Neural Control of Movement

Wii-based exercise program in persons with intellectual disabilities: technological perspective to improve motor performance

Maysa Venturoso Gongora Buckeridge Serra[1], Cynthia Yukiko Hiraga[2], Marisa Afonso Andrade Brunherotti[1], Maria Georgina Marques Tonello[3]

[1]*Universidade de Franca, Departamento de Promoção de Saúde, Franca, SP, Brazil;* [2]*Universidade Estadual Paulista "Júlio de Mesquita Filho", Instituto de Biociências, Rio Claro, SP, Brazil;* [3]*Associação de Pais e Amigos dos Excepcionais, Franca, SP, Brazil.*

Associate Editor: Paulo Henrique Guerra, Universidade Estadual Paulista "Júlio de Mesquita Filho", Instituto de Biociências, Departamento de Educação Física, Rio Claro, SP, Brazil.
E-mail: paulo.guerra@unesp.br.

Abstract - Aims: To examine the effects of Wii-based exercise program on individuals with intellectual disability (ID). **Methods:** The study consisted of a case reports design involving six individuals with ID who attended a special needs school. The Wii-based exercise program for participants consisted of twenty sessions. The Motor Development Scale (MDS), the Beery-Buktenica Developmental Visual-Motor Integration (Beery VMI) test, and their additional tests (i.e., fine motor coordination and visual perception) were administered before and after the Wii-based exercise program; the researcher manually recorded games scores practiced in the program for further analysis. **Results:** The Wii games' results showed that participants significantly improved their performances during twenty sessions. Regarding the results of the applied tests, supplementary test results for motor coordination of the Beery VMI showed that the participants' performances improved significantly before and after the Wii-based exercise program. However, there were no significant changes in the results of the Beery VMI visual-motor integration, visual perception, and MDS before and after the Wii-based exercise program. **Conclusions:** These reports suggest that, although participants did not demonstrate significant improvements in motor development assessments, the Wii-based approach allows them to practice and enhance specific motor skills, such as coordination, movement speed, accuracy, and balance control, while maintaining regular exercise routines, which promotes overall health.

Keywords: intellectual disability, exergame, active video game, intervention.

Introduction

Individuals with Intellectual Disability (ID) require interventions to meet their needs and functional person's deficits. Well-developed basic motor skills serve as the bases of context-specific and skillful movements such as sports, leisure, lifelong physical activities and essential to perform daily living activities[1,2]. Active video games, also called exergames interventions, recently becoming popular for therapeutic usage, including a wide range of fun games for children, adults, and elders of any gender[3,4]. For active video games such as Nintendo Wii, individuals can play at their own pace and beginner skill level for as long as they choose[5].

The innovative concept behind Nintendo Wii is how the user interacts with the game using physical gestures and pressing buttons of the controller device, with an intuitive and realistic interaction[6]. Wii games have become an alternative to promote physical exercise to allowed chronic obstructive pulmonary disease patients to show similar cardiovascular demands to traditional pulmonary rehabilitation programs[7]; to effectively improved physical fitness, functional mobility, and motor proficiency of adults with Down syndrome[2]; for children with cerebral palsy for improving functional and dynamic balance when combined with conventional therapies[1]. Practice with Wii games usually increases the enjoyment of exercising by the challenge and feedback as a key that improve exergames enjoyment.

A study[4] showed that Wii games associated cognitive training enhanced visual perception and behavioral functions in children with ID. A systematic review[5] of randomized controlled trials showed computerized cognitive training protocols had a high intervention adherence rate. However, another part of the studies had a low dropout rate of people with ID and conclued that video gaming is a valuable therapy for improving physical and cognitive function in people with ID. Thus, this case report study has two main objectives. First, to evaluate motor development and sensory-motor performance in individuals with

ID before and after participating in a Wii-based exercise program. Second, to evaluate the participants' video game performance during the Wii-based exercise program across all sessions.

Methods

The present study is a case reports and adopts the one-group pretest-posttest design, part of the quasi-experimental method[8]. Such design allows comparing an index of change before (a pretest) and after (a posttest) the treatment.

