Physical and Cognitive Therapy Enhancement Using Game-Based Learning

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Abstract Artificial intelligence has been used in the medical field for many years finding its way in assisting medical professionals to solve complex tasks in almost every application domain. Patient care and health care costs are in the forefront of any medical system. With the emergence of electronic games (EG), originally entertaining in nature, potential was seen for their application in the medical field in terms of exploring the capabilities of educating patients in the areas of need. Design of serious games emerged with a focus on helping with the patient’s therapeutic modality. Some of the medical field serious games are part of the daily work of a medical professional. With the development of mobile devices, this type of gaming has also become available to the wider population. The aim of this research was to demonstrate the possibilities and benefits of using EG in the daily clinical work of medical professionals. This work has a descriptive character where a section of the literature is given outlining the increased research interest in using serious games as therapy enhancements. We limited ourselves to research involving patients who need medical treatment or intervention.

Keywords Game-based learning · Medical therapy · AI

1 Introduction

The use of electronic games (EG) began in the 1970s, and was immediately employed in the therapeutic modality of a particular pathology [28]. With the development of...
smart devices, the availability of software has become widespread, and thus the use of it has become more common in all domains. Hence, seeing this potential, the academic community has increasingly begun to create smart EGs that would contribute to the treatment of disease [48]. In the 1990s, the concept of serious games (SG) was developed, which included all software solutions that could support educational and training activities [65]. In the modern world, EG are not a category that is restricted only to children and adolescents, but a category that is also present among the adult population, since demographic data on video gaming indicates that the mean age of video game players is 31 years [44].

In order to improve health outcomes, researchers and game developers must first define the primary goal of the game and the specific research problem they want to address. The target audience, game mechanics, game-play, and marketing strategy will vary based on the goal of the game. This way, “we can measure specific outcomes in many ways, as opposed to measuring many outcomes in limited ways” [33]. Tate et al. also recommend a focussed approach to serious game development [55]. It should be emphasized that the research question posed too narrowly may not produce a measurable effect, so it should be given special attention and use of a multidisciplinary approach.

An increasing body of research is using serious games as distractors for various reasons. They can be cognitive or behavioural distractors. Both have the power to divert a person’s attention from the problematic (painful) procedures to more comfortable and enjoyable activities. Cognitive interventions are more thought and feelings oriented while behavioural interventions are “based on principles of behavioural science for the purpose of changing the children’s behaviour in a fearful situation” [41]. However, regardless of the intervention, the common conclusion is that games must require action and engagement in order to increase the level of distraction, and thus increase the level of tolerance for pain or the like. Additionally, this active distraction also needs to be “fun for children” [41].

Recently, we have been witnesses to an epidemiological crisis throughout the world when COVID-19 becoming a pandemic. In an attempt to reduce the wider spread of this virus, many governments are taking measures which range from social distancing to complete lock down for certain age-groups such as the elderly and minors. Critical services are operating, yet all others are transferring their operations on-line thus reducing daily activities in the open and minimizing further risks of acquiring COVID-19. In this new mode of human existence children with special needs are especially vulnerable. Author in [40] offers “ten tips for helping parents and caregivers of young children” with autism spectrum condition (ASC) half of which are technology-based. Use of serious games is a first suggested technology-based tip for parents and caregivers of young ASC children as they provide a mixture of educational and social cognition aspects which are much needed in times of stress and interrupted routine. At the same time, special attention is recommended as over-using serious games could result in isolation of the child suffering from ASC. Serious games, such as the one presented in [58], are designed as an attempt to raise awareness amongst people by reinforcing measures recommended by the World Health Organization (WHO) when in public places. It is a simple 2D game, pixel-
based top-down style, that educate young users about using masks and hand sanitizers in public as well as keeping a safe distance from others. The game was evaluated on twenty subjects, teenagers and young adults 17–25 years of age, and even though standard factors such as learning outcomes, usability and player experience each score more than 3.5 (on the scale of 5) the authors did not provide any follow-up in terms of psychological study after playing a game. The game depicts concepts such as “Decreasing lifeline of player affected with virus” or “Player infecting other individuals” that could possibly create new issues for children already experiencing emotional, mental and physical changes as teenagers.

