the proper distance from the sensor.
Leap Motion ***Caterpillar count***	No joystick needed Start the game by pointing to PLAY The indicator pointed to the screen moves the centipede to the next number. In the end, the centipede becomes a butterfly	Difficulty for the child to put his hands at the proper distance from the sensor. Knowledge of number sequence required PLAY and GO options are in English.
Timocco ***Buble bath***	The game is controlled by 1 or 2 balls attached to the child's hands by a handle. Simple and intuitive The choice of the game is made by images. Start and stop are represented by symbols. The child must move his hand to pop the bubbles The bubbles appear slowly and have high contrast to the background. The child follows his progress by visualizing a monkey climbing the leaders as he reaches the goal of the game. There is no mistake In the end, the child gains pennies	Few difficulty levels
Timocco ***Falling fruits***	The game is controlled by 1 or 2 bubbles attached to the child's hands by a handle. Simple and intuitive The choice of the game is made by images. Start and stop are represented by symbols. The child should move his hand to pick and drop the fruits in the basket. Fruits appear slowly and have a high contrast to the background. The child follows his progress by visualizing a monkey climbing the leaders. There is no mistake In the end, the child gains pennies	Few difficulty levels
Nintendo Wi ***Mario Kart***	Driving is an activity known by children. Funny It can be played alone or in pairs The steering wheel makes the game easier	The game setup is complex with the choice of an avatar, a cart, a race track, and the number of players Following the race through a window next to the screen is confusing for the children. When leaving the track, there are no indications of the direction to be taken. It is not clear what the child should do with the objects appearing on the track. It requires pushing and releasing joystick buttons Instructions are provided in English.
Nintendo Wii ***Tennis***	Funny It can be played alone or in pairs The racket makes the game easier	Game setup is complex when choosing the game, number of players, avatar and match type It requires pushing and releasing joystick buttons Repetitions of the games confuse the child Instructions are provided in English. It is important to know how to play tennis

Source: The authors, 2018.

Some children did not realize that the game was in the replay and continued playing (n = 3), others danced to celebrate each hit, losing the next moves (n = 1), or moved the racket all the time without realizing that they could not interact with the game (n = 2). Despite the poor performance compared to the other games experienced, all children showed to be having fun.

The Wii platform racing game was much easier than the tennis game for all the children in the survey. They had no doubt how to move the steering wheel to drive the car, and managed to complete the route.

The biggest difficulty was getting back to the race track in the right direction after a crash in another car or on the sides (n = 5). None of the children used the reference of their position in the circuit that was available on the right side of the screen. The games on this platform were played standing up.

Some problems were repeated in the games on the *Leap Motion* platform. The most frequent problem was the difficulty in maintaining adequate hand distance from the sensor (n = 5). The children tried to touch the screen for the computer to respond to the movements they were performing, or to shake their hands in the hope that something would happen. In the *Caterpillar count* game, some players needed help to continue the numerical sequence (n = 3). One child was tired by having his arm raised and changed hands.

Balloon buzz on the same platform has been described as very easy by the children. The only needed command was to move a hand in front of the computer screen and pop the balloons.

All players scored at least 30 points, some scored over 60 points in 60 seconds (n = 4), others showed tiredness and changed hands throughout the game (n = 4), and one child performed circular movements in front of the computer screen, popping several balloons. The games on this platform were played in a sitting position.

The games in Timocco platform had 12 of the 13 children who participated in the study playing without difficulty and understood the purpose of the game. The games on this platform could be played sitting or standing, and most of the children chose to play standing (n = 10).

3.3 Children's performance during the game experience recorded in the observation protocol

Comparing the three platforms, the children showed better performance on platform C (Timocco) in all the evaluated skills, as shown in Table 3.

Table 3. Comparison of children's ability variables by platform (n = 78).

