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Original Article

The contributions of game therapy concerning motor performance of individual with cerebral palsy[1]

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Abstract: Objective: In this study, it was analyzed the use of the videogame console Nintendo Wii™ as a motor (re) habilitation tool for individuals with Cerebral Palsy. Method: This is a field study with an exploratory and quantitative nature, in which is presented a case study. The participant's motor skills were assessed and reassessed using the standardized protocol GMFM-88 (Gross Motor Function Measure - 88). It were performed 10 game therapy sessions using the videogame "Aladdin Magic Racer" through February and March 2013. Results: The participant achieved a percentage increase of 10.06% in the total score of GMFM in the reassessment compared to the one achieved in the initial assessment. Thus, the data analysis showed that the participant's motor performance changed after the intervention using the Nintendo Wii™. Conclusion: Game therapy might be used as a motor (re)habilitation method for individuals with Cerebral Palsy, as well as Nintendo Wii™ might be a component of a (re)habilitation program for this population, focusing on gross motor function.

Keywords: *Cerebral Palsy, Rehabilitation, Technology.*

As contribuições da gameterapia no desempenho motor de indivíduo com paralisia cerebral

Resumo: Objetivo: O estudo tem como objetivo analisar a utilização do Nintendo® Wii como recurso de (re) habilitação motora para indivíduos com paralisia cerebral (PC). Método: Esta é uma pesquisa de campo de caráter exploratório e quantitativo, na qual foi utilizado um estudo de caso. O sujeito foi avaliado e reavaliado quanto às habilidades motoras por meio do protocolo padronizado GMFM-88 (*Gross Motor Function Measure-88*) e foram realizadas dez sessões de gameterapia com o jogo *Aladdin Magic Racer* no período de fevereiro a março de 2013. Resultados: O sujeito obteve aumento percentual de 10,06% no escore total da GMFM na reavaliação em relação ao obtido na avaliação inicial. Portanto, a análise dos dados denota uma mudança no desempenho motor do sujeito após a intervenção utilizando Nintendo® Wii. Conclusão: A gameterapia pode ser utilizada como um método de (re)habilitação motora para indivíduos com PC, bem como o Nintendo® Wii pode ser componente de um programa de (re)habilitação voltado a esse público, com foco na função motora grossa.

Palavras-chave: *Paralisia Cerebral, Reabilitação, Tecnologia.*

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1 Introduction

The motor development consists of qualitative and quantitative changes in the motor actions of the human being over time, due to the interaction between the demands of the task, the maturational aspects of the individual and the environmental conditions. These changes enable the daily activities in movement patterns that are characterized by the progression of diversification and complexity (GALLAHUE; OZMUN; GOODWAY, 2013; MASCARENHAS, 2008; SANTOS; DANTAS; OLIVEIRA, 2004).

In childhood, this process encompasses acquiring a diversified spectrum of motor skills that allow the child a broad mastery of his body in static and dynamic postures, moving around the environment in different ways and manipulating several objects and instruments (SANTOS; DANTAS; OLIVEIRA, 2004).

However, neurological disorders, such as cerebral palsy (CP), may negatively impact motor development and, consequently, functional performance, that is the performance of individuals in the motor, cognitive, social, and other functions.

CP is described as a group of movement and posture disorders with diverse etiologies and conditions, causing limitations in the exploration of the environment due to non-progressive central nervous system (CNS) injury in the early stages of child development (OZU; GALVÃO, 2005; ROSENBAUM et al., 2007; SANTOS; DANTAS; OLIVEIRA, 2004).

The injury causes different levels of motor deficits, compromising the child's development and ability to actively explore and learn in the environment, because they cause chronic functional limitations, leading to difficulties in daily activities (KOTT; HELD, 2003; MASCARENHAS, 2008; OZU; GALVÃO, 2005).

In this sense, the voluntary movement of the child, which is typically complex, coordinated and varied, becomes uncoordinated, stereotyped and limited due to the low selective control of the activity of the muscular groups (DIAS et al., 2010; KOTT; HELD, 2003; ROSENBAUM et al., 2007).

Thus, when compared to individuals with typical development, the person with CP develops at a slower rate. It is noteworthy that regardless of the cognitive level, individuals with CP reach their motor levels later and many of the fundamental motor patterns that should emerge at certain stages of development may be absent (GALLAHUE, 2003; MADEIRA; CARVALHO, 2009).

