Case Report

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Effect of training with non-imersive virtual reality on the performance of the real motor task in the elderly: case reports

Efeito de um treinamento com realidade virtual não imersiva sobre a execução da tarefa motora real em idosos: relato de casos

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ABSTRACT | INTRODUCTION: In the context of rehabilitation in gerontology, the improvement of the ability to perform motor tasks is highlighted to promote autonomy, so it is necessary to investigate tools to achieve this clinical objective. **OBJECTIVE:** To evaluate the effect of training with non-immersive virtual reality on the execution of the real motor task in the elderly. **MATERIALS AND METHOD:** This is a case report, with a single intervention using the Nintendo® Wii, with subjects over 60 years old who underwent intervention with throw training in the game Wii sports resort and evaluated with video angular kinematic analysis with the Kinovea® software before and after the intervention, a protocol consisting of a battery of ten shots before and after the intervention, in addition to the subjective assessment of post-training improvement. **RESULTS:** Four subjects participated in the research, 3 females, with a mean age of 70.7 years ± 7.13 and schooling 8 years ± 6.16. For the angular variables, it was found that, after training with the Wii, in the initial throwing posture, there was an accentuation in the shoulder flexion and a decrease in the elbow for the same movement in the final position. There was a decrease in the elbow extension and an increase in the wrist flexion. It was also verified an increase in the jump and a decrease in the task execution time. **FINAL CONSIDERATIONS:** Given this, it is possible to conclude that the Nintendo® Wii is a potential resource for improving gestures in real life for the elderly.

KEYWORDS: Learning. Aged. Biotechnology.

RESUMO | INTRODUÇÃO: No contexto de reabilitação em gerontologia surge como destaque a melhoria da capacidade de execução de tarefas motoras a fim de promover a autonomia, dessa maneira, é preciso investigar ferramentas para viabilizar esse objetivo clínico. **OBJETIVO:** Avaliar o efeito de um treino com realidade virtual não imersiva sobre a execução da tarefa motora real em idosos. **MATERIAIS E MÉTODO:** Trata-se de um relato de casos, com intervenção única, utilizando o *Nintendo® Wii* com sujeitos de idade superior a 60 anos submetidos à intervenção com treinamento de arremesso no jogo wii sports resort, e avaliados com analise cinemática angular de vídeo com o software Kinovea®, antes e depois da intervenção, protocolo composto por uma bateria de dez arremessos, antes e após a intervenção, além da avaliação subjetiva da melhora pós-treino. **RESULTADOS:** Participaram da pesquisa 4 sujeitos, sendo 3 do sexo feminino, com média de idade 70,7 anos ± 7,13 e escolaridade 8 anos ± 6,16. Para as variáveis angulares verificou-se que, após o treino com *Wii*, houve acentuação na flexão de ombro e decréscimo no cotovelo para na postura inicial do arremesso; já na posição final do arremesso, ocorreu decréscimo na extensão de cotovelo e aumento da flexão de punho. Também foi verificado aumento do salto e diminuição no tempo de execução da tarefa. **CONSIDERAÇÕES FINAIS:** Diante disso é possível concluir que o *Nintendo® Wii* se mostra um recurso potencial para melhoria de gestos no âmbito real para idosos.

PALAVRAS-CHAVE: Aprendizado. Idoso. Biotecnologia.

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Introduction

The increase in the number of elderly people in Brazil and the world has led to a change in paradigms in political, scientific, and social contexts, translating into the development of public policies that help or contribute to improving the quality of life of this age group. Associated with these strategies, great advances in technology for health promotion and rehabilitation of the elderly population also emerged.[1-2] These resources provide support for the most diverse aspects that are involved in the aging process.[3]

From this perspective, in 2005, a virtual reality resource appeared, initially aimed at entertainment. However, which was soon incorporated into rehabilitation programs, the exergame Nintendo® Wii (Foxconn, Taiwan) was used to recover various disorders and different age ranges, including in elderly patients.[4] This feature has sensors capable of capturing movements in three dimensions through a gyroscope located on the control, which uses Bluetooth technology to send the information to a station (the console), with the movements performed by the player, contextualized in virtual reality not immersive, in the various existing games.[4]

The use of Nintendo® Wii as a therapeutic resource has been described in the literature as a possibility in the intervention of various pathologies such as Parkinson's, treatment of motor sequelae resulting from Stroke and balance disorders, being well evidenced as an effective and motivational therapy for the elderly population.[5-7]

Among the discussions about the effectiveness of this new technology in the health area, the question arises about how much training with this virtual reality can interfere with gains applicable in the real environment. Currently, some authors defend the idea that the training of daily motor activities with the Nintendo® Wii would not add significant quality to the movement when in its original context.[8] On the other hand, some studies demonstrate that using this resource can optimize the functional capacity of the elderly.[9,10]

The literature[11] argues that after using virtual reality training, changes in movement biomechanics may appear on the first day of the intervention due to neural adaptations that make up motor learning. This phenomenon is not exclusive to the young population, where some studies[12,13] show that although the elderly suffer neuronal degeneration in the physiological aging process (senescence), the hypothesis of an increase in dendritic arborization is also reported, enabling plastic alterations such as the formation of new motor engrams, in the face of new stimulations from the external environment.