Variables		Mean (SD)	Minimum	Maximum	p-value
Visual-manual coordination					
	Platform A	6.4 (2.6)	5.4	7.5	*< 0.001
	Platform B	8.1 (2.5)	7.1	9.2	
	Platform C	9.0 (1.1)	8.5	9.5	
Spatial orientation (Discriminating the different spatial positions that the objects occupy)					
	Platform A	6.5 (2.5)	5.4	7.5	*0.005
	Platform B	7.3 (3.0)	6.1	8.6	
	Platform C	8.8 (1.5)	8.1	9.4	
Rhythm					*0.005
	Platform A	6.3 (2.9)	5.1	7.5	
	Platform B	7.8 (2.8)	6.7	8.9	
	Platform C	8.6 (1.9)	7.9	9.4	
Global motor coordination					*0.010
	Platform A	6.6 (2.4)	5.6	7.6	
	Platform B	8.2 (2.3)	7.2	9.1	
	Platform C	8.5 (2.2)	7.6	9.4	
Temporal organization (Before and after; fast and slow)					*0.001
	Platform A	6.1 (2.6)	5.0	7.2	
	Platform B	7.9 (2.7)	6.8	9.0	
	Platform C	8.7 (2.0)	7.8	9.5	
Spatial organization (Top, bottom, front, back, side) and distance (far, near, short)					*< 0.001
	Platform A	3.5 (3.9)	1.9	5.1	
	Platform B	8.7 (2.3)	7.8	9.7	
	Platform C	9.2 (1.2)	8.7	9.7	

Platform A – Nintendo Wii® / Platform B – *Leap Motion* / Platform C – Timocco; *Significance level p<0.05.

In the performance variables, the highest means were obtained in the Timocco platform, in all of the skills, as shown in Table 4.

In the social variables, there was no significant difference when comparing the three platforms for communication, permanence in the game, respect for the rules and acceptance of the end of the game, as shown in Table 5.

Comparing the platforms, the children showed more satisfaction in the participation of Nintendo Wii® games (p = 0.045), dancing and vibrating with each play, even when the game was in Replay, or they did not hit the bubble, as shown in Table 6. This assessment was made by the occupational therapist completing the Child Assessment Guide during the experience of the game.

Table 4. Comparison of performance variables by platform (n = 78).

Variables		Mean (SD)	Minimum	Maximum	p-value
The child understood the rule					0.359
	Platform A	8.4 (1.8)	7.6	9.1	
	Platform B	8.9 (2.5)	7.9	9.9	
	Platform C	9.2 (1.9)	8.4	10.0	
The child paid attention to the demo					0.644
	Platform A	8.3 (2.0)	7.4	9.1	
	Platform B	8.0 (3.4)	6.6	9.4	
	Platform C	8.7 (1.8)	7.9	9.4	
The child showed interest					0.296
	Platform A	9.2 (1.0)	8.8	9.6	
	Platform B	8.6 (2.7)	7.5	9.7	
	Platform C	9.3 (1.2)	8.8	9.8	
The child had initiative					0.116
	Platform A	9.0 (1.0)	8.6	9.4	
	Platform B	8.1 (3.3)	6.8	9.5	
	Platform C	9.4 (1.4)	8.8	9.9	
The child knew what to do in his turn to play					*0.030
	Platform A	7.4 (2.6)	6.3	8.5	
	Platform B	8.3 (2.6)	7.3	9.4	
	Platform C	9.2 (1.9)	8.4	10.0	
The child respected the distance indicated for each platform					*0.003
	Platform A	8.0 (1.9)	7.2	8.9	
	Platform B	5.9 (3.4)	4.5	7.3	
	Platform C	8.2 (2.4)	7.2	9.2	
The child played with autonomy					*0.021
	Platform A	7.0 (2.6)	5.9	8.7	
	Platform B	7.8 (2.8)	6.7	9.3	
	Platform C	9.8 (2.3)	8.1	10.0	
The child was concentrated in the game					0.099
	Platform A	9.0 (1.0)	8.6	9.4	
	Platform B	7.8 (3.3)	6.5	9.2	
	Platform C	9.0 (1.9)	8.2	9.8	
The child had performance in the game					*0.001
	Platform A	6.7 (2.6)	5.6	7.7	
	Platform B	7.7 (2.6)	6.6	8.8	
	Platform C	9.0 (1.1)	8.6	9.5	

Platform A – Nintendo Wii® / Platform B – *Leap Motion* / Platform C – Timocco; *Significance level p<0.05.