Furthermore, the COVID-19 pandemic is creating educational disruptions throughout the world with students of primary, secondary and post-secondary education being affected. Authors in [30] present the Chinese experience when it comes to providing uninterrupted learning mechanisms to the students. It is suggested that motivational factors are very closely connected to interactivity in choosing learning resources. Academic games, of either individual or group type, were rated highly as teaching and learning strategies in an on-line context. Medical students, a subset within the student body, are greatly affected by the COVID-19 outbreak. Employing all the technological advancements for establishing and improving on-line resources for educational continuity and professional training is a present challenge [20] as most of their educators are directly involved in the front lines of fighting the pandemic. Clinical encounters are an invaluable part in the professional training of future doctors. A presently viable way of delivering such services to medical students is by replicating clinicians’ experiences using, for example, serious games amongst other artificial intelligence tools.

In the following chapters, we discuss the implications of SG in Medical Sciences (Chap. 2), the use of Artificial Intelligence applications in therapy (Chap. 3) and existing serious games developed for health purposes (Chap. 4). Finally, implications of using serious games for health and future-direction for research in this area are discussed in Chaps. 5 and 6. A table of all cited papers with approaches used and related fields of health care is given in Fig. 1.

2 Implications of SG in Medical Sciences

In the medical world, information technology is an integral part of the medical care organization. Databases that enable strategies for health system development, clinical decision support systems, expansion to mobile clinical decision support systems are becoming part of the daily practice of physicians. Using SG as part of the electronic gaming industry, found its first application in neuropsychiatry, with the following benefits: (i) improving psychosocial functioning in patients including reducing disfigurement-related distress, (ii) managing stress, (iii) solving self-confidence problems, (iv) assisting in socialization of the individual, and (v) improving the patient’s quality of life [28, 49]. In addition, serious games were employed in stimulating psychoeducation, therapeutic attainment of moods, relaxation, treatment of pain,
| References     | Analytical | Scientific | Data-driven | Temporal approach | Temporal approach (Generative) | Model-based | Model-free | Physiotherapy | Rehabilitation (manual) | Speech-recognition | Classifiers | Control |
|---------------|------------|------------|-------------|-------------------|--------------------------------|-------------|-----------|--------------|--------------------------|----------------------|------------|---------|
| Alliari et al. [11] |            |            |             |                   |                                 |             |           | Osteopathy   |                         |                      |            |         |
| Amberg et al. [2] | x          |            |             |                   |                                 |             |           | Category     |                         |                      |            |         |
| Bajraktaragic et al. [3] |            |            |             |                   |                                 |             |           | Physiotherapy |                         |                      |            |         |
| Beranovski et al. [4] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Buck et al. [5] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Byers et al. [6] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Burke et al. [7] |            |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Chen et al. [8] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Correa et al. [9] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Daley et al. [10] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Dalbeck et al. [11] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| De Freitas et al. [12] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Dithmer et al. [13] | x          | x          | x           |                   |                                 |             |           |             |                          |                      |            |         |
| Ebert et al. [14] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Frey et al. [15] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Gruen et al. [16] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Herriger et al. [17] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Hewson et al. [18] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Hoffmann et al. [19] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Hoffmann et al. [20] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Holmes et al. [21] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Hoppe et al. [22] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Hulihan et al. [23] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Huang et al. [24] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Kamodjerski et al. [25] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Kato et al. [26] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Kesel et al. [27] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Kato et al. [28] | x          | x          | x           |                   |                                 |             |           |             |                          |                      |            |         |
| Lien et al. [29] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Magyar et al. [30] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Mavridis et al. [31] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Massinger et al. [32] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Narici et al. [33] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Nilsson et al. [34] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Ola et al. [35] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Olgun et al. [36] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Peng et al. [37] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Primack et al. [38] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Rajak et al. [39] | x          | x          | x           |                   |                                 |             |           |             |                          |                      |            |         |
| Saran et al. [40] | x          | x          | x           |                   |                                 |             |           |             |                          |                      |            |         |
| Salouci et al. [41] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Salvonius-Patton et al. [42] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Santamaria et al. [43] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |
| Shi et al. [44] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Sirri et al. [45] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Sikk et al. [46] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Sjostrom et al. [47] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Sjostrom et al. [48] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Tark et al. [49] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Thome et al. [50] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Vaisemberg et al. [51] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| V引擎al et al. [52] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Vos et al. [53] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Ward et al. [54] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| White et al. [55] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Veh et al. [56] | x          | x          |             |                   |                                 |             |           |             |                          |                      |            |         |
| Zivota et al. [57] | x          |            |             |                   |                                 |             |           |             |                          |                      |            |         |