Participants

Six individuals with mild ID, aged between 11 and 32 years old, registered at a special needs school of a municipality in the state of São Paulo, participated in the present study. The inclusion criteria required participants to have a diagnosed ID, be physically capable of interacting with the Nintendo Wii video games, and possess sufficient intellectual capacity to understand the objectives of the games proposed in this study. All participants were diagnosed with mild ID. They demonstrated the ability to engage in social and communication interactions. Additionally, the adult participants were able to adapt to and integrate into a professional work environment. The university's ethics committee approved all experimental procedures of the present study.

Procedures

The Motor Development Scale – MDS assessed the level of motor development before and after the Wii-based exercise program. The MDS aims to assess the following domains: fine and global motricity, balance, body schema, and spatial and temporal organization in children aged 2 to 11[9]. Examinees proceed to the previous or next developmental age task depending on failure or success on the task, respectively. It is a suitable instrument for special populations as it permits motor and chronological age comparisons. The MDS provides a motor age for each domain and a general motor age based on the task completion in each domain. The general motor age divided by chronological age and multiplied by 100 results in a general motor quotient. Finally, the general motor quotient classifies the MDS performance as superior, superior, normal high, normal average, normal low, inferior, and much inferior.

The Beery VMI includes the visual-motor integration test e two additional tests, one for visual perception and another for fine motor coordination[10]. In the present study, the participants executed the tests before and after the Wii-based exercise program. The visual-motor integration test assesses how individuals can integrate their visual and motor abilities. This test presents a sequence of drawings of geometric forms (e.g., a line, a square, or a cube) in which the examinee has to copy each drawing. The drawings are presented one at a time in an increasingly complex sequence until the participant fails to reproduce them or he/she finishes all the sequences.

The second test is the visual perception test which assesses how the visual system perceives the information a person receives. This test presents a sequence of progressively complex geometric drawing models. The task is to identify and point out the identical match of the drawing model with a pencil in a set of similar drawings. The examinee has to discriminate the drawings in three minutes.

The final test of the Beery VMI assesses the level of fine motor coordination. The fine motor coordination test begins with rudimentary drawings and advances to more challenging ones like the other tests. The individual receives specific directions to trace the interior of the route of each drawing without crossing over the drawing's borders. The examinee has five minutes to trace the drawings.

The Wii-based exercise program for the participants consisted of the games on the Nintendo Wii console called Pose Mii, Soccer Heading, and Ski Slalom. Two accessories of the Wii console were necessary for the games chosen, the Wii remote and the Wii balance board. The Wii balance board used for the Soccer Heading game is a force platform with four force transducers that assess force distribution and the resulting movement in the center of pressure[8]. Moreover, the user controls the game situation by adjusting their weight on either leg on the medial-lateral and anterior-posterior axes.

The purpose of the Pose Mii game is to pop bubbles that float downwards before the bubbles touch the bottom surface. The participants had to position their Mii pose with the contour pose inside the bubble before touching the bottom surface. The game required participants from a standing position to hold the Wii remote control in hand, pointing and twisting towards a bubble and pressing a button to pop each bubble. Participants scored every time they matched the poses of their Mii to the contour inside the bubbles. The game ended when the participant missed three bubbles that touched the surface.

The purpose of the Soccer Heading game is to head the soccer balls while dodging non-balls objects. This game required the participants to tilt their bodies on the balance board in the direction of each kicked ball, one after the other. The participants scored points for every successful ball heading, with extra points for consecutive ball headings. However, the participants lost points when heading to an object that was not a ball. The game ended with a total of 80 balls thrown to the participants.

The Ski Slalom game aims to ski down a slalom course between two flags as quickly as possible. This game required the participants on the balance board to lean left or right to pass between the area marked by the two arrow signs and lean forward to increase speed. The

score for statistical analysis was the number of failures across the slalom course. In this case, the lower the value, the better the score.

All testing protocols and the Wii-based exercise program took place in a quiet and comfortable room at the participants' school during the same period they were there for their studies. A schedule was organized for each participant to adequate the training sessions among other activities and classes. The Wii-based exercise program was composed of 20 sessions, three times per week, with each session per participant lasting approximately 20-30 minutes, time enough to practice three times each Wii game. The experimenter manually registered the game scores of every training session for statistical analyses.

Statistical analysis

The data collected from the assessments and the Wii-based exercise program were entered into a Microsoft Office Excel spreadsheet for further analysis. The sum of the three attempts of each game per day served for statistical analyses. The Statistica software helped to run the statistical analyses. The normality of data was verified using the Shapiro-Wilk test. The Student's t-test calculated differences for the MDS and the VMI Beery scores before and after the training sessions. Friedman's rank-sum test for repeated measurements calculated the performance changes across 20 sessions in each game of all participants. The alpha level for statistical significance was at $\alpha < 0.05$.