Table 5. Comparison of children's social skills variables by platform (n = 78).

Variables		Mean (SD)	Minimum	Maximum	p-value
The child communicated during the game					0.097
	Platform A	7.3 (3.1)	6.1	8.6	
	Platform B	7.3 (3.4)	5.9	8.7	
	Platform C	7.7 (3.2)	6.4	9.2	
The child behaved properly					0.187
	Platform A	9.0 (1.3)	8.5	9.6	
	Platform B	8.2 (3.1)	6.9	9.4	
	Platform C	9.2 (1.4)	8.6	9.8	
The child stayed until the game ends					0.144
	Platform A	9.8 (0.3)	9.6	9.9	
	Platform B	8.7 (2.7)	7.6	9.8	
	Platform C	9.3 (1.9)	8.5	10.0	
The child respected the rules					0.840
	Platform A	9.1 (1.1)	8.6	9.6	
	Platform B	8.9 (2.2)	8.0	9.8	
	Platform C	9.2 (1.7)	8.5	9.9	
The child accepted the end of the game					0.239
	Platform A	9.1 (1.2)	8.6	9.6	
	Platform B	9.6 (1.0)	9.2	10.0	
	Platform C	9.3 (0.9)	8.9	9.7	

Platform A – Nintendo Wii / Platform B – *Leap Motion* / Platform C – Timocco; Significance level $p<0.05$.

Table 6. The child showed satisfaction (n = 78).

Variables		Mean (SD)	Minimum	Maximum	p-value
The child showed satisfaction					0.045
	Platform A	9.3 (0.8)	9.0	9.7	
	Platform B	8.0 (3.1)	6.7	9.2	
	Platform C	9.1 (1.5)	8.5	9.8	

Platform A – Nintendo Wii® / Platform B – *Leap Motion* / Platform C – Timocco; Significance level $p<0.05$.

There was a moderate positive correlation between the game performance and the children's interest demonstration score (Rsa = 0.435; $p < 0.001$). The higher the mean obtained in the game performance, the more the children showed interest in the games.

3.4 The choice of the child's favorite game

The children assessed the platform and the games and showed that the favorite platform was Timocco, and the chosen game was *Falling fruits*, from the same platform. It is a sound, visual, tactile, motor and manipulation sensory exercise game; make-believe and simple rule, featuring as a dexterity and math game. The cognitive behaviors required concrete sensorimotor, intuitive and operative skills with the skills of classification, spatial, temporal relationship, simple coordination, and concrete reasoning. The skills required to play were the same as all other games and involved visual, hearing, tactile perception, grasping and dynamic movement in space, playing actions, rules, visual attention, hearing, visual memory, hand-eye coordination, dexterity, agility,

speed, precision, and concentration, being a solitary, non-competitive activity. The main reason for its choice was because the game was fun (n = 8), the child had in his opinion a good performance (n = 4), or because he found it easy (n = 1).

4 Discussion

Three virtual reality game platforms were selected, each one with two games to describe the participation of 13 Down syndrome children, 10 to 13 years old, using interactive these games, and evaluating the most accessible platform. These games required physical exercises and required manual dexterity, exploration, imitation, and actions, being games with simple rules in which sensory-motor, intuitive or operative-concrete behaviors were necessary. For two of the platforms, Timocco and Nintendo Wii®, it was necessary to hold a sensor in hand, which was not the case on the Leap Motion platform.

