






The effectiveness of the use of video games and software-based programs for asthma education and self-management for children and teenagers

A eficácia do uso de videogames e programas baseados em software na educação e autogestão em asma para crianças e adolescentes

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Abstract

Introduction: Asthma is a chronic disease of the lower airways characterized by usually reversible airflow obstruction, inflammation, and hyperreactivity to various types of stimuli. It is one of the most common chronic respiratory diseases among children and adults, with an incidence of 300 million people worldwide. **Objective:** To evaluate the quality of the existent evidence in the literature in order to support the use of videogames and software-based programs on asthmatic children and teenager's knowledge capacity and self-management compared with standard education. **Methods:** Search, selection and analysis (starting March 2016) of all the original articles on virtual reality (VR) 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, MedLine and LILACS, obtained by using the descriptors: asthma, video game, virtual reality, pulmonary rehabilitation, physical training. **Results:** Only six original articles were obtained. Of these, five (80%) presented level of evidence A, and one (20%) presented level of evidence B. 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 videogames and other software-based systems can be used to improve knowledge capacity and self-management skills in children and teenagers with asthma diagnosis.

Keywords: Asthma. Children. Pulmonary rehabilitation. Systematic review. Videogame.

Resumo

Introdução: A asma é uma doença crônica das vias aéreas inferiores, caracterizada por obstrução ao fluxo aéreo geralmente reversível, inflamação e hiper-reatividade a vários tipos de estímulos. É uma das doenças respiratórias crônicas mais comuns entre crianças e adultos, com incidência de 300 milhões de pessoas em todo o mundo. **Objetivo:** Avaliar a qualidade das evidências existentes na literatura a fim de apoiar o uso de videogames e programas baseados em software na capacidade de conhecimento e autogestão de crianças e adolescentes asmáticos em comparação com a educação padrão. **Métodos:** Pesquisa, seleção e análise (a partir de março de 2016) de todos os artigos originais sobre realidade virtual (RV) utilizada com crianças e adolescentes asmáticos (idades de 3 a 18), publicados até outubro de 2017, em português, inglês e espanhol, nas bases de dados eletrônicas Pubmed, Web of Science, MedLine e LILACS, obtidas por meio dos descritores: asma, videogame, realidade virtual, reabilitação pulmonar, treinamento físico. **Resultados:** Apenas seis artigos originais foram obtidos. Destes, cinco (80%) apresentaram nível de evidência A e um (20%) apresentou nível de evidência B. Todos os autores apontam o tratamento da asma por RV como uma terapia segura e inovadora, considerando que a motivação e intensidade do tratamento com o uso da RV melhora a capacidade de autogerenciamento e capacidade aeróbia do paciente asmático. **Conclusão:** O presente estudo busca contribuir com a literatura ao demonstrar que videogames e outros sistemas baseados em software podem ser utilizados para melhorar a capacidade de conhecimento e autogerenciamento de crianças e adolescentes com diagnóstico de asma.

Palavras-chave: Asma. Crianças. Reabilitação pulmonar. Revisão sistemática. Videogame.

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

Although the use of video games and other software-based programs 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

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; uncontrolled, partially controlled and controlled asthma; use of rehabilitation programs that included the use of video games 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 evidenced 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 the 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 and 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, dyspnea, 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.⁴ Education and self-management have been a successful alternative in asthma control, especially 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 education to training.⁴

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 video games or software-based applications in the treatment of asthmatic patients for self-management or disease training has been widely used in recent years.⁵ At the end of the search process conducted in this research, seven articles were found (Table 1). These were repeated between the databases.

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.

Currently, there are technologies for digital games, that in addition to broadening some of our sensory systems, increase knowledge capacity, contribute to maintaining the individual's awareness and self-management

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).

The first clinical investigation of an educational videogame for children with asthma was conducted in 1986. Rubin et al.⁶ 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.

