NEURODIGITAL PROTOCOLS AND PARAMETERS FOR ASSESSING MOTOR SKILLS IN ELDERLY PEOPLE: AN INTEGRATIVE LITERATURE REVIEW

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ABSTRACT

This study aims to investigate neurological protocols used to assess motor skills in older adults, with special emphasis on active digital games or exergames. The integrative literature review was conducted based on automated searches using descriptors by area of interest. The time frames were searched between January 1, 2022, and August 29, 2024, on the Scopus, PubMed, Scielo, and Periódicos Capes platforms, chosen for their relevance in the areas of motor development and control. The search strings were: ("Elderly") AND ("motor skill") AND ("exergames") OR (exergaming) AND ("assessment"). Initially, 109 articles were found by title. After applying the inclusion and exclusion criteria, 31 articles remained, of which 20 had full text available. Next, the titles, abstracts, and full texts were analyzed. During this process, one repeated study, one incomplete study, and one study related to children were excluded, thus 17 articles were selected for final analysis. As a result, exergames show great potential to stimulate and improve health in the elderly, with proven efficacy in most of the studies analyzed. However, their use as an assessment tool has not been explored, highlighting a gap in the literature. There is a need for research that investigates their application for more accurate assessments and comparisons with traditional methods. Exploring this potential can optimize the use of exergames and expand their benefits for this population.

Keywords: Elderly. Motor skills. Exergames. Assessment.

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INTRODUCTION

The aging process is a phenomenon that occurs in all societies. It is dynamic and progressive, manifesting itself through a series of biological, psychological, and social changes. These changes can vary from individual to individual and, in turn, can affect well-being and quality of life in old age. With the increase in the elderly population, it becomes essential to consider aspects such as fullness, wisdom, quality of life, and rebirth for this new phase of life (NAKANO, MACHADO, ABREU, 2019). The authors report that family support, subjective perception of health, and satisfaction with life also play significant roles. According to the Brazilian Institute of Geography and Statistics – IBGE (2021), demographic trends are related to population aging. Recent discoveries have provided important information about the specific changes in motor skills resulting from aging. Research conducted by Johnson et al. (2021) demonstrated that older people tend to have a decrease in walking speed and balance ability, which can increase the risk of falls and injuries. Furthermore, a systematic review conducted by Chen et al. (2020) highlighted that aging is associated with a reduction in precision and coordination of movements.

The decline in motor skills can have a significant impact on the functionality and quality of life of older people. Studies have shown that older people with impaired motor skills have a higher risk of functional disability, dependence, and early mortality (PETERS et al., 2019). In addition, the loss of independence in activities of daily living can lead to a decrease in self-esteem and psychological well-being.

Several factors can contribute to changes in motor skills during the aging process. Sarcopenia, for example, is a common phenomenon in older people, characterized by the loss of muscle mass and strength, which can negatively affect the ability to perform motor tasks (CRUZ-JENTOFT et al., 2019). Furthermore, changes in the central nervous system, such as decreased neural plasticity and deterioration of sensorimotor pathways, also play a significant role in the changes observed in motor skills (SEIDLER et al., 2022).

Seidler et al. (2022) assess that protocols and parameters for assessing motor skills in older adults play a crucial role in identifying functional deficits and designing appropriate therapeutic interventions. With a comprehensive approach and the use of validated protocols and relevant parameters, it is possible to perform an accurate and reliable assessment of motor skills in older adults.

In addition to specific protocols, several parameters are considered in the assessment of motor skills in older adults, including speed, range of motion, coordination, balance, and endurance. These parameters provide detailed information about motor performance and can be used to monitor progression over time (SEIDLER et al., 2022).

Balance testing is crucial in assessing motor skills in older adults, as balance is a fundamental component for performing activities of daily living.

