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VIRTUAL REALITY IN THE TREATMENT OF ASTHMA PATIENTS: SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Virtual reality provides venues for the use of new methods to perform physical activity in pulmonary rehabilitation programs for asthmatic patients. Virtual reality (VR) here is understood as the practice of recreational activities, entertainment, and interactivity associated with standardized physical activity. **Objective:** The objective of this work is to evaluate the quality of the existent evidence in the literature in order to support the treatment of asthmatic patients through Virtual Reality on asthmatic children and teenager's rehabilitation, compared with the standard treatment. **Data sources and study selection:** Search, selection and analysis (starting March 2016) of all the original articles on virtual reality concerning asthmatic children and adolescents (ages 3 to 18), published up to October 2017, in Portuguese, English and Spanish, at the electronic databases Pubmed, Web of Science, MedlLine and LILACS, obtained by using the descriptors: asthma, video game, virtual reality, pulmonary rehabilitation, physical training. **Results:** Only seven original articles were obtained. Of these, six (85%) presented level of evidence A, one (15%) presented level of evidence B and no article presented level of evidence C. All authors point out the treatment of asthma from VR as a safe and innovative therapy considering that the motivation and intensity of treatment from the use of VR improves the self-management capacity and aerobic capacity of asthmatic patients. **Conclusion:** The present study seeks to contribute to the literature by demonstrating that VR can be used to improve knowledge capacity and self-management skills in addition to physical fitness and clinical control in asthmatic children.

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INTRODUCTION

Asthma is a chronic disease of the lower airways characterized by usually reversible airflow obstruction, inflammation, and hyperreactivity to various types of stimuli, manifested by episodes of wheezing, shortness of breath, chest tightness, and cough, having a higher incidence at night or soon after waking up. Asthma is one of the most common chronic respiratory diseases among children and adults, with an incidence of 300 million people worldwide [1]. Asthmatics experience increased airflow resistance, especially expiratory resistance, pulmonary hyperinflation, leading to mechanical changes in thoracoabdominal dynamics and inspiratory muscle impairment.

Increased breathing energy expenditure combined with the possible deterioration of respiratory muscles (acute hyperinflation, steroid myopathy, and malnutrition) puts asthmatic patients at risk for respiratory muscle fatigue. This weakness of the respiratory muscles increases morbidity and mortality and may be a factor of doubt in the general clinical assessment of respiratory performance [2]. The use of pulmonary rehabilitation programs for the treatment of asthmatic patients has been a breakthrough in the past three decades. The inclusion of physical exercises in the life of these patients seeks to reduce the need for hospitalization and readmission for the disease in the Brazilian Unified Health System (SUS) [3]. Although the use of Virtual Reality (VR) is recent in our lives and especially in a rehabilitation program, it

has already shown great potential for the area, being considered effective and safe, due to the easy access to technology and the interest of children and adolescents in this new method [3].

MATERIAL AND METHODS

In March 2016, the search for original scientific articles in the Pubmed, MedLine, Web of Science and LILACS electronic databases was started, and the keywords used were: Video Game, Virtual Reality, Virtual Rehabilitation, always associating with the word Asthma. The articles generated by the search were initially selected through the information contained in their titles and abstracts. The methodological quality assessment included all existing studies that met the inclusion criteria: population aged 3 to 18 years; controlled asthma; partially controlled and uncontrolled; use of rehabilitation programs that included the use of VR in the Spanish, English and Portuguese languages. The selected articles respected the classification of the evidence levels that were made by the GRADE system and have been published in all languages since the search led to a limited number of studies. For the evaluation of the methodological quality of the articles found, it was decided to use the GRADE System of qualification of scientific evidence, which is a clear and explicit system, which takes into account the study design, its execution, consistency and linear direction in the evaluation of the evidence quality for each important outcome / consequence. According to the GRADE system, the quality of the evidence is classified according to the levels: high, moderate, low and very low. Some organizations when using GRADE combine the low and very low categories.

Quality of GRADE evidence by the American College of Chest Physicians/ACCP 2012:

- High (A): Consistent, with evidence in randomized controlled trials or meta-analyses, without major limitations or with exceptionally strong evidence from observational studies. Further research is unlikely to change confidence in the estimated effects;
- Moderate (B): Evidence of randomized controlled trials with important limitations (inconsistent results, methodological flaws, inaccuracy, indirect results). Additional research is likely to impact confidence in the estimate of the effect and may change this estimate;
- Low (C): Evidence of at least one important outcome from observational studies, case series, or randomized controlled trials with severe failures or indirect evidence. Additional research is likely to have a significant impact on the confidence of the effect estimate and is likely to change the estimate;
- Very Low (D): Any effect estimate is uncertain.

