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Review Article

The Use of Computer Technology and Game Therapy for the Rehabilitation of Individuals with Duchenne Muscular Dystrophy: A Review

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ABSTRACT

The Duchenne Muscular Dystrophy (DMD) is a hereditary disease with progressive symptoms that gradually increase physical limitation and causes a reduction of daily activities. There are different possibilities of rehabilitation for DMD, however the use of new technologies with computers can be considered a promising tool to the future of DMD rehabilitation. Therefore, the aim of this review is to identify studies which utilized computer technology to assist rehabilitation in individuals with DMD. Thus, we conducted a structured search in the PubMed, Virtual Health Library (VHL) and cochrane library databases to identify studies related to the use of computer technologies to assist in the rehabilitation of individuals with DMD. This search revealed 10 studies included a total of 252 DMD and 179 typical development participants, ranging in age from 10 to 34 years. Studies have used only upper limb computer task and showed that the application of non-immersive virtual reality was the most used computer technology. Moreover, most studies used low-cost computer technology and probably facilitated access to DMD individuals in a low-income country. Although we found some positive results, we believe that ten studies represent just a first step in the use of computer technology and new studies should be created to improve knowledge in the area.

Keywords: Duchenne muscular dystrophy; Virtual reality exposure therapy; Task computer; Serious game; Rehabilitation

INTRODUCTION

The Duchenne Muscular Dystrophy (DMD) is a hereditary disease, recessive, caused by a mutation of the dystrophin gene, located on the chromosome Xp21. Dystrophin protein is essential to the muscle performance and the total or near-total loss causes reduction of muscle fibers and incapacity of regeneration. Thus, the individuals with DMD present progressive symptoms and gradually increase with physical limitation that causes a reduction of daily activities [1].

The progression of these limitations develops from the lower to upper body segments and in a proximal to distal direction and progressively results in disuse of musculoskeletal and cardiorespiratory systems, which leads to wheel chair dependency at approximately 10 years of age. Thus, it is important for individuals with DMD to attend rehabilitation programs in order to increasingly delay the motor dysfunctions generated by DMD and provide a better quality of life [2].

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There are different possibilities of rehabilitation for DMD with some positive results considering gait, vibration exercises respiratory muscle training, strength training and aerobic exercise and cardiopulmonary dysfunction. However the use of new technologies with computers is an interesting approach, can be considered a promising tool in treatments and the future for DMD rehabilitation. Computer technology can be used in several populations, with various types of exercises providing multiple stimuli simultaneously (such as motor, sensory, proprioceptive and cognitive) and have the possibility to be complementary to conventional interventions. The possibility to control variables, provide different tasks using modern technology and analysis of patient's performance through visual and auditory feedback, are considerate important characteristic for computer use. Moreover, computer technology can leads to the motivation of the subject and even provide fun practice, especially using competitive tasks, people playing together against the computer, as other participants or even against themselves [3].

Due to the importance of computer technology to rehabilitation we found systematic review for stoke cognitive impairment, alzheimer, spinal cord injury, but we did not find any systematic review on the use of technology in DMD. Therefore, the aim of this review is to systematically identify all studies which utilised computer technology to assist rehabilitation in individuals with DMD [4].

LITERATURE REVIEW

Search strategy

For this review, studies were searched in the databases PubMed, Virtual Health Library (VHL) and cochrane library, throughout the month of May 2020.

The terms used, isolated and combined, in the search were "Duchenne muscular dystrophy" and "Task computer" or "Virtual reality" or "Video games" or "Computer technology" or "Game therapy". To make the searches more comprehensive, the works of interest were searched without restriction of publication dates. In addition, such filters were also used to analyze the references of the papers included at the end of the selection [5].

Inclusion and exclusion criteria for selection of studies

The articles were screened for the following inclusion criteria: Individuals with DMD undergoing virtual reality exposure therapy with task computer, virtual reality, video games, computer technology or game therapy [6].

Thus, the following were not included: Abstracts and expanded abstracts and complete articles that (1) were not data-based (e.g. books, theoretical papers or secondary reviews), (2) were not written in English or Portuguese or Spanish and (3) did not cover both virtual reality exposure therapy and duchenne muscular dystrophy. In case of disagreement, a third author was consulted. Duplicate records and studies were excluded.

Data extraction

The data were extracted from the included studies using a spreadsheet. Data on study design, participants, interventions, games and game technologies, virtual reality, outcome variables and study findings were extracted [7].

Selection of studies

In total, 80 studies were found that listed the keywords used in the literature search. After the first filter, we identified 14 articles which appeared to meet the inclusion criteria. After the second filter, 9 remained in the analysis process. Subsequently, in the third filter (using abstract information), 10 met the eligibility criteria for full text screening (Figure 1) [8].

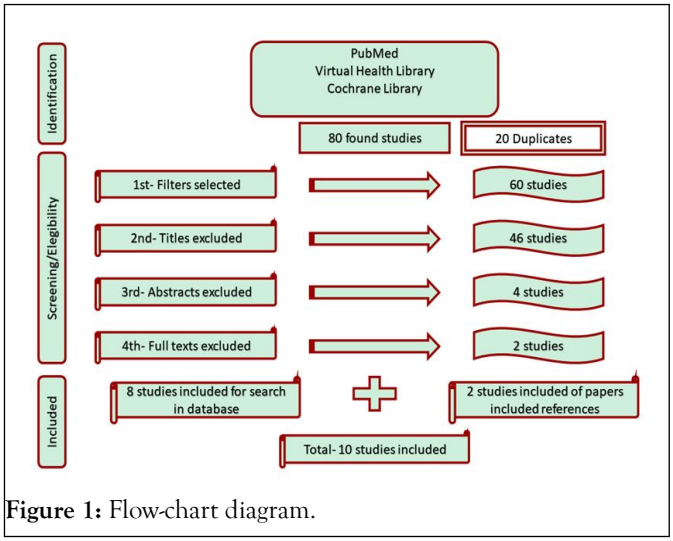

Figure 1: Flow-chart diagram.