Results

The results of the MDS (Table 1) showed an increase in general motor age from 53 months (4 years and five months) to 57 months (4 years and nine months) on average. It was not statistically significant, $t(5) = 1.08$, $p = 0.32$. Concerning the general motor quotient in the pre-and post-Wii-based exercise program, all participants were classified as 'much inferior'.

About the scores of the Wii-based exercise program obtained along 20 sessions, the Friedman analyses of variance showed a statistically significant difference between mean ranks across the twenty sessions, Pose Mii, X^2 (19, $n = 6$) = 85.06, $p < 0{,}0001$; Ski Slalom, X^2 (19, $n = 6$) = 58.54, $p < 0{,}0001$; and for Soccer Heading, X^2 (19, $n = 6$) = 85.06, $p < 0{,}001$. A box plot provides a basic idea of the distribution of the data. If the box plot is relatively short, then the data is more compact. If the box plot is relatively tall, the data is spread across participants' scores. Overall, the lengths of the box plots are not consistent across the sessions but rather vary according to the Wii game.

Pose Mii (Figure 1) scores in the box plots are more condensed in the first five sessions, whereas box plots are more spread from the sixth toward the last session. It means that participants' scores were relatively close together at the beginning of the intervention program. A visual inspection of individual data indicated that the scores of participant 4 and 6 produced the spread of the box plots. Furthermore, a score of the participants 6 produced whisker tallness.

The profile length of the box plots for the Soccer Heading (Figure 2) game across sessions appear to be similar and more compacted than spread. It draws attention to the maximum values from the tenth session to the twentieth. A visual inspection of individual scores indicates that the scores of participant 6 produced the whisker tallness. The medians and lengths of the box plots across sessions suggest that participants did not show great improvements except for participant 6.

The aim of the participants in the Ski Slalom game (Figure 3) is to reduce errors, then the lower the score better, in contrast to previous Wii games. The length profiles of the box plots indicate variation across sessions. The medians oscillate up and down across sessions more than in the previous games, but overall, participants could significantly reduce errors. A visual inspection of individual

Table 1 - Results of MDS test of the participants in the pre-and post-intervention.

	General motor age			General motor quotient		
	Pre	Post	Pre	Clas.	Post	Clas.
Part. 1	46	43	15	MI	15	MI
Part. 2	68	62	28	MI	28	MI
Part. 3	40	46	17	MI	17	MI
Part. 4	54	74	28	MI	28	MI
Part. 5	60	60	18	MI	18	MI
Part. 6	50	58	42	MI	42	MI

Note: Clas.: classification; Part.: participants; MI: much inferior.

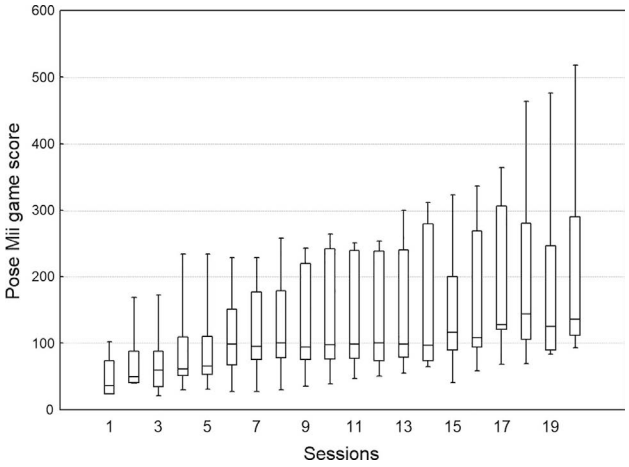

Figure 1 - Box plots for the median (dashed line within each box), ± inter-quartile range (IQR) values, and the minimum and maximum values indicated by the whiskers ends, for the Pose Mii game across the twenty sessions in the Wii-based exercise program.