Another important aspect that would also support the effectiveness of virtual training would be the optimal time for the task (Timing). Some studies point to reducing the activity execution time in the real environment after training with virtual reality, both in the elderly and in young people.[14]

Therefore, the relevance of this study is presented as it seeks to reflect on the biomechanical aspects and timing of the task concerning virtual training and its consequences on the motor act in its real context, contributing to the discussion about this resource. Thus, the present study aimed to evaluate training with non-immersive virtual reality on the execution of the real motor task in the elderly.

Methods

Sample

This is a case report carried out with elderly people linked to a fall risk prevention clinic of a Teaching Assistance Unit in the city of Maceió, Alagoas. The study had the protocol approved by the Ethics and Research Committee of Centro Universitário CESMAC under number 1453/2012.

Individuals aged 60 years or over, of both sexes, were included. Those who presented clinical disorders that made it impossible to carry out the functional activities of the protocol used in the research, such as locomotion disorders, uncontrolled hypertensive patients, and those with postural instability, severe and cognitive impairment, which was assessed by the Mine Examination of the Mental State, were excluded.

Due to the specificity of the study, the target population, the physical limitations, and the resources needed for data collection, we chose to work with a non-probabilistic sample for convenience for this research.

The elderly were recruited where the fall risk prevention clinic activities took place.

Procedures

Initially, the researchers explained the study procedures to the elderly and subsequently invited them to participate after signing the Informed Consent Form (FICF).

The Mini-Mental State Examination was used to assess the cognitive function of the sample, it is an instrument widely used in national and international studies, and it was validated in Brazil by Bertolucci et al.[15] It consists of a total score of 30 points and assesses orientation, immediate and recall memory, concentration, calculation, language, and spatial mastery. For the illiterate, the cutoff point of 18 points is considered. For those with schooling between one and four years, the cutoff point of 24 and above four years, 26 points, is adopted. Those with values below the cutoff point are likely to have a cognitive deficit.

After explaining the research procedures and signing the consent form, the elderly were taken to the data collection site, a room specifically reserved for this purpose.

The study was divided into three stages: Initially, all participants answered a questionnaire on socioeconomic and demographic data: gender, age, and education. After the initial data collection, the participants were referred to a multi-sport gym where the functional task chosen for this study was evaluated (basketball throwing). In assessing the task, the elderly person was asked to throw two batteries of 10 repetitions, and only the second was considered.

The elderly were positioned at a distance of 3.83 meters in front of the hoop of the basket, which was 3.74 meters above the ground. The movements performed during the throws were filmed from three angles through three Nikon Coolpix P500 camcorders positioned in front and on the right and left sides. The three cameras were positioned equidistantly at 3.43m from the shooting location. The choice of distance footage was defined due to favoring the analysis of the subjects' movements, as it was only possible to record the subject's entire body with the distance previously reported.

In a second moment, right after the evaluation of the pitches, the elderly were submitted to intervention with the Nintendo® Wii, lasting 20 minutes, through the game Wii Sports Resorts, a basketball sport modality, which virtually simulates the basketball game through pitches reproduced by upper limb movements with the wireless control positioned in the patient's hands.

During training with the Nintendo® Wii, all individuals were placed in front of the television at a distance of 1 meter, with the monitor positioned at eye level, being instructed in a standardized way during the intervention, focusing on the biomechanics of wrist mobility, jumping and extension of upper limbs during the task. At the end of the virtual training, the elderly people repeated the real task (post-test), which was measured following the same methodology as the initial assessment (pre-test).

At the end of the post-test, the participants' perception of improvement in task performance was evaluated using a visual analog scale (VAS), in which the elderly were asked to give a score from zero to ten regarding the improvement in their performance in the shots after training with the Nintendo® Wii, with zero being a note that would represent no improvement and ten, an excellent improvement. In addition, they were asked about which components they perceived improvement.