Fig. 1  The summary of all cited papers with the used approaches
development of social skills, development of skills to solve a particular problem, process of motivation, as well as in the development of therapist-client interaction [28, 47]. Sajjad et al. have attempted to potentiate the immune response to tumour onset through EG [47]. That also implicated use for SG in the treatment of oncological changes.

Granic et al. stressed that, in addition to the previously exacerbated adverse effects of games, EGs did not create cooperation, support and assistance in behaviour and civic engagement [21]. With regard to EG, brain activity is most commonly monitored by electroencephalography (EEG), and, due to its decreased availability, rarely by functional magnetic resonance imaging or functional near-infra-red spectroscopy [42]. An analysis of the type of stress has sought to determine whether the induction of one type of stress can be used for therapeutic purposes [1]. By stratifying game types, puzzles have been shown to improve concentration, memory, and harmony between the hands and the brain. Runner games affect a person’s mood [1]. Virtual reality with occupational therapy has its benefits in the treatment of multiple sclerosis [60]. Telerehabilitation also has a place in multiple sclerosis therapy [22]. Benefits of using EG have also been found in the treatment of Parkinson’s disease, post-stroke therapy, and in the behavioural aspect, but also in the movements of certain parts of the body [6]. Sin and Lee showed the benefit of using video games on Xbox Kinect in upper extremity function on a sample of 40 patients who had suffered a stroke [51]. Video games have found their place in cardiology as well. Using video games, such as “The Heart Game,” allows the patient a social and active approach to telerehabilitation” [13].

The use of exercise video games has found its place in both physiotherapy and physical rehabilitation, as well as in the therapeutic modality of improving cardiovascular health [5]. Primack et al. showed that video games improved 69% of psychological therapy outcomes, 59% of physical therapy outcomes, 50% of physical activity outcomes, 46% of clinician skills outcomes, 42% of health education outcomes, 42% of pain distraction outcomes, and 37% self-management disease outcomes [46]. All of the above demonstrates the great potential of video game use in medical pathology, with the knowledge that EG use in the everyday world is increasing in number.

### 3 Artificial Intelligence Application in Therapy

Medical care practices are changing rapidly in the artificial intelligence (AI) era, and in part due to the lack of synchronization between the increase of an ageing population in the developed world and a rise in the number of medical care providers. There is a need to employ emerging technologies and customize them in various medical applications in order to achieve progress in patient care and at the same time provide much-needed quality assurance taking into consideration data sensitivity. Application fields which are already benefiting from using AI are patient diagnostics, physical therapy, medical assistance, elderly patient care and robot-assisting surgeries. Numerous studies confirm the benefits of using image analysis and pattern
recognition techniques for reliability improvement in diagnostic accuracy. Unlike the consequences of automation during the industrial revolution, job security for medical workers is guaranteed, as employing AI technologies in the previously mentioned application fields is predominantly assistive in nature although, as authors in [61] suggest, it affects “the performance of workers at different skill levels”. In this light, the change should occur in reassessing medical workers’ duties on the job.