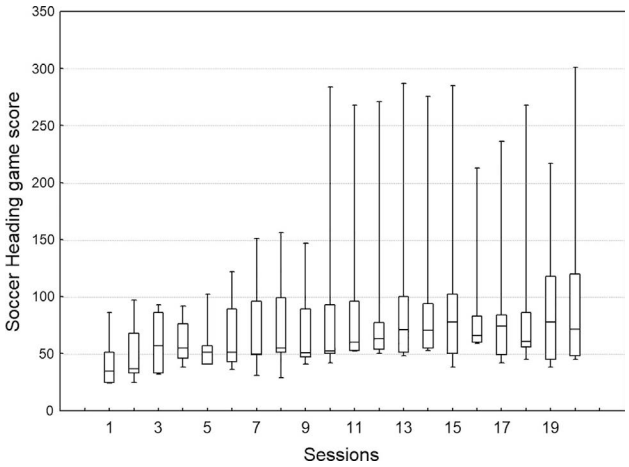

Figure 2 - Box plots for the median (dashed line within each box), ± inter-quartile range (IQR) values, and the minimum and maximum values indicated by the whiskers ends, for the Soccer Heading game across the twenty sessions in the Wii-based exercise program.

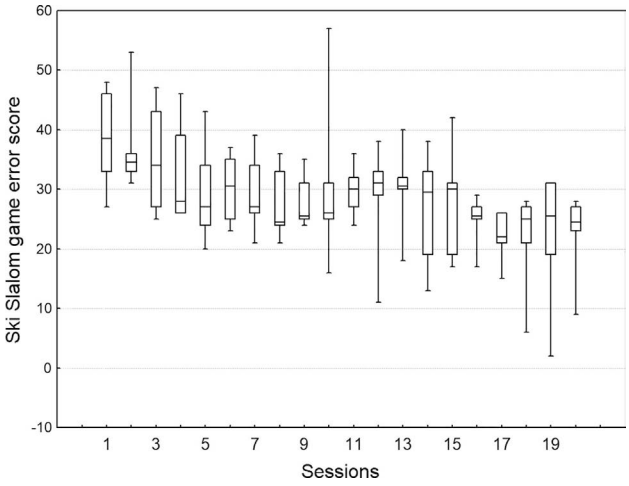

Figure 3 - Box plots for the median (dashed line within each box), ± inter-quartile range (IQR) values, and the minimum and maximum values indicated by the whiskers ends, for the Ski Slalom game across the twenty sessions in the Wii-based exercise program.

scores indicates that the scores of participant 6 produced the whisker tallness in the last three sessions again.

The results showed that the assessment for fine motor coordination improved significantly between pre- and post-intervention of the Wii-based exercise program, $t(5) = -3.18$, $p < 0.05$. In contrast, the assessments for visual-motor integration and visual perception (Table 2) between pre-and post-intervention of the Wii-based exercise program did not show significant differences, $t(5) = -2,28$, $p < 0.07$; and $t(5) = -1.18$, $p = 0.28$, respectively.

Discussion

Several studies have shown significantly lower motor proficiency levels in children with ID compared to their peers without ID[11]. These motor deficits often persist throughout life and tend to worsen without appropriate intervention. This highlights the need for effective strategies that promote physical activity and motor development in this population. The present report presents a technology-based exercise modality, exergames, which allow for engaging, interactive, and fun experiences that can lead to improvements in motor performance. Exergames provide a way to deliver physical exercise tailored to different age groups, offering motivating features such as individual scoring, real-time feedback, and progressively increasing difficulty levels[4]. These elements help maintain participant engagement and ensure that physical activity remains challenging and rewarding, potentially enhancing motor skills and overall health.

Table 2 - Scores for VMI Beery tests of all participants for pre-and-post the Wii-based exercise program.

	VMI		VP		FMC	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Part. 1	4	4	15	10	10	19
Part. 2	4	15	21	19	13	17
Part. 3	8	8	17	18	4	9
Part. 4	8	15	16	26	13	14
Part. 5	12	15	15	20	15	16
Part. 6	4	7	18	26	14	24
Mean (SD)	6.6 (3.2)	10.6 (4.9)	17.0 (2.28)	19.8 (5.9)	11.5 (4.0)	16.5 (5.0)

Note: FMC: Fine Motor Coordination; Part.: Participants; Pre: Pre-intervention; Post: Post-intervention; VP: Visual perception; VMI: Visual-motor integration; (SD): standard deviation.