The kinematic analyses of the movements were carried out through filming using Kinovea® (ARRUDA, Brazil), a video editing program designed to analyze images and videos, allowing video timing and measuring angular movements in cuts and marking points reference.[16]

The reference points for the measurements for each joint used of the dominant limb during the throw were the third metacarpal, ulnar styloid process, olecranon, acromion, and iliac crests.

Statistical analysis

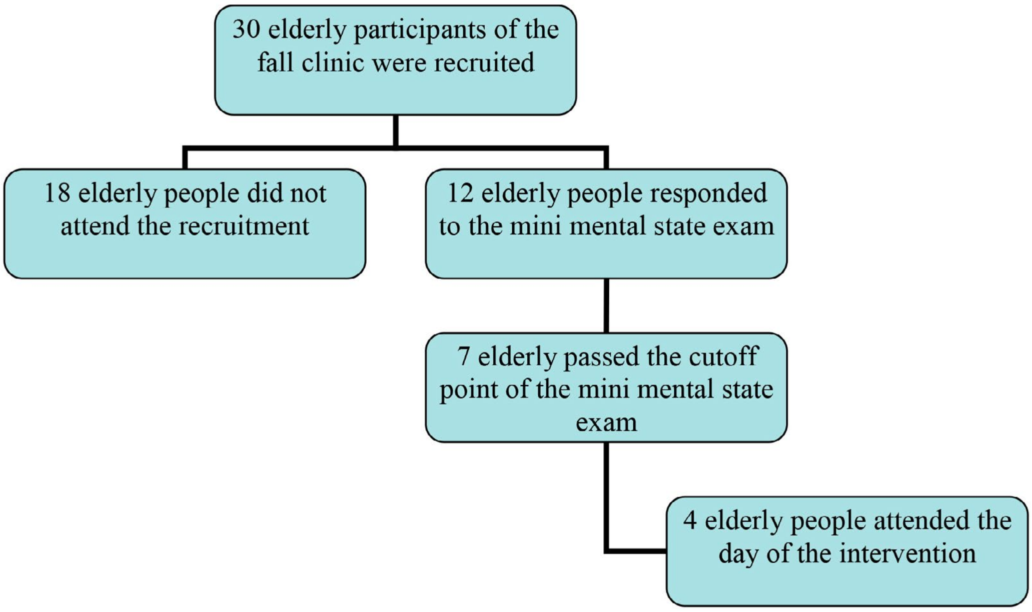
For the presentation of sociodemographic data, descriptive statistics were used in Excel® 2003 software (Microsoft, USA) with mean and standard deviation. In addition, angular movement data obtained through the Kinovea® software in the pre- and post-evaluation were organized in tables for presentation with descriptive statistics without applying inferential statistics due to the sample size.

Outcomes

The study sample consisted of 4 elderly people, 3 female and 1 male. The mean age found was 70.7 years (sd = ± 7.13), with a minimum of 61 and a maximum of 77 years. Most of the subjects evaluated had a high level of education, with an average of 8 years of study (sd = ± 6.16).

In flowchart 1 below, it is possible to understand how the study participants were recruited.

Flowchart 1. Recruitment of study participants



The presentation of the data referring to the biomechanical evaluation of the movement is distributed in four tables. In table 1, it is possible to observe the angular positioning of the shoulder, wrist, and elbow in the initial position of the shot performed in the usual basketball with the ball above the head, comparing before and after the intervention with the Wii resource. For the four elderly individuals, an angular increase in the shoulder and elbow joints was observed after the intervention. In the wrist, there was an increase in three subjects.

Table 1. Comparison of the angle in the initial posture of the throw-in situations before and after intervention in the wrist, elbow, and shoulder joints.

JOINT		ELDERLY 1	ELDERLY 2	ELDERLY 3	ELDERLY 4
WRIST	Pre	132,8	109,7	159,8	127,5
	Post	121,3	116,8	161,7	140,6
ELBOW	Pre	58,4	50,2	57,4	66,8
	Post	69,2	60,7	61,5	77,4
SHOULDEN	Pre	45	43,2	82,3	78,9
	Post	64,3	46,8	88,8	107,2

Source: The authors (2021).

Table 2, similarly, shows the final position of the throw before and after the intervention for the same joints, where there was an angular increase in the wrist and a decrease in the elbow in 3 subjects.

Table 2. Comparison of angle in the final throwing posture in the pre and post-intervention hypotheses in the wrist, elbow, and shoulder joints

JOINT		ELDERLY 1	ELDERLY 2	ELDERLY 3	ELDERLY 4
WRIST	Pre	187,3	184,1	199,5	189,8
	Post	179,6	187,5	209,3	190
ELBOW	Pre	165,8	159,7	149,8	142,8
	Post	159,9	163,6	143,8	126,5
SHOULDER	Pre	108,1	102,9	113,3	107,2
	Post	112,7	110,7	104,4	98,8

Source: The authors (2021).