Bravo et al. (2019) highlight that among the balance assessment protocols, the Timed Up and Go (TUG) is widely recognized as one of the most cited tests in the literature when it comes to assessing the risk of falls in older adults while walking. In parallel, the Tinetti balance scale, known as the Tinetti Balance Assessment: Performance Oriented Mobility Assessment (POMA), is also frequently referenced to assess balance. About ten years after the validation of the TUG, the Four Square Step Test (FSST) emerged, a clinical test to assess dynamic balance. This test is notable for its ease of scoring, speed of administration, minimal space requirements, and lack of need for special equipment.

Despite the challenges associated with aging, appropriate interventions can help minimize the decline in motor skills and promote active and healthy aging. Physical exercise programs, balance and coordination training, and multidisciplinary interventions have shown benefits in improving motor skills and reducing the risk of falls in older adults (GILLESPIE et al., 2022). In this sense, the search for themes related to the assessment of motor skills in elderly people, through neurodigital parameters and protocols, is of significant importance, given the growth of this population worldwide. In this context, the objective was to collect articles in which JDAs were used to assess motor skills in elderly people.

The adaptive nature of JDAs allows for the customization of activities according to the needs and individual capacities of older adults, thus improving the accuracy of the assessment. Despite the potential benefits, assessment through JDAs also presents challenges and limitations. For example, issues related to accessibility, familiarity with technology, and adaptation to cognitive abilities can influence the effectiveness and validity of the results (BOLETSIS and McCALLUM, 2020).

For Schneider, Berlese, and Barbosa (2023), active digital games emerge as a beneficial tool for improving motor and cognitive skills. Thus, future research must focus on the development and validation of assessment protocols based on JDAs, which must be sensitive, reliable, and culturally appropriate for this population. In recent years, JDAs have stood out as a promising alternative for stimulating various capacities in older adults, offering an interactive and engaging approach.

Although JDAs appear to be a promising tool for stimulating and rehabilitating motor skills, there are still challenges to be faced. Research is needed to better understand the long-term effects of JDAs, in addition to exploring forms of assessments through JDAS, as well as making interventions accessible and personalized for different populations (MOLINA et al., 2022); thus, it is in this sense that this work is developed. Thus, the present study has

as its research problem the following question: how do neurological methods and protocols, particularly JDAs, stimulate and assess motor skills in older people? This article aims to investigate neurological protocols used in the assessment of motor skills in older people, with special emphasis on active digital games or exergames.

METHODOLOGICAL PROCEDURES

This study is characterized as basic research in terms of its nature and, in terms of the approach to the problem, as qualitative, aiming to locate how many and which are neurological parameters and protocols used to assess motor skills in older people. Regarding the technical procedures, this is an integrative literature review article.

For this integrative literature review, the process of defining the automated search strings was based on the use of descriptors, separated according to their set of interests. The time frames were performed between January 1, 2022, and August 29, 2024, on the Scopus, PubMed, Scielo, and Periódicos Capes platforms. These databases were chosen for their relevance in the areas of motor control. The following strings were established for the search for articles: ("Elderly") AND ("motor skill") AND ("exergames") OR (exergaming) AND ("assessment").

A total of 109 articles were found, with 3 exclusion criteria. After applying the first criterion, which consisted of only Clinical Study, Clinical Trial, Randomized Controlled Trial, and meta-analysis studies, 31 articles were found. As an exclusion criterion, only free full-text articles were selected, thus leaving 20 articles. After reading the titles, abstracts, and full text and excluding one repeated study, one incomplete study, and one related to children, 17 articles remained, which were used for the study. Figure 1 shows the flowchart with the databases found.:

Figure 1: Databases and number of studies found
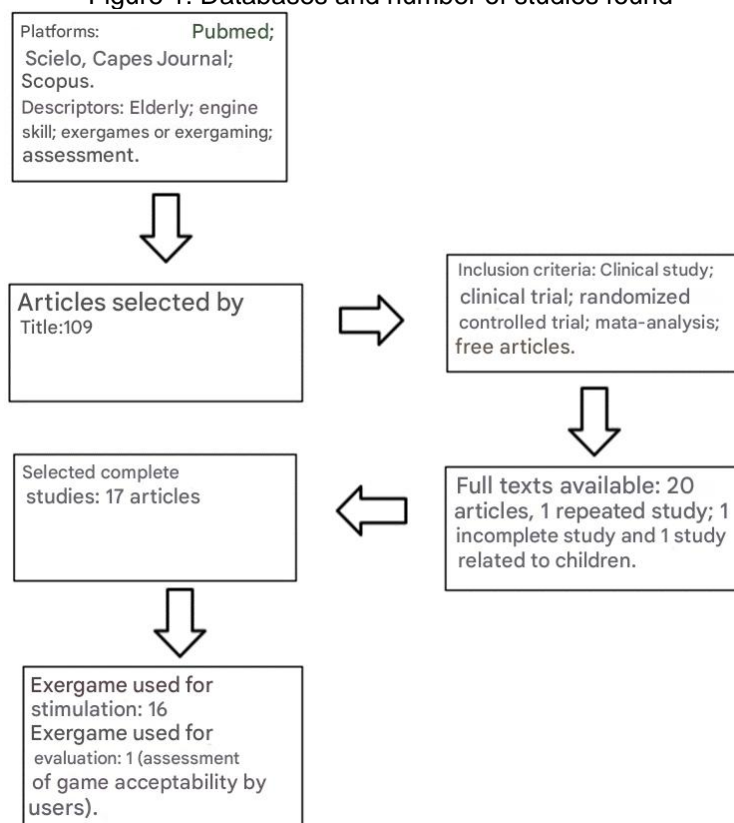
SOURCE AUTHORS.

PRESENTATION AND DISCUSSION OF RESULTS

The results obtained from the Integrative Literature Review will be presented and discussed to identify studies that utilized neurological protocols and parameters to assess motor skills in older adults. The initial analysis focuses on presenting the selected studies, followed by a systematization of the main findings, allowing for a deeper understanding of the approaches and methodologies employed in the reviewed investigations. Table 1 presents the selected studies according to the inclusion and exclusion criteria.

Table 1 – Selected studies considering the study's inclusion and exclusion criteria

AUTHORS / TITLE / YEAR	OBJECTIVES	METHODS AND EXERGAMES USED
Peláez-Vélez, Francisco-Javier, et al. "Use of Virtual Reality and Videogames in the Physiotherapy Treatment of Stroke Patients: A Pilot Randomized Controlled Trial", 2023.	Analyze the effects of combining traditional neurological physiotherapy with a VR program in the treatment of post-stroke patients.	Pilot Randomized Controlled Trial with immersive virtual reality simulation using Quest goggles.
Turoń-Skrzypińska, Agnieszka, et al. "Impact of virtual reality exercises on anxiety and depression in hemodialysis", 2023.	Assess the relationship between virtual reality physical activity and symptoms of anxiety and depression in hemodialysis patients.	Meta-analysis. Exergame used for stimulation: prototype of the NefroVR system.