In this context, considering the changes presented and the difficulty in maintaining postures, it is fundamental for the individual with CP to be included in habilitation and rehabilitation programs enabling their participation in relevant contexts (MONTEIRO et al., 2010).

Therapeutic programs based on the promotion of motor learning have the potential to enable both the process of recovery of lost skills (rehabilitation) and the development of new skills (habilitation). Therefore, these two processes will be grouped under the (re) habilitation term.

Thus, it is highlighted that one way of minimizing the limitations coming from the CP is the promotion of new experiences to the individual, enabled by the use of technological resources. The use of video games is a progressive trend in the (re) habilitation of individuals with CP (OLIVEIRA, 2010; MONTEIRO et al., 2011).

Video games emerged in the late 1970s and are considered a virtual reality (VR) modality since they allow the individual to visualize virtual environments, manipulate the existing elements in the scenario and move within the space. The scenarios are fully computer-generated and, by transporting the virtual elements to the real world, promote opportunities for unique interactions (CORRÊA et al., 2011).

For Batista et al. (2012), video games can be used in (re) habilitation of physical and/or cognitive disabilities, aiming at the promotion of a motivating environment for the recovery or development of perceptual motor abilities and skills.

In this sense, this VR modality is characterized as a form of physical, cognitive or psychological intervention based on the use of games and virtual environments to enable functionality to individuals with different disabilities (CORRÊA et al., 2011).

In this perspective, the Nintendo Wii stands out, whose differential element is the Wii Remote or Wiimote (wireless remote control), which is connected to the console via Bluetooth and it has three accelerometers responsible for interpreting the three-dimensional movements in the x, y and z axes. This control captures and reproduces the movement performed by the individual on the game screen (CORRÊA et al., 2011; SAPOSNIK et al., 2010).

In this way, when moving the control, the movements of the player are captured and transmitted by a sensor bar, triangulating and inferring position

and alignment. Thus, the physical movements of the user are reflected in the projection, in a way that the virtual movements are similar to those of the material plane (CORRÊA et al., 2011).

Therefore, the Nintendo Wii is easy to apply, promoting stimulation of the sensorimotor and cognitive systems, as well as offering a high degree of motivation during the treatment (BATISTA et al., 2012).

In this perspective, this resource can be used in the context of the treatment of physical disabilities and neuromotordisorders (including CP), since the feedback provided by the screen generates a positive reinforcement, facilitating the training and improvement of motor tasks (CORRÊA et al., 2011; SAPOSNIK et al., 2010).

Also, there are studies indicating that this is a very promising area, both for practical use and for conducting research that indicate the efficacy of VR in improving the functionality of people with different disabilities (CORRÊA et al., 2011; SAPOSNIK et al., 2010). There is scientific evidence supporting the use of video game consoles, along with conventional treatment, as therapeutic resources in (re) habilitation of individuals with CP (SEGALA; OLIVEIRA; BRAZ, 2014).

In a study developed by Monteiro et al. (2011), the Nintendo Wii bowling game was used with a group of five children with CP to check the potential of the task of promoting motor learning. The analysis of the data indicates that learning occurred, considering the improvement in the performance of the scores obtained - the number of collapsed pins - pre- and post-intervention. In this study, participants had motor skills compatible with levels II and III of the Gross Motor Function Classification System (GMFCS).

In another study by Tavares et al. (2013) with two children with CP evaluated by the GMFM-88 and the Pediatric Balance Scale (PBS), Nintendo Wii Fit was used in 20 sessions, and there were increases observed in the total scores of GMFM and PBS. This result indicated the efficacy of the resource in improving gross motor function and in the balance of children with CP with mild impairment, that is, with motor skills compatible with levels I and II of GMFCS.

Besides these studies, there are other studies addressing the use of Nintendo Wii in children and adolescents with CP, aiming at improving upper and lower limb motor function, balance, postural control and activities of daily living (SILVA et al., 2011; SILVA; IWABE-MARCHESE, 2015; TARAKCI et al., 2013; WINKELS et al., 2013).

Thus, it is verified that the use of the Nintendo Wii as a motor (re) habilitation resource for individuals with CP is supported by the scientific literature, as well as the theoretical bases related to VR and results of practical research with this group of individuals based on this resource. However, there is still a shortage of national studies and, specifically, in the Occupational Therapy area.