The study results showed minimal changes in the pre-and-post assessments of the Wii-based exercise program. The first objective of this study was to evaluate motor development and performance in individuals with ID before and after participating in a Wii-based program. The only significant improvement was observed in fine motor coordination, where the scores of all participants increased. While there were improvements in motor development scales, as well as in visual-motor integration and visual perception tests, these gains were modest following the intervention. Despite the modest results, these minor improvements suggest that individuals with ID demonstrate behavioral flexibility and cognitive plasticity when provided with appropriate opportunities.

Studies highlight that exergame-based programs are effective in enhancing life skills, language development, social interaction, and educational outcomes for individuals with disabilities[12]. Technologies like the Nintendo Wii have also been beneficial for motor skill development, particularly balance, in children and adolescents with atypical development. However, further research is needed to confirm their reliability and reproducibility. For instance, a Kinect-like console for visual-motor cognitive stimulation

in individuals with Down Syndrome[13]. After four sessions of 15 exercises, while statistical results showed no significant differences between control and experimental groups, observational data indicated improvements in visual-motor cognitive skills.

Exergames offer an engaging way for individuals with ID to participate in physical activity. By combining movement with fun, these games help improve motor skills and health, while also encouraging long-term participation through immediate feedback and progress tracking. In the present study, after 20 sessions, the researcher observed that participants consistently demonstrated enthusiasm and excitement during the sessions, attending all scheduled days and engaging actively and positively throughout the entire intervention. These findings are supported by literature[6,14] who similarly found that interventions using active video games provide an opportunity for individuals with ID to engage in physical exercise, while also generating interest and yielding positive outcomes even after just a few sessions.

The second objective of this study was to evaluate the participants' video game performance during the Wii-based exercise program across all sessions. The results showed a gradual but significant increase in performance across all Wii games practiced throughout the sessions. Literature[13,15] suggests that individuals with ID quickly learn to interact with gestural interaction platforms, as evidenced by a continuous decrease in noncognitive errors over time. Additionally, these errors tend to diminish as participants become more familiar with the tasks. Active video games can effectively promote motor development by engaging key motor skills, such as endurance, coordination, strength, balance, and movement speed[11].

In this study, each video game required specific skills. For example, the Soccer Heading game requires controlling the center of pressure within the limits of body balance on the board. In the Ski Slalom game, participants demonstrated the ability to prioritize task demands, as they were instructed by the researcher to control errors by skiing slowly, as speed was not considered for scoring. In the Pose Mii game, the participant had to adjust their pose by angling left, right, or upside down, then twist their arm and point the Wii remote to align their Mii pose with the contour as quickly as possible. Fine motor coordination and the ability to rapidly orient the Wii remote to pop bubbles were critical to succeeding in this game.

The literature[12] on the use of video games for individuals with ID is limited. However, the existing studies suggest that interventions using active video games, such as those on the Nintendo Wii, can benefit people with ID. The present study demonstrated that participants improved their motor performance through the use of these games, consistently increasing their final scores each day. Some researchers[16] highlight that focused and repetitive interventions promote cortical reorganization and neuroplasticity, leading to improvements in motor performance. Active video game programs provide entertaining yet challenging tasks that require frequent practice, transforming the gaming experience into a motor performance training program.

Techniques that enhance motivation and action control can strengthen habit formation through repetition. Although habit formation studies typically span 12 weeks, longer follow-ups-up to 24 months-are rare[15,17]. Future research on exergames should include longitudinal studies in real-life settings, such as homes or institutions frequented by individuals with intellectual disabilities (ID). Video games create an engaging environment that keeps players focused, which is particularly useful for improving visual-motor integration, a critical skill often compromised in people with ID[14,17]. Active video games provide an effective platform to train essential skills like visual reception, cognitive processing, and fine motor coordination, potentially enhancing both motor performance and daily life activities.

Conclusions

Although participants did not demonstrate significant improvements in motor development assessments, the findings suggest that exergame-based programs provide a feasible form of physical exercise for individuals with ID. The Wii-based approach allows them to practice and enhance motor skills, such as coordination movement speed, accuracy, balance control, while maintaining regular exercise routines, which promotes overall health. This case report, involving six individuals with ID, highlights the need for further research on the effects of active video games in this population. Additional longitudinal studies with representative samples are required to confirm these findings and to assess whether individuals with severe and profound levels of ID can also benefit from such interventions

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Corresponding author

Maysa Venturoso Gongora Buckeridge Serra.
Universidade de Franca, Departamento de Promoção de Saúde, Franca, SP, Brazil.
E-mail: ma_buckeridge@hotmail.com.

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