MacIntyre, Erin et al. "Get Your Head in the Game: A Replicated Single-Case Experimental Design Evaluating the Effect of a Novel Virtual Reality Intervention in People With Chronic Low Back Pain", 2023.	Evaluate the effects of a gamified VR-graded activity intervention in individuals with chronic low back pain, using both commercially available and customized VR programs.	Experimental study. Exergames used for stimulation: Three exergames were used in the intervention: HoloBall, HoloDance, and RoBow Agent.
Campo-Prieto, Pablo, et al. "Feasibility and Effects of an Immersive Virtual Reality Exergame Program on Physical Functions in Institutionalized Older Adults: A Randomized Clinical Trial", 2022.	Assess the satisfaction of using IVR-based exercises among older adults.	Randomized clinical trial. Exergame used for stimulation: immersive virtual reality (IVR) TheBlue: Steam VR Home.
Tuan, Sheng-Hui, et al. "Assessing the Clinical Effectiveness of an Exergame-Based Exercise Training Program Using Ring Fit Adventure to Prevent and Postpone Frailty and Sarcopenia Among Older Adults in Rural Long-Term Care Facilities: Randomized Controlled Trial", 2024.	Evaluate the effectiveness of an exergame program administered via RFA in improving muscle mass and functional performance in older adults in LTCFs.	Randomized clinical trial. Exergame used for stimulation: exergame – RFA.
Fluet, Gerard, et al. "The influence of scaffolding on intrinsic motivation and autonomous adherence to a game-based, sparsely supervised home rehabilitation program for people with upper extremity hemiparesis due to stroke. A randomized controlled trial", 2024.	Examine motivation, adherence, and motor function improvement in two groups undergoing an upper-limb home rehabilitation program.	Randomized clinical trial. Exergame used for stimulation: Home Virtual Rehabilitation System (HoVRS).
Wu S, Ji H, Won J, Jo E, Kim Y, Park J. "The Effects of Exergaming on Executive and Physical Functions in Older Adults With Dementia: Randomized Controlled Trial", 2023.	Investigate the effects of exergames on executive and physical functions in older adults with dementia compared to regular aerobic exercises.	Randomized Controlled Trials using the game *Alchemist's Treasure*, a racing game based on *Talesrunner IP*, co-developed with *ExerHeart*.
Seinsche, Julia, et al. "A Newly Developed Exergame-Based Telerehabilitation System for Older Adults: Usability and Technology Acceptance Study", 2023.	Evaluate the usability, acceptance, engagement, and safety of the modified COCARE system for older adults and healthcare providers, identifying facilitators and barriers to its home implementation.	Mixed methods, including qualitative (think-aloud) and quantitative (EEQ, SUS, and UTAUT) analyses of system perceptions and home implementation barriers. Exergame used: Dividat Senso Flex.
Nuic, Dijana, et al. "Home-based exergaming to treat gait and balance disorders in patients with Parkinson's disease: A phase II randomized controlled trial", 2024.	Evaluate the effectiveness of a personalized exergaming system for patients with PD and gait or balance disorders resistant to dopamine treatment.	Phase II randomized controlled trial using RGB-D Kinect® motion sensor and the exergame Toap Run for stimulation.
Hajebrahimi, Farzin, et al. "Clinical evaluation and resting state fMRI analysis of virtual reality-based training in Parkinson's disease through a randomized controlled trial", 2022.	Investigate the therapeutic effects of VR-based exergaming on motor and cognitive symptoms of PD and its influence on neuroplasticity.	Randomized controlled trial. Exergame used for stimulation: NW Fit Plus games.
Tiba, Alexandru, et al. "T-RAC: Study protocol of a randomized clinical trial for assessing the acceptability and preliminary efficacy of adding an exergame-augmented dynamic imagery intervention to the behavioral activation treatment of depression", 2023.	Assess the acceptability and preliminary efficacy of adding an exergame to behavioral activation treatment for depression.	Randomized controlled trial. Exergames used for stimulation: (Xbox Kinect™).