In this study, the method using video games for therapeutic resources is called game therapy. Thus, based on the aforementioned literature and the need for new studies, this research aims to analyze the use of game therapy as a motor (re) habilitation method for individuals with CP.

2 Method

2.1 Ethical aspects

The study was submitted to the Ethics in Research Committee (CEP) involving human beings at the Para State University in April 2014. It was approved in June of that year, issuing the Certificate of Presentation for Ethical Appreciation (CAAE) Number 30678214.2.0000.5174 and Opinion Number 673965.

2.2 Characterization of the study

This is an exploratory and quantitative field research, in which a case study was used.

2.3 Environment

The research was carried out at theCenter of Assistive Technology and Accessibility Development (Nedeta) of the Biological Sciences and Health Center (CCBS) of the Para State University (UEPA).

In this institution, Occupational Therapy students and professionals elaborate therapeutic programs based on the functional and occupational deficits specific to each patient, identified by means of standardized and non-standardized assessment instruments. It is noteworthy that most patients of this service have severe neuromotor disorders, mainly CP.

This study specifically addresses a therapeutic program based on the principles of game therapy, focused on improving motor skills.

2.4 Participant

In order to protect the identity of the study participant, his name was replaced by the alias "Yoshi". He is athetoid type CP, male, 12 years old, attending the fourth year of Elementary School in a regular educational institution and regularly attending Nedeta. Yoshi is also assisted by other professionals in the areas of Occupational Therapy, Physical Therapy and Speech Therapy.

The motor function of the participant is characterized by slow, smooth involuntary movements and athetotic upper limb movements. He also has deficits of global and fine motor coordination, with the presence of dyssynergia of opposing muscle groups, affecting the execution of movements such as flexion, extension, pronation, and supination of upper limbs.

It is emphasized that the participant walks independently, despite the deficit of dynamic balance. He also establishes social interaction independently through nonverbal language, since he cannot communicate verbally.

Yoshi was classified as level I for gross motor function according to GMFCS - R&E (revised and expanded) criteria for the age group between 12 and 18 years old. This classification is due to the fact that Yoshi performs independent walking in different contexts (home, school, Nedeta) and participates in several daily activities without needing ancillary devices for mobility, differentiating him from a subject in level II of GMFCS.

2.5 Instruments and materials

2.5.1 Gross Motor Function Measure-88 (GMFM-88)

The GMFM or gross motor function measure is a clinical instrument for evaluating the gross motor function of people with CP. It has two versions that differ by the number of items: the original, GMFM-88, and the most recent, GMFM-66 (RUSSEL et al., 2011).

This instrument was validated for using it in the Brazilian context and it covers a spectrum of activities corresponding to the abilities of a 5-year-old child without any motor impairment, involving lying down and rolling; sitting; crawling and kneeling; standing, and walking, running and jumping (NUNES, 2008).

The application requires the child to demonstrate the different skills indicated in the guidelines and it includes a 4-point scoring system: 0: not achieved; 1: starting; 2: partially; 3: totally. In GMFM-88, the scoring consists of the sum of the scores of the different items to obtain a raw or percentage score in each of the five dimensions, as well as target areas and the total score (RUSSEL et al., 2011).

2.5.2 Gross Motor Function Classification System (GMFCS)

The GMFCS or gross motor function classification system is a five-level system used to classify gross motor function in people with CP. It is reliable to be used in Brazil by health professionals with different levels of experience (PALISANO et al., 2007; SILVA, 2013).

In general, the distinction between levels is as follows: I: walking without limitations; II: walking with limitations; III: walking using a manual mobility device; IV: limited mobility, which may be motorized mobility; V: carried in a manual wheelchair (PALISANO et al., 2007).

The expanded and revised version of the system can be used with children and adolescents up to 18 years old, so there are descriptions of specific functional abilities and limitations for the following age groups: less than 2 years old (considering corrected age), between 2 and 4 years old, between 4 and 6 years old, between 6 and 12 years old and between 12 and 18 years old (PALISANO et al., 2007).

2.6 Stages of research

2.6.1 Subject selection

The inclusion criteria of the research were: individuals with a diagnosis of CP, between 10 and 18 years old; motor functions of levels I to III in the GMFCS, since in the levels IV and V the subjects may present deficits in trunk and neck control, which may interfere with the maintenance of visual-motor coordination during the execution of the task; establishing effective communication with researchers; not presenting cardiorespiratory diseases; regular attendance to Nedeta; agreeing to the informed assentform; legal guardians must accept the clauses proposed in the informed consent form.