Physical therapy operations are changing constantly in the light of new emerging technologies and providing more effective and efficient patient care. For example, we are witnesses of new robotic implementations that create outstanding and fascinating breakthroughs in the medical field. Physical therapy (Fig. 2) could be categorized as paediatric, geriatric, orthopaedic, neurological, cardiovascular and pulmonary as well as vestibular rehabilitation focusing on improvement of impaired movement and ability that can occur due to various illnesses or injuries. For example, orthopaedic physical therapy should aid individuals in preventing or recovering from injuries in addition to eliminating existing pain relief. Recent research shows that machine learning techniques, in particular deep learning, can be utilized for assessment of physical rehabilitation exercises and patients’ performance [36].

Paediatric physical therapy, and, in some cases, geriatric physical therapy, deals with patients who might not be fully aware of the reasons of their involvement. The focus of the therapy is to evaluate and provide treatment for various deficiencies in motor development processes while providing a safe and motivating environment. Robot-assisted therapy has been used in paediatric patients for emotional rehabilitation therapy for an extended period [50] to introduce animal-style robots. The authors presented a subjective evaluation of the importance and benefits of physical child-robot interaction in their work. Furthermore, the authors in [8] examined the use of humanoid robots as a motivational factor for children with disabilities. Although the study involved a limited number of patients with cerebral palsy, the results show that procedures using assistive robotic feedback implemented in a scenario of virtual reality therapy game offer a promising rehabilitation path. A similar approach, using social robots, presents an attempt at a various spinal disorders prevention path in healthy children [37].

In contrast to younger patients, geriatric patients have a higher occurrence of being diagnosed with more than one disease simultaneously—such as atherosclerosis,
osteoarthritis— all of which require diagnostics and continuous professional supervision [29]. Artificial intelligence tools allow at-home monitoring through various patient monitoring platforms. On the other side, acquisition and processing of biometric data such as ECG is being implemented nowadays in wearable devices. Detection of falls, which in case of geriatric patients can be fatal if not observed promptly, is also implemented in wearable devices by means of artificial intelligence tools. Finally, care management systems utilize AI techniques for simple tasks such as medication adherence via voice-enabled virtual assistants as well as more complex tasks such as daily living assistance, companionship and assist geriatric doctors in decision making processes realized through cognitive robotic helpers [59].

Robotic surgeries frequently used in joint replacements such as knee or hip arthroplasty advanced from planning phases of joint replacement nearly thirty years ago to simultaneous robot teleoperation performed recently using 5G technology [23]. Physical therapy following orthopaedic surgeries evolved from traditional in-person therapy, then advanced to telerehabilitation, and, in recent years, to state-of-the-art systems using artificial intelligence tools. The benefits of using virtual reality systems in orthopaedic physical therapy are nowadays threefold: providing a highly controlled and at the same time stimulating environment for the patient as well as reducing the cost of the patient’s rehabilitation process. These systems use biofeedback in order to increase the patient’s performance and devotion to the program. A clinical team monitors the patient’s progress in real-time and as needed adapts the program remotely by utilizing machine-learning algorithms [9]. Besides post-surgical rehabilitation, these systems could be tailored to address the field of sports medicine and provide strengthening and stretching exercises as well as prosthetic training where needed.