Table 1 - Main features of the studies

Authors	Rubin et al., 1986 ⁶
Delimitation	Randomized clinical trial with random distribution.
Sample	54 children with moderately 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) played Asthma Command, which was specifically design for this study. The game emphasizes four principles in the management of childhood asthma: the recognition of symptoms and allergens, the appropriate use of medications, the appropriate use of the emergency room and physician's office, and the encouragement of school attendance.
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 a standardized educational intervention, through asthma-specific computer gaming, can significantly affect knowledge and behavior related to the management of asthma.
GRADE	High (A)
Authors	Homer et al., 2000 ⁷
Delimitation	Randomized Controlled Clinical Trial.
Sample	137 children aged between 3 and 12 years old with physician-diagnosed 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. The children were asked to return for three visits to play the game (intervention group) or review an age-appropriate asthma education book and play a noneducational computer game. The study did not specify the duration of each visit, nor the timespan between each visit.
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.
GRADE	High (A)
Authors	Huss et al., 2003 ⁸
Delimitation	Randomized Clinical Trial
Sample	101 children with a medical diagnosis of mild intermittent, mild persistent and moderate/severe persistent asthma, divided into two groups (control and intervention). The individuals ranged from 7 to 12 years old, English speaking, ability to complete questionnaires and perform needed tasks, presence of a telephone in the home or access to a telephone in a neighbor's home. The only exclusion criteria was the presence of chronic illnesses other than asthma that impair lung function. Most participants were non-Hispanic Black with a mean age of 9.6 years.
Intervention	Wee Willie Wheezie was the Computer-Assisted Instructional (CAI) used for the study. It 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. The intervention group received conventional education through written asthma materials and nonasthma-related computer program, and the computer-based instructional asthma game. The control group received only the conventional education. All subjects received an initial home visit, a 6-week reinforcement phone call, and a follow-up home visit at least 12 weeks after the initial visit. The study did not specify the duration of each visit, nor the timespan between each visit.
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 although there were some positive effects of the intervention on children's knowledge of asthma, the CAI game did not have the effects on asthma symptoms and quality of life that was predicted. Also, there were no significant changes in the severity of asthma between pre and posttest periods for the intervention and control groups.
GRADE	High (A)
Authors	Shames et al., 2004 ⁹
Delimitation	Randomized Clinical Trial
Sample	119 children aged 5 to 12, from low-income urban areas, with a medical diagnosis of moderate to severe asthma. More specifically, these were children diagnosed as having asthma at least 6 months before enrollment, had parental reports of significant asthma symptoms at least three times a week, or at least two asthma attacks per week, or daily use of bronchodilator therapy, and had required substantial health care utilization for asthma hospitalization or two acute care or emergency department visits for asthma during the past year.
Intervention	Subjects were randomized to participate in the disease management intervention or to receive their usual care (control group) in a 1:1 assignment. Randomization was performed within four strata defined by sex and age (5-8 years old and 9-12 years old). The subjects were assessed for clinical and quality of life outcomes at weeks 8, 32, and 52 of the study. Children in the intervention group followed a disease management program, which included (1) assignment to an asthma case manager, who delivered a 3-session, standardized curriculum on asthma self-management based on the education goals recommended by the National Heart, Lung, and Blood Institute; (2) a Super Nintendo asthma video game (Bronkie's Asthma Adventure) designed to teach children self-management strategies and provide feedback on their performance; (3) two visits to a boardcertified pediatric allergist/immunologist affiliated with the study (at weeks 2 and 4), including a full history and physical examination, allergen skin testing, and development of an acute and chronic asthma management plan that was provided to the family, the case manager, and the primary care provider; and (4) access to an 18-hour per day toll-free hotline staffed by pediatric nurses who had access to each participant's individualized asthma management plan. Control group subjects received their usual care and the use of a nonviolent Super Nintendo video game. The objective was to determine the effectiveness of an asthma education video game in reducing morbidity among high risk, school-aged children with asthma.
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. Although the intervention achieved statistically significant improvements in asthma knowledge and quality of life, no statistically significant reductions in asthma morbidity measures were observed.
GRADE	High (A)
Authors	Yawn et al., 2000 ¹⁰
Delimitation	Randomized Controlled Clinical Trial
Sample	87 fourth-grade children, 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. In the two intervention classrooms an interactive computer-based game designed specifically as a asthma educational tool was introduced (Air Academy: TM The Quest for Airtopia.) The game presents asthma disease knowledge and management skills, with tools for reinforcement, as it supports motivation for children to better understand the management of the disease. Children in intervention classrooms were allowed to play the game as desired for the last 20 minutes of computer labs held three times each week over a period of six weeks. Children in the control classroom continued with the usual fourth grade health and science education programs that did not include information on asthma. No other education programs dealing with asthma exist in the school health curriculum.
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.
GRADE	High (A)
Authors	Bartholomew et al., 2000 ¹¹
Delimitation	Prospective pretest-posttest study with randomly allocated intervention
Sample	171 children with a medical diagnosis of moderate to severe asthma. They were chosen from four inner-city asthma clinical site. The mean age was 10.9 years (range 7-17). A total of 112 males and 59 females.
Intervention	Subjects aged between 7 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 chosen interactive multimedia application was "Watch, Discover, Think and Act", which was created to help children learn how to manage asthma, develop asthma-specific skills and incorporate self-regulatory processes into asthma management routines. The protagonist's asthma characteristics were adapted to be like those of the subject. The subjects 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 in 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.
GRADE	Moderate (B)

Note: GRADE system for evidence quality, evidenced by the American College of Chest Physicians/ACCP 2012.



Figure 1 - Video game demonstration.¹²

Homer et al.⁷ used a self developed computer game, but a more modern and updated version that had the 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 3 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.⁸ evaluated the effectiveness of a computer game for treating and controlling asthma patients. A research was conducted with 101 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: forced expiratory volume in the first minute (FEV1), peak expiratory flow (PEFR), and their predicted mean values.⁸ This study shows that video or computer games 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 or PEF.

Shames et al.⁹ met previous research using a video game to improve self-awareness and management of asthma in 119 children aged 5 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 asthma attacks and less urgent baseline care visits (decreased severity).

Yawn et al.¹⁰ conducted a before-and-after survey of 87 children from three fourth grade elementary grades, aged 6 to 12 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.,¹¹ in their study of 133 children aged between 6 and 17 years old with a clinical diagnosis of asthma, evaluated the use of 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 computer gaming was too complex for some children. The impact of the program promoted improved knowledge and control of asthma.

There are few published articles (six) that analyzed the effectiveness of video and computer games as education and self-management tools for children and adolescents with asthma; however, most of them are randomized controlled trials, which increases the quality of the study. All of the studies aimed to use video games for asthma management, with the purpose of education and disease control.

Using video games requires little physical space, is easy to handle and has a huge acceptance. We believe that soon many other studies will be done through video games aiming at education, physical training and many other valences, as well as the use of virtual reality for the treatment of asthma and other pathologies will be effective.

Conclusion

The present study contributed to the literature by demonstrating that video games and software-based programs can be used to improve knowledge capacity and self-management, in asthmatic children. An analysis of the existing evidence was made in order to support a treatment and educational program for asthmatic children and adolescents through video games. After a thorough search, only six 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.

Authors' contributions

RMI was the creator of the project, participating in all phases of the article. PJCM and SSMB, professors of the project, participated in all phases of the article.

MMS participated in the analysis of the results, statistics and final review of the project. CTR participated in the analysis of results, statistics and translation and final writing of the article.

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