Also, about the angular variables, table 3 shows the angular deltas of the throwing movement (calculated by subtracting the angulation value in the final joint position from the angulation value in the initial position of the same joint) before and after the intervention. For this variable, lower values were obtained for the elbow and shoulder in three and four subjects, respectively.

Table 3. Comparison of the angular delta in pre- and post-intervention situations in the wrist, elbow, and shoulder joints

JOINT		ELDERLY 1	ELDERLY 2	ELDERLY 3	ELDERLY 4
WRIST	Pre	54,5	74,4	39,7	62,3
	Post	58,3	70,7	47,6	49,4
ELBOW	Pre	107,4	109,5	92,4	76
	Post	90,7	103,3	82,3	49,1
SHOULDER	Pre	63,1	59,7	31	28,3
	Post	48,4	63,9	15,6	8,4

Source: The authors (2021).

Table 4 shows the results regarding the execution time and the jump height of the motor task before and after training on the Nintendo® Wii, where there is a decrease in time and an increase in the jump in all subjects.

Table 4. Comparison of motor task execution time and jump height in pre-and post-intervention situations

		ELDERLY 1	ELDERLY 2	ELDERLY 3	ELDERLY 4
TIME (s)	Pre	24,3	20	21,1	24,9
	Post	22,7	14,6	17,2	17,5
JUMP (cm)	Pre	15,32	5,97	5,97	9,91
	Post	18,73	8,44	7,48	13,82

Source: The authors (2021).

The subjective data regarding the perception of improvement of the participants and the evaluator, described in two categories (yes or no), and the analog scale of perception of improvement and aspects self-reported as an improvement by the study subjects are distributed in table 5.

Table 5. Distribution of data regarding subjective evaluations

Variable	Category	N
Subjective perception of improvement in post-Wii training shot quality (Evaluator)	YES	4
Subjective perception of improvement in post-Wii training shot quality (Evaluator)	YES	4
Analog Scale of Post-Wii Performance Improvement Perception	7	1
	8	1
	10	2
Components that have improved (self-report)	WRIST	1
	JUMP	2
	WRIST AND JUMP	1

Source: The authors (2021).

Discussion

The findings of this study refer to the results of an immediate and unique intervention with Wiirehabilitation in a specific group of elderly people. Despite the small group studied, there was a higher prevalence of females, which agrees with other studies in the area, which indicate women as the group that most seeks alternative prevention concerning aspects related to health and quality of life.[17] Despite this finding, it is important to highlight that this profile is currently undergoing equality between gender.[18]

The high educational level presented can be explained by the nature of the studied group, as these were subjects who were inserted in a primary health care group, in agreement with the findings of Lima-Costa[19] that defend the relationship of high educational level and better care with the health, being represented in the present study by the participation in a prevention program.

No studies were found in the literature with similar methodology, making more direct comparisons impracticable, so the call for further studies in this perspective becomes relevant. However, despite this observation, it is possible to discuss the improvement of the motor task through training in virtual reality based on the motor control theory of Fitts & Posner.[20]

These authors divide motor learning into three phases: cognitive, associative, and autonomous. In the first, there is the beginning of the assimilation of the gesture with the presence of frequent errors, but with noticeable changes in the quality of the movement since the first intervention. In the second, there is the refinement of the motor task in learning, where mistakes are less frequent. In the third and last one, there is the automation of the motor skill with the possibility of performing other tasks simultaneously, but it is worth noting that this can take years to establish itself.[21]

Thus, considering the object of this study to evaluate the influence of immediate virtual training on the improvement in real performance for the same activity, the characterization of the cognitive phase for the present experimental model of this research is clear.[22] Therefore, the probable occurrence of this phase during the intervention with virtual reality provides the transfer of motor control acquired virtually to the real environment.

The improvement in the various variables presented here, after training with the Nintendo® Wii, can be attributed to the direction given in the protocol with intense feedback for the throwing movements, as defended by Wulf et al.[21] Furthermore, likely, plastic changes at the cortical level may already occur through the subject's selective attention, which acts by causing intense cortical activity in the basal ganglia, as approached by Yarrow et al.[22]

A study carried out by Baumeister et al.[8] in Germany at the University of Paderborn, with ten professional golfers, sought to compare the cortical activity in the performance of the putt in the real and virtual environment provided by the Nintendo® Wii, using simultaneous electroencephalographic reading to perform the sports gesture.