The judicious evaluation of the quality of the evidence was performed by two reviewers independently, with no disagreement between them, and the final result is presented in Table 1.

RESULTS

At the end of the search process, seven articles were found (described in the following tables). These were repeated between the databases.

Table 1. Main Features of the Studies

AUTHOR	[4]
DELIMITATION	Randomized clinical trial with random distribution.
SAMPLE	54 children with moderate and severe asthma randomly assigned to two groups.
INTERVENTION	Both groups were seen approximately six times during one year of the study. The control group (n = 29) played routine computer games. The experimental group (n = 25) performed the asthma command.
RESULTS	Compared with children in the control group, experimental subjects showed improved knowledge of asthma (P <0.001), behavior related to asthma management (P <0.008), and a tendency to reduce acute asthma visits (P <0.13). Children in the experimental group also had higher results in assessing asthma management-related behaviors that were specifically addressed by the intervention provided by the Asthma Command (P <0.01). Differences between the control and experimental groups showed an improvement in the experimental group in 21 (84%) of the 25 outcome variables in the study (P = 0.004, Sign test).
CONCLUSION	The study indicates that asthma-specific computer gaming can significantly affect knowledge and behavior and may affect morbidity in childhood asthma.
AUTHOR	[5]
DELIMITATION	Randomized Controlled Clinical Trial.
SAMPLE	137 children aged between 3 and 12 years old with a medical diagnosis of asthma, randomly assigned into two groups.
INTERVENTION	An interactive educational computer program, asthma control, designed to teach children about asthma and its management. Using a graphical display of a child going through simulated daily events, the game emphasizes: 1) monitoring; 2) identification of allergens; 3) use of medicines; 4) use of health services; and 5) maintenance of normal activity. Control group participants reviewed printed educational materials with a research assistant.
RESULTS	Both intervention and control groups showed substantial improvement in all outcomes during the 12-month follow-up period. In addition to improving knowledge, after using the computer program, no differences between the two groups in primary or secondary outcome measures were demonstrated. Children reported satisfaction with the program use.
CONCLUSION	This test of an educational software program found that it produced no greater improvement than revised traditional written materials. Because both groups showed substantial improvement over baseline, computer-based education
AUTHOR	[6]
DELIMITATION	Randomized Clinical Trial.
SAMPLE	101 children with a medical diagnosis of asthma, divided into two groups, in individuals from seven to 12 years old.
INTERVENTION	A Computer-Assisted Instructional (CAI) that focused on reducing environmental irritants/allergens and the correct use of prescription drugs to prevent asthma symptoms was used with 101 children (56 in the intervention group and 45 in the control group). The primary outcome assessed a change in childhood asthma symptoms as measured by responses to nine symptom questions in the Juniper Pediatric Asthma Quality of Life Questionnaire (PAQOL) and measures of lung function.
RESULTS	There were no significant changes in asthma symptoms between the two groups before and after the intervention. There were no significant changes in PAQOL scores for activities, emotions and total PAQOL score, lung function measurements, and asthma severity between the two groups. Knowledge about asthma in both groups was high before the intervention, but there were no significant changes between groups after the intervention.
CONCLUSION	Findings indicate that this IAC game was not effective in improving asthma symptoms in this group of children.