Zhang, Bingyu, et al. "Study protocol on the efficacy of exergames-acceptance and commitment therapy program for the treatment of major depressive disorder: comparison with acceptance and commitment therapy alone and treatment-as-usual in a multicenter randomized controlled trial", 2024.	Assess the effectiveness of the e-ACT program with exergames in reducing depressive symptoms in patients with MDD, comparing it to ACT and control (TAU) at three points: pre-intervention, post-intervention (8 weeks), and 24 weeks later.	Multicenter randomized controlled trial. Exergame used for stimulation: e-ACT training program.
Van Santen, Joeke, et al. "Cost-effectiveness of exergaming compared to regular day-care activities in dementia: Results of a randomized controlled trial in The Netherlands", 2022.	Evaluate the cost-effectiveness of exergaming versus regular day-care activities for people with dementia and their informal caregivers.	Randomized clinical trial. Exergame used for stimulation: e-Health 'Exergaming'.
Huber, S K et al. "PEMOCS: Evaluating the effects of a concept-guided, Personalized, Motor-Cognitive exergame training on cognitive functions and gait in chronic Stroke-study protocol for a randomized controlled trial", 2024.	Evaluate the effect of a personalized motor-cognitive exergame on cognitive and motor functions in chronic stroke survivors.	Randomized controlled trial. Exergame used for stimulation: Dividat Senso (Dividat AG).
Sonbahar-Ulu, Hazal, et al. "Active video gaming in primary ciliary dyskinesia: a randomized controlled trial", 2022.	Investigate the effects of active video games (AVGs) on lung function, muscle strength, exercise capacity, muscle oxygenation, physical activity, ADL, and quality of life in PCD.	Randomized clinical trial. Exergame used for stimulation: Xbox-Kinect-360.
Skrzatek, Anna, et al. "Brain modulation after exergaming training in advanced forms of Parkinson's disease: a randomized controlled study", 2024.	Investigate the effects of a home-based exergame training protocol on brain volume and resting-state functional connectivity (rs-FC) in people with PD.	A randomized controlled study using a customized full-body movement exergame with an RGB-D Kinect® motion sensor.
Kircher, Eva, et al. "A Game-Based Approach to Lower Blood Pressure? Comparing Acute Hemodynamic Responses to Endurance Exercise and Exergaming: A Randomized Crossover Trial", 2022.	Determine whether an exergaming session in an innovative fitness game can be as effective as moderate endurance exercise in improving blood pressure.	Randomized crossover trial. Exergame used for stimulation: ExerCube.

Source: prepared by the author (2024).

RESULTS AND DISCUSSION

When systematizing the data from the 17 articles identified in this systematic review, it was observed that, in 16 of them, the authors used exergames as a simulation tool, while only one study applied exergames as an evaluation method. Of the articles analyzed, three investigated patients who had suffered a stroke, two focused on patients with dementia, three explored individuals with anxiety disorders and depression, three evaluated functional capacity, two examined the quality of life of participants, and one study each was dedicated to Parkinson's conditions, rehabilitation, blood pressure control, and neuroplasticity. It is worth noting that, in the 16 studies that used exergames for stimulation purposes, the evaluations of the results were carried out through traditional protocols, such as cognitive function tests and physical capacity assessments, demonstrating the predominance of the use of exergames for therapeutic and rehabilitation purposes. Only one study stood out for using exergames specifically as an evaluation tool. Below is a summary of the articles

selected for this study. The study by Peláez-Vélez et al. (2023) investigates the use of virtual reality (VR) as a non-invasive therapeutic tool that creates immersive three-dimensional environments through varied sensory stimuli. VR allows users to interact and navigate in a convincing virtual space, recreating experiences close to reality. The authors explain that, during the use of VR, mirror neurons are activated, which generates motor responses similar to real actions, promoting physical improvements. Although VR is considered promising as a complement to traditional treatments, the authors emphasize the need for further studies to prove its effectiveness. Based on these concepts, the authors conducted a pilot clinical trial with 26 patients in an outpatient clinic in Murcia, Spain, who had undergone rehabilitation after a stroke. The study combined traditional neurological physiotherapy with VR stimulation, using Quest glasses to generate an immersive virtual environment. The results suggest that the integration of VR with traditional physiotherapy can be an effective strategy in the motor recovery of patients, standing out as a promising approach for the rehabilitation of individuals who have suffered a stroke (PELÁEZ-VÉLEZ et al., 2023). In this sense, Turoń et al. (2023) highlight that virtual reality (VR) offers the opportunity to modify the environment and isolate the user from visual and auditory stimuli that may negatively affect their mood. VR programs are widely used in the treatment of balance, coordination, and mobility disorders in neurological diseases. However, there are few studies on its use in the rehabilitation of patients with chronic kidney disease. In the study with 85 hemodialysis patients, the authors applied VR exercises with the NefroVR prototype, observing a significant reduction in anxiety and depression. They recommend encouraging this practice and exploring its use in other therapies for kidney patients. According to MacIntyre et al. (2023), virtual reality (VR) is an increasingly accessible technology that can improve adherence to exercise programs through gamification. Using VR to make exercise more enjoyable and motivating can, in turn, improve clinical outcomes. In this sense, the authors concluded that the VR-graded activity intervention led to a significant reduction in pain intensity (effect estimate = −1.0, standard error = 0.27, P < 0.001), with four participants showing a pain reduction greater than 30%, considered a minimal important change. The intervention also had a significant effect on pain catastrophizing, although it showed no impact on measures of pain-related fear or anxiety. These findings provide preliminary support for the efficacy of a VR-graded activity program in reducing pain in people with chronic low back pain (CLBP).