On the other hand, subjects who presented other pathology, diagnosed intellectual disability, and with low assiduity to the Nedeta were excluded. In addition, people that could not establish effective communication with the researchers, with the motor function above level III in the GMFCS, who presented cardiorespiratory diseases and that had seizures were excluded.

The research participant was selected based on a non-random sampling technique, in which the subject met the inclusion criteria, showed availability of time compatible with the researchers´ time and showed interest in the use of the console as a (re) habilitation method.

2.6.2 Pre-intervention evaluation

Initially, the subject was assessed for motor skills using the GMFM-88 standardized protocol.

This instrument has been the most appropriate quantitative assessment to be used for the detection and measurement of changes in gross motor function in subjects with CP. However, it sets up a system to quantify motor function and not to know how the subject performs this function that is, characterizing his level of function without considering the quality of the performance (FERNANDES, 2009).

2.6.3 Interventions

Subsequently, ten sessions of game therapy were performed with the subject, in which Nintendo Wii was used as a therapeutic resource in sessions of approximately 40 minutes, twice a week, from February to March 2013.

The operative research protocol was adapted from the study by Tavares et al. (2013). The number and frequency of the sessions were arbitrarily defined according to the logistics at Nedeta.

The video game Aladdin Magic Racer, which is a racing game in which flying carpets are used as vehicles, was specifically chosenbecause of its unique gameplay mode: bimanual movement of the control without the need to push buttons. In this way, the task is simplified and becomes more accessible to subjects with motor disabilities, since it does not need the manual dexterity to perform the right-left movement using control buttons, usually necessary to command the vehicle in typical racing games.

It is emphasized that, in the game environment, there are four other virtual players and the subject needs to avoid obstacles during the course. Also, there are resources that can give the character more speed during the game.

Based on these variables of the game, it is possible to identify improvement in the performance of the subject according to the parameters “average of time” and “better placement”, since they are directly related to changes in the motor skills of the player underlying the improvement in the abilities to surpass the opponents, avoiding obstacles and using the resources that give it the most speed.

2.6.4 Post-intervention evaluation

At the end of the interventions, the reassessment was performed using GMFM to verify the individual’s performance after occupational therapy intervention using game therapy and to analyze the changes in the pre- and post-intervention scores.

2.6.5 Analysisofresults

The data analysis was done by quantifying the subject’s performance during game therapy sessions and comparing the evaluation and reevaluation GMFM scores, aiming to identify the subject’s motor performance after the intervention.

3 Results and Discussion

3.1 Pre-intervention evaluation

In the initial evaluation with GMFM, the participant had difficulties in all dimensions of the protocol. This can be attributed to athetosis and to gross motor coordination deficit, hindering the performance of motor tasks involving the coordinated action of muscle groups.

Despite this, according to information from the mother, Yoshi is able to be independent in his daily activities, although he needs more time to carry out the tasks, mainly those of bimanual and visual-motor coordinations.

From the motor profile traced by the GMFM, interventions were performed aiming to promote the improvement of the motor function, mainly of upper limbs. The game chosen was Aladdin Magic Racer, as it enables a task requiring integrated upper limb movements and eye-hand coordination to perform the actions required by the game.

3.2 Performance during the intervention

Yoshi's performance during the game therapy sessions is presented in Table 1 and Figure 1, demonstrating that the subject managed to decrease, in a non-linear way, the average time of execution of the task throughout the intervention. This denotes the acquisition phase in the motor learning process, in which the subject progressively develops adaptive patterns of movement, leading to better results in the context of the game.

This process of acquisition of motor learning can be inferred through performance, while the improvement can be observed by increasing consistency, fluency in movement, reduction of execution error and reduction in total movement time to perform the task (MONTEIRO et al., 2011).

As mentioned in the methodology, the parameters "average time" and "best placement" denote the progressive improvement in the subject's ability to play the game more efficiently. These parameters are directly related to the process of acquiring the abilities to surpass the opponents, to avoid obstacles and to use the resources of the game that give it the most speed.

Thus, the decreasing time becomes important as a data that demonstrates the development of motor skill through the practice during the sessions, which influenced at the time and made the task easier to be performed.