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AUTHOR	[7]
DELIMITATION	Randomized Clinical Trial.
SAMPLE	119 children aged 5 to 12 with a medical diagnosis of moderate to severe asthma.
INTERVENTION	Patients were assessed for clinical and quality of life outcomes at weeks 8, 32, and 52 of the study.
RESULTS	Compared to controls, the intervention group showed significant improvements in physical domain (P .04 and P .01 at 32 and 52 weeks, respectively) and social activity domain (P .02 and P .05 at 32 and 52 weeks, respectively) of asthma quality of life in the Child Health Survey for Asthma and Child (P .02 at 8 weeks) and parent (P .04 and .004 at 32 and 52 weeks, respectively) with self-management knowledge.
CONCLUSION	A multicomponent educational, behavioral and medical intervention targeting high-risk children and asthma infants can improve knowledge and quality of life.
AUTHOR	[8]
DELIMITATION	Randomized Controlled Clinical Trial.
SAMPLE	87 children with a medical diagnosis of asthma, divided into three groups, two experimental and one control.
INTERVENTION	This randomized control study was based on a pretest and two posttest assessments of childhood asthma knowledge comparing the results of control and intervention room examinations.
RESULTS	After the intervention, both intervention classes had higher mean scores than the average control room scores, one class being more clearly different from the other (sum of p = 0.20 and 0.0009, respectively). Neither the inclusion of a 30-minute asthma conversation nor longer playing times (6-hour average versus 12-hour average) had a significant impact on pretest-posttest scores in the two intervention classrooms. Combining the two intervention classes, post-test 1 scores in the intervention classes were significantly higher than the control room score (sum of p = 0.008).
CONCLUSION	Using the game improved asthma awareness in intervention classes. Children in the active participation classroom gained significantly more knowledge about asthma during the observation period compared to the non-computer-playing classroom. The knowledge gained was maintained over a four week period and the addition of physician-led discussions seemed to add little to the knowledge gained.
AUTHOR	[9]
DELIMITATION	Prospective pretest-posttest study with randomly allocated intervention.
SAMPLE	171 children with a medical diagnosis of asthma were evaluated before and after the intervention.
INTERVENTION	Subjects aged between 6 to 17 years old were recruited from four pediatric practices and randomly assigned to the computer intervention condition or to the usual care comparison. The main character of the game could match the subject in gender and ethnicity. The protagonist's asthma characteristics were adapted to be like those of the subject. The guys played the computer game as part of their regular asthma visits. The time between pre and posttest ranged from 4 to 15.6 months (mean, 7.6 months).
RESULTS	Covariance analysis, with pretest score, age and severity of asthma as covariates, found that the intervention was associated with fewer hospitalizations, better symptom outcomes, increased functional status, better knowledge of asthma management, and better self-management behavior. infant those in the condition of intervention.
CONCLUSION	This suggests that video game or computer gaming has had an impact on asthma knowledge and control, as well as decreasing the number of hospitalizations. However, the game was too complex for less able children.
AUTHOR	[10]
DELIMITATION	Single-blinded Randomized Controlled Trial.
SAMPLE	36 children with moderate to severe asthma were randomly allocated to the video game group and a control group.
INTERVENTION	Both groups completed a nine-week supervised program with two 40-minute weekly sessions. Pre-training and post-training assessments involved the Asthma Control Questionnaire, Expired Nitroxide Levels (FeNO), Maximum Exercise Test (Bruceprotocol), and Lung Function.
RESULTS	No differences were found between VGG and TG at baseline. Improvements occurred in both groups regarding asthma control and exercise capacity. Later, a significant reduction in FeNO was found in VGG ($p < 0.05$). Although the average energy expenditure at rest and during physical training was similar for both groups, the maximum energy expenditure was higher in VGG.
CONCLUSION	The present finding strongly suggests that aerobic training promoted by an active videogame had a positive impact on children with clinically controlled asthma problems, improved exercise capacity and reduced inflammation.

Table 2. GRADE System for evidence quality.

AUTHOR	HIGH	MODERATE	LOW	VERY LOW
[4]	X			
[5]	X			
[6]	X			
[7]	X			
[8]	X			
[9]		X		
[10]	X			

DISCUSSION

Asthma is a chronic inflammatory airway disease in which many cells and cell elements play a role. Chronic inflammation is associated with airway hyperresponsiveness, which leads to recurrent episodes of wheezing, dyspnoea, chest oppression, and cough, particularly at night or early in the morning. These episodes are a consequence of generalized and variable intrapulmonary airflow obstruction that is spontaneously reversible or treated [1]. Treatment should aim at increasing respiratory muscle strength and increasing respiratory muscle resistance to fatigue [2].

However, the training of respiratory and skeletal muscles is sensitive to physical training and with proper exercise they can improve their strength and endurance [11]. Pulmonary Rehabilitation Programs have been a successful alternative in asthma control when there is the inclusion of multidisciplinary work where all participating professionals set goals and objectives for the maintenance and control of the disease from intervention to training [11]. Video games and computer games are one of the most popular pastimes among children in middle- and high-income countries. Studies have been done to investigate its potential benefits for our health and education. The use of VR in the treatment of asthmatic patients for self-management or disease training has been widely used in recent

years [12]. As a medium that crosses gender, socioeconomic and cultural boundaries, video games are considered an ideal way to get children interested and to meet their own medical needs. Asthma, as one of the most common chronic diseases among children, has been the focus of many video games and computers in recent years. In the scenario of increasing physical inactivity and current physical inactivity [13-15], culture and lifestyle are considered strategic in the prevention and health promotion. Currently, there are technologies for digital games that use VR environments that, in addition to broadening some of our sensory systems, contribute to maintaining the individual's fitness and enable the rehabilitation of patients with heart, lung and neuromuscular diseases. These digital games can assure users an unconventional, intuitive, physically active and essentially playful way. Thus, the use of this technology can help combat a sedentary lifestyle, providing a paradigm shift in the interaction of young people with virtual environments and incorporate specific techniques for cognitive and functional rehabilitation [16]. The major change in the physical activity paradigm can be made through a digital platform and sensors that accompany body movement, games that challenge physical and mental capabilities, providing the patient with efficient exercise (Figure 1).