The study showed that the Timocco platform achieved the highest means on all items and the skills that statistically showed significant difference were to know what to do; respect the indicated distance to the platform; play independently; and game performance.

The data from this study corroborate the literature that shows the Timocco platform as a platform developed by occupational therapists as a work tool in child rehabilitation. Their games are simple, with well-defined goals, related to daily life activities and easy to play. The action time is determined by the child who, in the games used in this study, had to pop the soap bubbles or store the fruits in the basket on their own time. The games have levels as the child performs well at the previous level. It is a supportive tool to strengthen children's motor, cognitive and communicative skills (TRESSER, 2012; CABRAL et al., 2016; REIFENBERG et al., 2017).

Studies like Tresser´s study (2012) who used the Timocco platform with a child of 5 years and 2 months old, diagnosed with dyspraxia, used the game *Falling fruit*; Reifenberg et al. (2017) study used the platform in the rehabilitation work of a child with cerebral palsy in their home; and Benham and Gibbs (2017) study used it with two children aged 5 and 7 years old, with difficulties in fine motor coordination, carried out at school, showed that the use of playful tools in working with children with disabilities increases the interest and motivation in performing rehabilitation activities through games, and the use of the Timocco Platform enabled the development of motor coordination skills.

The platform games allow the adjustment of the difficulty level and enable the development of specific skills such as increased muscle tone, bilateral coordination, range of motion and passage of the midline, or goals related to attention and perception. Also, the therapist can control several parameters within the game environment, such as the background, sounds, number of distractions, among others, enhancing the chances of the successful use of the platform (TRESSER, 2012).

Interactive software encourages active involvement in learning and gives the user the control experience during the process. They also create opportunities for people with intellectual disabilities to learn and to make mistakes without suffering the consequences or dangers related to them, during the process. For a good experience in virtual reality games, the most relevant aspects need to be highlighted, the abstract concepts and rules of participation should be conveyed simply and supported with the symbol system, the games need to contain tips and instructions at the beginning of the game that should be taken as the user becomes familiar with the task (STANDEN; BROWN, 2006).

Virtual reality games can present major challenges for children with disabilities. The video analysis has shown that, in the Wii platform tennis game, sports games that require agility, dexterity, and accuracy, the children had a hard time with the proper time to hit the ball. The study by Monteiro et al. (2011) of seven 11 to 18-year-old with Down syndrome on bowling on the same platform also reported that participants had difficulties in the motor interaction of pushing and holding the Wii controller button pressed down until the final swing of the arm when the ball should be released. Sometimes the participants released the button before the arm reached the front, which resulted in the ball not being thrown and a retry was required.

Other difficulties were observed when experimenting in Wii platform games requiring more motor skills compared to other platforms, and intuitive thinking was needed in some stages. Behaviors such as non-perception that the game was in replay, mid-match celebrations, and racket movement even when not interacting with the game were observed. In the racing game, the children had no doubt how to move the steering wheel to drive the car and were able to complete the course, but they had

difficulty getting back on track because they did not consider the information on the screen about the proper positioning of the car. These limitations can be explained by studies that show that people with intellectual disabilities may have problems with memory, attention, language, abstraction, perceptual skills, reasoning, generalization and knowledge acquisition (JEFFS, 2009; MALAQUIAS, 2013).

Although it was the platform on which children performed worse, from the assessment of occupational therapist, the research individuals show more satisfaction in the participation of games on the Nintendo Wii® platform. Such satisfaction was identified considering children's actions, such as dancing and vibration with each hit or circuit completed. This is maybe because they are sports games and involve competition. In this sense, it is essential that the occupational therapist develop strategies that favor the child's participation, since games of this nature require more training to improve performance, which was not the objective of this study, but could be of great value for a rehabilitation work, as described in other studies (ABDEL-RAMAN, 2010; MONTEIRO et al., 2011; WUANG et al., 2011).