The development of these motor patterns occurs through an internal process that produces consistent changes in individual behavior as a result of the interaction, experience, education and/or training with biological processes (MONTEIRO; PASIN, 2011).

Thus, the experience of interaction with the Nintendo Wii mobilized the occurrence of this internal process due to the interaction between the previously measured motor function of Yoshi with the demands of the game, leading to the learning of new patterns of movement. It is highlighted that the lack of linearity regarding the time factor during game performance refers to the notion that motor skill acquisition does not follow a linear pattern.

In this sense, motor development is understood in a dynamic perspective as a discontinuous process in which individual change over time is not necessarily quiet and hierarchical, nor need to involve a shift toward higher levels of complexity and competence in the motor system, since, although by definition, development is a continuous process, is not necessarily linear (GALLAHUE; OZMUN; GOODWAY, 2013).

Table 1. The score in the game *Aladdin Magic Racer*.

	Average time	Best placement
1	02' 23" 29	5º
2	02' 23" 92	4º
3	02' 25" 40	5º
4	02' 25" 08	5º
5	02' 22" 93	5º
6	02' 19" 30	1º
7	02' 24" 01	5º
8	02' 20" 86	4º
9	02' 17" 20	3º
10	02' 17" 66	2º

Caption: Average time in '(minutes),' (seconds), and Tenths.
Source: field research, 2013.

3.3 Post intervention analysis

Although they did not lead the individual to develop complex patterns of movement, the motor tasks performed through the Aladdin Magic Racer

Figure 1. Variation of the average execution time throughout the sessions. Source: field research, 2013.

game enabled the emergence of patterns of gross motor function underlying activities involving coordination of muscle groups (mainly wrist and elbow). These patterns were represented in the sessions by using the wireless controller to perform the tasks of the game.

This statement can be verified by the evaluation performed after the intervention. Table 2 and Figure 2 show the comparison between the scores presented by Yoshi in the pre- and post-intervention GMFM.

These data confirm the perspective that the performance of the Aladdin Magic Racer game over ten sessions enabled the development of motor patterns more adapted to the subject of this study. Regarding this, it was observed that there was an increase in the scores of practically all the dimensions of the protocol, except in D (standing), in which Yoshi obtained the same score.

Therefore, the dimensions A, B, C, and E showed a discrete increase in the individual scores, attributed to the successive practice of coordination of movements to obtain a more adapted pattern of gross motor function. Thus, as presented in Table 2, there was a percentage increase of 10.06% in the total GMFM score between evaluation (77.64%) and reevaluation (87.70%).

Also, there was a percentage increase of 11.76% in the re-evaluation score (94.11%) compared to the score obtained by the subject in the initial evaluation (82.35%) in dimension A, tasks performed in the lying position. This result can be attributed to the improvement in bilateral integration possible by the Nintendo Wii game mode. This ability favors the movement of both limbs to perform tasks that require a change of decubitus, which is a component of this GMFM dimension.

As for dimension B, tasks performed in the sitting position, there was a percentage increase of 1.67% between evaluation (91.66%) and re-evaluation (93.33%), which can be attributed to the performance of the game in the sitting position and the stimulation of the subject regarding the

Table 2. The score in the evaluation of the subject after the intervention.

Dimension	Score pre-intervention (%)	Score post-intervention (%)	Percentage progression (%)
A - Laying and rolling	82.35	94.11	11.76
B - Sitting	91.66	93.33	1.67
C – Crawling and kneeling	85.71	92.85	7.14
D – Standing	74.35	74.35	0
E - Walking, running and jumping	54.16	63.88	9.72
Total	77.64	87.70	10.06

Source: field research, 2013.