DISCUSSION

To the best of our knowledge, this review is the first study to provide a detailed descriptive and updated summary on the use and effectiveness of computer technology to rehabilitation of individuals with DMD. The first interesting result was that all of studies found was used for evaluation or treatment of the upper limb. Individuals with DMD start to lose function earlier on the lower limb, this justify the initial focus on lower limb considering research on gait, lower limb strength, lower limb joint contracture and flexibility. However, individual with DMD usually start using wheelchairs around the age of 10 and the use of computer technologies to provide effective interventions to improve upper limb function are necessary. All the studies found in this review tried to find possibilities using arm and hand task to increase daily activities and participation in society [9].

Analyzing the characteristics of the studies, we found that 5 studies used non-immersive virtual reality exposure task with different device such as mobile phone, webcam and kinect system. VR can be considered a computer technology that provides 3D artificial sensory feedback, whereby the user engages in experiences similar to real-life activities and engagement is an important factor to adherence in rehabilitation.

According to Picorelli, low rates of adherence to rehabilitation programs tend to limit the benefits that can be gained from exercise, a fact that needs to be taken into account by health professionals when designing intervention strategies. More interestingly, the non-immersive VR used in all studies were customized/specialized games, also called "serious games" (*i.e.*, a game developed for specific target), instead of commercial device. Michael Zyda defined "serious games" as a mental contest, played with a computer according to certain rules for amusement, recreation or winning a stake. Commercial games have limitations to be used with disable people, such as the calibration of the game's difficulty, adaptation of the system with phases for people with motor and cognitive difficulty and lack of possibility to control different variables for the rehabilitation team. Probably, those limitations in commercial games were responsible for the lack of studies which have utilized "serious gaming' application as a method to improve DVD individual performance [10].

According to Holm and Priglinger, virtual environments simulate objects found in everyday life, in addition to simulating tasks in which individuals must react as if they were performing real actions but they do not need to use physical contact. Thus, when performing a virtual task without tactile feedback (without physical contact), there may be a difference in performing a similar task in the real environment (with physical contact). Although the studies by Yano, et al. and Spence argue that the use of tactile sensations increases the sensitivity of other stimuli present in the same environment and provides an efficient communication channel. The motor difficulty that's characterized DMD decrease physical touch benefits and the possibility to use adaptative technology provide benefits with virtual task. According to Freitas, et al., people with DMD benefitted from the use of non-immersive virtual technologies as compared to touch interfaces in acquisition and retention of performance during tasks. Contrary to what was expected from authors that non-contact devices would result in worse performance compared to contact device, the results demonstrate that in individuals with difficulty in moving the upper limbs as DMD, there is an improvement in performance when using a virtual reality interface and this result is probably due to the possibility of virtual interface enabled distal muscle functioning and ease of VR instrument adjustment for individuals with DMD. Although some discussion comparing virtual and real intervention and more important, the transfer of performance between intervention, it seems that virtual reality presented benefits and can be considerate a promise intervention for the future [11].

Another interesting result found was the use of computer technology during practice of different type of tasks. This comparison evaluated the first and the last practice moment in DMD and control group in 7 studies and results showed an interesting outcome when VR is utilized for DMD individuals. However, all studies showed DMD performance has always been worse when compared to the Typical Developed (TD) individuals. Mattar and Sobreira studied hand weakness and Nakafuji and Tsuji assessed perceptual motor processes and bilateral transfer in individuals with DMD and age-matched controls and both studies found significant differences between the two groups. Their results suggest that the protocols used for individuals with TD can generate different results from individuals with DMD. Dias, et al., designed the study to determine how different levels of difficulty related to speed and accuracy influence the motor performance of DMD compared with TD individuals and showed that DMD had difficulty performing fast movements without difficulty in accuracy. They propose that increasing the interfaces of technological devices to use smaller and more accurate approaches will allow people with DMD to better engage and higher performance as the disease progresses. The authors also suggest that rehabilitation strategies to increase the distance and speed of movement may prolong and maintain functioning and increase participation in activities of daily living for a longer period in the DMD group. Probably the DMD characteristic such as progressive muscle weakness and fatigue due to deterioration of the myofibril and increased connective tissue (fibrosis) was responsible for the worth performance when compare to TD individuals, but the use of computer technology can be considerate an option to provide task performance improvement [12].

CONCLUSION

Although benefits in using computer technology presented in this review, it is important to emphasize the existing of several limitations. The first limitation is the random sequence generation topic. The randomization of subjects into groups is indicated to provide similar groups as possible with more confinable results and in our review half of the studies were randomized even though only three of them compared DMD with TD. A second limitation was the performance analysis (blinding of participants, researchers and personnel topics). Although blinding applicators and participants is difficult to do in intervention protocols and only Heutinck, et al. had clinical applicators blinding, at least blinding the people who are involved in the statistical analysis should be reported. A third limitation was that nine were cross-sectional studies, these studies evaluated the performance of upper limbs and the works by Oliveira, et al. and Nizamis, et al. also analyzed the software used. A fourth and interesting limitation that we need to report is the homogeneity of the laboratory studies. Seven studies found are from the same study group in a low income country (Sao Paulo-Brazil). Probably, the use of low cost computer technology as presented in those studies can provide access to disable individuals in a low income country. Nevertheless, we believe that ten studies represent just a first step in the use of computer technology and random studies with blind protocol in a longitudinal project seem to be the future to improve those limitations and the knowledge in the area.

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