The most frequently observed problem in the usability of the Leap Motion platform was the difficulty in maintaining proper hand distance from the sensor. Initially, it was seemed an advantage not having an object in hand, but proved to be a difficulty for all participants. The use of the Leap Motion platform demanded more mediation from the researchers.

As for the Timocco platform games, 12 of the 13 children who participated in the study understood the purpose of the games and played independently. This platform accessibility was reflected in the choice of the game they liked the most. The opinion of children is extremely relevant in the process of using virtual reality games and should be considered in the practice of occupational therapist.

The results showed that the game *Falling fruits* on the Timocco platform was chosen, mostly because the games were fun; the child performed well; or found it easy to play. The children's favorite game was not the easiest game of the six games studied, which was *Balloon buzz*, dexterity game, nor was the simplest of the Timocco platform, the *Buble bath*. The choice was mathematics game that required skills that most of the group had, especially considering the necessary cognitive behavior, concrete operative thinking. It was also a game with clear and very intuitive rules, in which the children performed it well.

There was a positive correlation between the child's interest and their performance in the game, which is a fundamental aspect to consider when choosing the therapeutic resource for children, as very difficult games can frustrate the user, decrease their motivation, leading to a refusal to continue playing.

Some components are critical for a video game to generate more motivation for its players, such as: clear goals and objectives; feedback on performance; elements that enable the development of skills and mastery; level according to player skills; elements favoring concentration; effortless immersion; control by the player over his actions in the game; and elements that benefit social interaction (SWEETSER; WYETH, 2005). The choice of the children for the Timocco platform as a more accessible and intuitive platform confirms this premise.

The accessibility of the games was another aspect to be considered for all the platforms. Starting Wii games required choosing the avatar, game type, and other options that the researchers needed to make due to the lack of accessibility of the platform showing all the information in English. On the Leap Motion platform, a study by Felippsen (2017) showed that the use of games with deaf and illiterate children required the support of a fluent Libras teacher to provide explanations as there were no self-explanatory icons in the games.

The study by Pelosi (2017) showed the possibility of using the Timocco platform, with the games *Buble bath* and *Falling fruit*, the same ones of this study, as a resource for eye mouse training as a way of computer access by children with motor disability, demonstrating that there are other possibilities of access to Timocco platform games that include children with more severe motor difficulties.

Finally, the review study conducted by Malaquias and Malaquias (2016) highlighted the role of virtual reality in the learning process of people with intellectual disabilities. The study showed that virtual environments help people with intellectual disabilities to develop spatial knowledge, learn logical-mathematical concepts, perform day-to-day activities such as grocery and school shopping, and repeated practice in virtual environments increases the probability of generalization in real-world situations and daily circumstances.

The virtual environment is safe for the development of learning, tolerant of error, allowing the children to use their movements, according to their ability, in pleasurable activities (BROOKS; PETERSSON, 2005; VERHAGEN et al., 2009).

5 Final Considerations

The Timocco platform presented the highest mean in all the researched variables, showing to be the most accessible for children with intellectual disabilities among the researched ones and pointing to the importance of conducting new studies in which platform games can be used as a resource for occupational therapy with children with Down syndrome, stimulating the development of learning.

This referral will be facilitated by the diversity of platform games with cognitive development as a proposal, and to the motor aspects already mentioned. The games available enable the tasks of categorizing, quantifying, working with numbers, visual perception, color and shape discrimination, sequence hearing memory, among others, in non-competitive activities, where errors are not computed. Also, the platform's virtual reality games have a monitoring system that assists the development of research and case studies of the children being followed.

The results of this study should be viewed based on its limitations. As previously highlighted, the research was conducted in a therapeutic toy library and during occupational therapeutic consultations, difficult for other professionals to participate at the time of the evaluations. However, it is expected that the results of this work will guide other professionals who are interested in using these resources in their care, favoring the knowledge about the positive and negative points of each platform and directing the development of other research with different approaches on this topic.

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