Campo-Prieto et al. (2022) emphasize that physical activity plays a crucial role in active aging, being one of the fundamental pillars for maintaining health and functionality in

older people. However, adherence to physical exercise programs among this population has historically been low, which represents a significant challenge for promoting healthy aging.

In this context, immersive virtual reality (IVR) emerges as an innovative and attractive solution for physical training, particularly given the increase in the elderly population, characterized by frailty, comorbidities, and disabilities that affect quality of life and increase social and health costs. The study conducted by Campo-Prieto et al. (2022) demonstrated that IVR is a valuable tool reliable and effective for implementing personalized exercise programs, promoting improvements in physical function, and contributing to healthier and more active aging.

The intervention using exergames combined with physical resistance exercises (RFA) demonstrated significant improvements in muscle mass, strength, and functional performance among older adults in rural long-term care facilities (LTCFs), offering a new approach to address frailty and sarcopenia (TUAN et al., 2024). For the authors, exergames overcome the limitations of repetitive and monotonous physical exercises by providing attractive and multisensory game environments with an immersive experience in which interaction occurs through full-body movements. The gamified approach and immersive scenarios encourage older individuals to commit more to exercise and rehabilitation. Thus, the use of exergames not only reduces the time required by the team for intervention but also motivates patients to perform higher-intensity movements and increases their motivation for physical activity (TUAN et al., 2024).

Fluet et al. (2024) point out that game mechanics, which influence the flow, presentation of information, and feedback on success or failure, affect the frequency of use, playing time, and continuity of players. These mechanisms provide feelings of self-efficacy and progressive challenge, which is linked to motivation, and reinforced by clear feedback. Despite this, the study concluded that increasing challenges did not improve adherence compared to difficulty control. However, both treatments resulted in significant improvements in motor and cognitive function and daily activities.

In the study conducted by Wu et al. (2023), the effects of exergames, specifically the Alchemist's Treasure game, were investigated on the executive functions and physical condition of 24 elderly individuals with moderate dementia, comparing them with regular aerobic exercise. The authors define executive functions as a set of essential cognitive abilities, responsible for the execution of complex tasks and the suppression of interference, classified into two levels. The first level, called core, encompasses inhibition, working memory, and cognitive flexibility. The second, higher level, encompasses planning and problem-solving skills, both strongly associated with the frontal lobes.