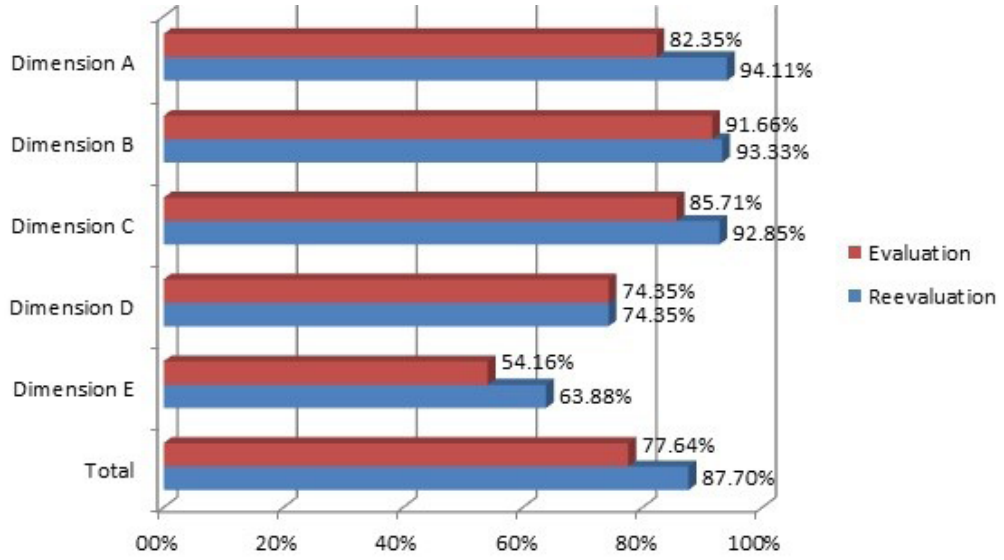

Figure 2. Variation of GMFM scores by dimension. Source: field research, 2013.

maintenance of the posture during the sessions. The improvement in the performance of activities in the sitting position caused a slight progression in the performance of the tasks inherent to this dimension.

In dimension C (tasks performed in the four point position and kneeling), there was a percentage increase of 7.14% between evaluation (85.71%) and re-evaluation (92.85%). This can also be assigned to the improvement of the bilateral integration resulting from the performance of the Aladdin Magic Racer game and mainly resulted in a better performance of the crawling task that requires coordinated movement of the members and composes the scope of tasks of this dimension.

The subject did not have an evolution of the score in the dimension D (standing position), which remained stable in the percentage of 74.35% between evaluation and reevaluation, attributed to the difficulty of the subject to maintain a static position due to the athetosis.

Finally, in the dimension E (tasks performed in dynamic positions, with change of the base of support), there was a percentage increase of 9.72% between evaluation (54.16%) and reevaluation (63.88%), which can be attributed, once again, to the improvement in bilateral integration, enabling the subject to improve the ability to use balance reactions necessary to perform the tasks of that dimension.

Thus, data analysis denotes that there was a change in the motor performance of the subject after the intervention using Nintendo Wii. This is supported by the increase in most GMFM scores, from the simplest tasks in the sitting position to those of more complex character in positions of dynamic change of the support base, such as running and jumping. In this sense, this resource can be used in the context of treatment of physical disabilities and neuromotordisorders (CORRÊA et al., 2011).

4 Conclusion

It is verified that the motor tasks of the video game stimulate the improvement of the gross motor function. Thus, game therapy, specifically through the Aladdin Magic Racer game, can be suggested as a motor (re) habilitation method for CP subjects.

Thus, the Nintendo Wii is a resource that can be part of a (re) habilitation program aimed at this audience, focusing on gross motor function, as it presented satisfactory results, supported by a standardized evaluation protocol.

Also, the development of gross motor function, with video game play, can enable better performance in daily life activities that require coarse motor coordination. In this sense, for example, the subject who improves the coordination of the muscular groups of the shoulder and the elbow, through the sessions of game therapy, can consequently acquire a better performance in writing, feeding, painting, tooth brushing, among other activities, requiring an adequate level of motor coordination to be developed.

5 Limitations

In this research, it was not possible to use an experimental model with a representative number of participants and/or use of a control group, due to factors such as time limitation for the research execution, low attendance of some participants, difficulties in obtaining appropriate places for interventions, among others.

The use of a case study represents a limitation on variables control and external validity, difficult to generalize the results to other CP subjects with motor skill degrees higher than I in GMFCS and/or spastic or ataxic CP. However, this case study was used to present an approach regarding the use of video games as a resource of (re) habilitation by occupational therapists and to provoke the replication and/or modification of the methodology in future research, including the use of control groups.

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Authors´ Contributions

The authors Thiago da Silva Dias and Karoline Faro da Conceição are responsible for the conception, bibliographical research, data collection, analysis, interpretation, and discussion of the results, as well as final essay writing. The authors Rafael LuizMorais da Silva and Ana Irene Alves de Oliveira

carried out the theoretical and methodological orientation of the study and assisted in the analysis and interpretation of the results. All authors approved the final version of the text.

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