However, the results confront the findings of this study, as the authors noticed a difference in cortical activation, concluding that real and virtual activities would not be similar. However, it is worth noting that the subjects of this research were experienced golf players, who already had motor engrams formed, most likely in the third phase of motor learning, which would imply that contact with the Wii would be a new situation; therefore, a new one motor learning process.[8]

It is also worth noting that it is mentioned in the literature[22] that the elderly tend to have great difficulties in going through the third stage of motor learning. Furthermore, it is known that this age group, unlike athletes, does not seek peak performance but rather a level of functional improvement.

In the present study, the findings showed a significant improvement in shoulder angulation in the initial position of the throw, where an increase in flexion of this joint was observed after the intervention. On the other hand, the elbow angles in the initial position of the throw after the intervention were smaller. That can be explained as a consequence of greater shoulder flexion, as if this modification were not performed, the ball would be positioned behind the head, which would end up making it difficult to perform the optimal gestural activity.

It is possible to attribute the improvement in the post-training period to the intervention with the Wii since the chosen game-used elements of basketball free-throw require the execution of wrist movement and shoulder flexion and the maximum number of balls to be thrown. Possible.

In this way, the biomechanical changes that occurred with the intervention of the Nintendo® Wii can be understood as something positive, because as pointed out by Okazaki et al.[23], these can occur for better control and maintenance of the precision of the motor act and to increase its speed, the which is confirmed in the present study, where there was a reduction in the movement execution time after the intervention of virtual reality.

In order to add power to this discussion, the result of the decrease in the angular delta of the shoulder and elbow joints is also evidenced, which end up supporting the consequent decrease in execution time and less angulation in the final position of the elbow after intervention with the virtual reality.

An increase in wrist flexion was also evidenced in the final positioning of the throw after intervention in three of the four subjects. This finding corroborates what has been elucidated above, reinforcing the idea of the effectiveness of virtual training on the improvement of gestural perception in the real context, as it is noteworthy that during the training, intense feedback was offered to the wrist movement, which probably contributed to these results. As Fitts and Posner[20] explain, intense feedback is needed in the cognitive phase of learning to be more effective.

Another variable that also improved in all subjects was the height of the jump, which in turn possibly strengthens the idea of learning as it would not be possible to gain strength by hypertrophic mechanisms in a single session, leaving only neural adaptations such as an increase in the recruitment of motor units, improvement in synergism and muscle reciprocity.[24]

The gestural activity perception variables were positive in terms of improving both by the participants and by the evaluators and the score attributed in the visual analog scale, factors that also reinforce the theoretical references discussed above.

Attention is drawn to the self-report of research participants inherent to the components they perceived improvement after training with the Nintendo® Wii. For example, they reported improvement in wrist movement and jumping at the time of throwing, variables that underwent major changes between the pre and post-test, which refers to a possible improvement in the proprioception of the sporting gesture. In turn, this is seen as an integral part of learning, as its increase refers to greater control of the body, offering greater precision in motor activity, as defended by Paiva et al.[25]

It is possible to find in the scientific literature other reports of the transfer of learning from the virtual reality to the real context; these are the studies on the use of the resource to improve medical techniques in surgical procedures, as in Paiva et al.[25], the latter being a randomized trial in which the possibility of transferring the skill from the virtual to the real context was verified. However, it is worth noting that this training model is based on an immersive form of the medium, differing from the Wii, which is a non-immersive virtual reality resource.

Despite these contributions, the constant expansion of studies with similar perspectives is necessary. As it was shown, it was not possible to carry out direct comparisons due to this scarcity. In addition, the reduced number of participants ended up not providing the formation of a control group and even a larger number of participants in the intervention group, decreasing the degree of scientific evidence of this contribution. Despite that, this research was of great value to kick-start this perspective for the elderly public.

Final considerations

Based on the findings of this research, it is possible to suggest that the use of the Nintendo® Wii as a therapeutic resource to improve the motor gesture generates a decrease in its execution time, which is possible due to the biomechanical changes observed, with a focus on shoulder joints and wrist, in addition to improved jumping.

Author contributions

Rebêlo FL, Carvalho HCL, and Fernandes BP participated in the conception, design, search, and statistical analysis of the research data, interpretation of results, writing of the scientific article. Barbosa JVP, Santos AIB, and Santos RS participated in collecting and interpreting data and the scientific article.

Competing interests

No financial, legal, or political conflicts involving third parties (government, corporations and private foundations, etc.) have been declared for any aspect of the submitted work (including, but not limited to grants and funding, advisory board participation, study design, preparation of the manuscript, statistical analysis, etc.).

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