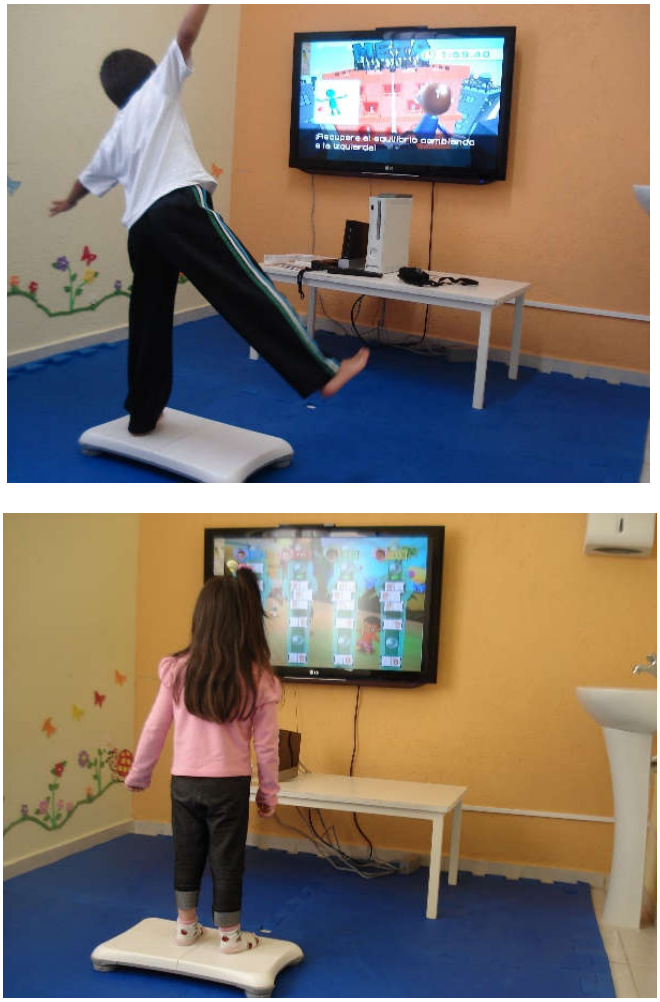

Figure 1. Virtual Reality Demonstration [15].

The first clinical investigation of an educational videogame for children with asthma was conducted in 1986 [6]. Rubin et al. [4] evaluated the results by relating a video game or computer game to asthma in 54 children ages between 7 and 12 years old with a medical diagnosis of asthma randomly assigned to two groups. Researchers reported that children playing video games showed a better understanding of the disease and how to manage it. The study showed that a standardized educational intervention in the form of a video game or computer can affect knowledge and behavior related to asthma management. The findings suggest that exposure of children with moderate and severe asthma to an asthma-specific computer game may affect the subsequent management of their chronic disease. Comparison of differences between control and experiment groups (Signal Test) revealed a greater improvement in the experimental group in 84% of the outcome variables in this study. Changes in behaviors related to asthma management were significantly related to computer game participation. Homer et al. [5] used a video game or computer game, but a more modern and updated version that had a goal to be achieved in the shortest possible time, with the same objectives as the previous version. The study was conducted with 137 children aged three to 12 years with a medical diagnosis of asthma, randomly divided into two groups. The study shows that substantial reductions occurred in the emergency department and outpatient visits. Parents in both groups also reported improvements in child behavior and the use of maximum flow meters. The experiment group had significantly better results than those who received the standard education program, showing greater knowledge about the disease.