Executive dysfunction, frequently observed in cases of dementia, significantly compromises independence in daily activities, aggravating the loss of autonomy. Although previous evidence suggests that exergames can improve executive function and reduce the risk of falls in elderly individuals with preserved cognition, the specific impacts of this intervention in elderly individuals with dementia, as well as the neural responses associated with executive function, are still little explored areas. However, the authors conclude that exergaming can be an effective intervention for this population, offering improvements in both cognitive functions and physical capabilities of elderly people with dementia (WU et al., 2023). In this sense, Seinsche et al. (2023) highlight the significant growth in the development of health technologies, with ICTs emerging as fundamental tools for the telerehabilitation of elderly people and other patients. Telerehabilitation involves the provision of rehabilitation services remotely, using technologies for remote training and management. Although exergames such as the Nintendo Wii and Xbox Kinect are widely used, they were not specifically designed for elderly people, which may limit their effectiveness in this group. The study carried out with the Dividat Senso Flex exergame evaluated the usability, acceptance, and safety of the COCARE system among 45 elderly people and 15 health professionals, concluding that the system needs to become more user-friendly and effective in improving cognitive and physical functions. The authors suggest future clinical trials to test its feasibility and effectiveness. Similarly, Nuic et al. (2024) evaluated the efficacy of a personalized home exergaming system for patients with Parkinson's disease (PD) who have gait and balance disorders resistant to aromatherapy, through a randomized controlled clinical trial. The study involved 50 patients with refractory disorders, using the Toap Run exergame. The authors concluded that home training with personalized exercises can be safe and effective in improving these symptoms. They highlight that gait and balance disorders are common in PD and often become resistant to conventional treatments, resulting in episodes of freezing of gait (FOG), falls, worsening quality of life, and increased healthcare costs. In addition, the authors mention that previous trials suggest that the combination of exergaming with home-based physical activity, complemented by remote training, can potentially mitigate motor impairments associated with PD. However, there is still insufficient evidence to definitively recommend the use of home-based exergaming combined with concurrent physical activity to treat gait and balance disorders in advanced stages of PD (NUIC et al., 2024). Hajebrahimi et al. (2022) report that the increase in the number of people living with dementia will result in increasing costs related to the disease worldwide. E-health interventions such as exergaming have the potential to improve the health and quality of life of people with dementia; however, their

cost-effectiveness is still unknown. Furthermore, the authors report that the use of exergaming can improve motor and cognitive functions in patients with Parkinson's disease (PD), especially when combined with traditional therapy. However, studies with larger samples and longer treatments are needed to assess the lasting effects of this approach (HAJEBRAHIMI et al., 2022).

Regarding psychological aspects, major depressive disorder (MDD) is a highly prevalent mental health condition among older adults, resulting in significant impairment in the quality of life of affected individuals. Although several effective treatments are available for the treatment of depression, the actual effectiveness of these treatments has been questioned. According to Tiba et al. (2023), studies indicate that, when research biases are removed, the observed impact of treatments is, in most cases, moderate to small. The same authors concluded, after their study with 110 participants, that exergaming is effective in motor rehabilitation and in reducing depression. Exergaming was well accepted and demonstrated to be feasible, justifying its further investigation in cognitive interventions for individuals with depression (TIBA et al., 2023).

FINAL CONSIDERATIONS

Based on the analysis of the 17 selected articles, it was evident that the use of exergames has significant potential for the stimulation and improvement of various health conditions. In 16 studies reviewed, exergames were predominantly used as stimulation tools, demonstrating their effectiveness in promoting functional and motor improvements in different clinical contexts, such as stroke, dementia, anxiety, depression, and general functional capacity.

However, the application of exergames as an assessment method was limited to only one study. This fact highlights a gap in the literature on the use of exergames for assessment, suggesting the need for further research exploring how these tools can be used to comprehensively and accurately assess the health conditions and progress of older people.

In addition, the studies analyzed indicate that, although exergames are effective for stimulation, there is a lack of evidence on their effectiveness compared to traditional assessment methods.

It is therefore essential that future research focuses not only on evaluating the effectiveness of exergames in different clinical conditions but also on exploring their potential for evaluation to optimize their use and maximize benefits. Combining exergames with other intervention and assessment methods may offer a more comprehensive and

integrated approach to rehabilitation and treatment of various health conditions, especially in older people.

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