Huss et al. [6] evaluated the effectiveness of a video game or computer game for treating and controlling asthma patients. A research was conducted with 148 children aged 7 to 12 years with a medical diagnosis of asthma, randomly divided into experimental group and control group. This study sought not only to find improvement in knowledge and treatment of asthma, but significant changes in the physiology of the disease such as pulmonary function (FEV1, PEFR, and their predicted mean values) [6]. This study shows that a video game or computer game did not significantly improve children's asthma symptoms compared to those who used a control program. In addition, the results indicate that there were no improvements in quality of life parameters or pulmonary function measured by FEV1 (Expiratory Volume in the First Minute) or PEF (Peak Expiratory Flow). Shames et al. [7] met previous research using a video game or computer to improve self-awareness and management of asthma in 119 children aged five to 12 years with a medical diagnosis of asthma. Following the pattern of the articles presented, the sample was divided into two groups. Although the intervention achieved statistically significant improvements in asthma knowledge and quality of life, no statistically significant reductions in asthma morbidity measures were observed. Most trends, however, were in one direction favoring the intervention group, with small effect sizes. We did not find consistently defined subgroups that more or less responded to the intervention. The intervention was significantly more effective in reducing symptoms compared to controls among children who reported a recent history of more wheezing episodes and lower onset bronchodilator reversibility (higher severity), but also those who reported recent history of fewer attacks. asthma and less urgent baseline care visits (decreased severity). Yawn et al. [8] conducted a before-and-after survey of 87 children from three fourth grade elementary grades, aged six to twelve years old. Intervention groups had a clear impact on the test results of asthma-related questions. Within each intervention class, there was an increase in scores between pretest and posttest one, with a

mean increase in each (Wilcoxon p-value = 0.001 and 0.002, respectively). In the control class, no evidence suggested any change in scores between pretest and posttest (sum of score = 0.53). After the intervention, both intervention classes had higher mean scores than the average control room scores, one class being more clearly different from the other (sum of p = 0.20 and 0.0009, respectively). Bartholomew et al. [9] in their study of 133 children, aged between 6 and 17 years old with a clinical diagnosis of asthma, evaluated the use of a video game or a computer game. The results of the study indicate that there was an increased knowledge of how to administer asthma for older children and those who scored higher on the pretest, suggesting that video game or computer gaming was too complex for some children. The impact of the program promoted improved knowledge and control of asthma.

Gomes et al. [10] conducted a randomized clinical study using the video game, but in a very different context from the other authors. Using VR, a study was conducted with 36 children with a clinical diagnosis of asthma who were divided into two groups. The difference of this study is in the form of assessment. When all other studies evaluate education and knowledge in asthma, this paper aims to practice physical exercise through the use of video games compared to standard rehabilitation. This study evaluated the following items: exercise capacity; pulmonary inflammation; pulmonary function and body composition.

After training, significant improvement in asthma control was found for both groups ($p < 0.05$). However, only the children in the VGG (Video Game Group) presented Hay induction ($p < 0.05$) ($p < 0.05$). Heart rate (HR) shows heart response during training sessions and both are different for training groups. However, the percentage of approximate HR produced during the training session was significantly higher in the VideoGame Group (VGG) compared to the Treadmill Group (TG) (90.5% versus 65.2%, respectively, $p < 0.01$). Both groups were exposed to an improvement in maximal aerobic capacity after training ($p < 0.05$; Table 3), however, the effect was greater on TG (1.6) when compared to VGG (0.7). Similar results were observed for other variables during the maximal exercise test, such as exercise duration, speed, and distance. Regarding cardiovascular variables, the VGG reached a percentage according to the maximum expected HR, the TG evaluation in the post-training, and both groups showed a significant decrease in the increase of the double maximum product. The previous study clearly demonstrated that exercise training using an active videogame system was effective, promoting clinical control and aerobic fitness and causing inflammation in children with moderate and severe asthma. In addition, energy expenditure during video game training was higher than aerobic training in the field. Thus, active video games seem to be an interesting exercise for asthmatic children and are probably more attractive to the pediatric population. The main goal of asthma treatment is to achieve and maintain good clinical control. Current results support the use of aerobic training combined with medication to achieve these values and are in line with data reported in previous studies on improved clinical control through increased aerobic capacity. There are few published articles (seven) on the use of VR in the treatment of asthma in children and adolescents; however, most of them are randomized controlled trials, which increases the quality of the study. Most of the studies presented aim to use VR for asthma treatment, with the purpose of education and disease control, and only one article brought rehabilitation as its main purpose. All authors point to the treatment of asthma from VR as a safe and innovative therapy since the motivation and intensity of treatment from the use of VR improve the self-management capacity and aerobic capacity of asthmatic patients. Using VR requires little physical space, is easy to handle and has a huge acceptance. I believe that soon many other studies will be done through VR aiming at physical training and many other valences, as well as the use of VR for the treatment of asthma and other pathologies will be effective.

Conclusions

The present study contributed to the literature by demonstrating that VR can be used to improve knowledge and self-management, as well as physical fitness and clinical control in asthmatic children. An analysis of the existing evidence was made in order to support a treatment and rehabilitation program for asthmatic children and adolescents through VR. After a thorough search, only seven articles met the inclusion criteria. Thus, it is clear that further research in this area is needed to introduce new technologies and new forms of treatment for asthma, especially in environments such as hospitals.

Data availability statement: Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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