Application of artificial intelligence in neurology aids in improving the quality of life for patients who have motor and sensory disorders of the central nervous system, such as cerebral palsy, multiple sclerosis, spinal cord injury, stroke, traumatic brain injury or other neuromuscular conditions. Virtual reality and robotic systems are already employed as assistive and therapeutic devices in the rehabilitation processes. This is due to advances in the sensor technology used for acquisition i.e. input data combined with advances in machine learning algorithms processing i.e. output data. Bottle neck remains the classification of brain states related to perceptions, thoughts, emotions, or intentions and closely related to input-output constraints of such systems. For example, the authors in [57] use brain computer interface technology to assist in communication of the patient with a loss of voluntary muscular control with the retention of normal cognition. Although progress is present, the task of the patient accurately and independently controlling a computer typing program is performed at a slow pace of two letters per minute. Brain-controlled prosthetic robots aiding the rehabilitation process of patients suffering from serious neuromuscular conditions such as stroke are reviewed by authors in [43]. In addition to a systematic literature review of the state of robotics in upper limb neuro-rehabilitation, the authors suggest new research directions in the autonomous rehabilitation process. The authors in [52] developed a hand exoskeleton system and demonstrated the mobility, strength,
and coordination of such a system in providing a better quality of life to the patient. System inputs combination of biopotential signals produced by electroencephalography (EEG) and electrooculography (EOG) methods, performs real-time processing on those signals resulting in control signals generation that via actuators move the exoskeleton hand.

The authors in [64] present an alternative method to employing artificial intelligence for balance training improvement as a response to relieving vestibular dysfunction in patients. Such a system uses a virtual reality game-based approach with focus on controlling the patient’s eyeball and head movement, stretching of extremities and body balance in accordance with traditional Cawthorne-Cooksey exercises. A sensor-based measuring system provides the necessary feedback and assesses the rehabilitation process almost in real time. The authors used the Statokinesigram (SKG) balance index together with six more indices derived from SKG as input features for the Support vector machine (SVM) classifier. A multi-class classification problem was devised in which patients were categorized in four groups: before treatment, undergoing treatment, after treatment and healthy subjects. Classification accuracy implies that after performing more treatment sessions patients become better at balance control and closer to healthy subject category indices. The authors in [31] use various machine learning algorithms to predict peripheral vestibular dysfunction in patients. Attributes needed for the prediction model were extracted using the foam posturography technique which is a measure of the center of the foot pressure (COP) movement during sway. Several machine learning models were developed and the best performance measures (Area under the ROC curve and Recall were considered) were obtained by two ensemble algorithms: gradient boosting and bagging classifiers. In comparison to traditionally used statistical methods, the prediction ability of ensemble algorithms was superior.

Machine learning algorithms are, because they have access to large amounts of unstructured data, often applied to prediction tasks. In pulmonology, prediction tools are concerned with solving problems such as how to differentiate and prioritize asthma patients in respect to likeness of experiencing an asthma attack [39]. In addition, we want to predict the occurrence of such attacks and hence improve the level of patient care. In order to achieve this, a large subset of the population needs to be sampled and wider predictive factors need be considered: (i) environmental factors such as air pollution, season, and humidity; and (ii) personal health indicators [62] such as polysomnography, actigraphy and ECG.

The main applications of AI in cardiology, capable of solving complex tasks, are concerned with disease diagnostics, prognosis with a prevention of the disease, and risk stratification. All of this is combined with attempts at cost reduction in health care while maintaining, if not improving, the level of patient care. In general, applications in cardiovascular pathology are used to detect rhythm disturbances, to aid decision-making in a variety of circumstances, and to help predict outcomes or complications. On the other side, the acquisition and processing of bio-metric data such as ECG is implemented nowadays in wearable devices. There are a number of mobile applications that are used to detect rhythm disturbance, especially for the detection of intermittent atrial fibrillation, which is an etiologic factor of the cerebrovascular
and cardiovascular occurrences. Mobile applications development and usage are supported by competent authorities in the field (European Society of Cardiology). For example, preventive cardiology uses artificial intelligence concepts to develop an exercise-based cardiovascular rehabilitation process employing exercise-mediated factors with the factors influenced by metabolism and immunity [18]. Cardiac rehabilitation exercises need to be at the appropriate level for the patient and the authors in [35] developed a cardiac rehabilitation sensor for the automatic subject-specific exercise prescription based on the patient's exercise history.

4 Serious Games for Healthcare

Serious health games can address a number of different issues such as distraction, self-management, disease prevention, and the like. Specific examples include the following: a game for older stroke patients [7], raising awareness of exercise among children [10], increasing pain tolerance and reducing disruptive pain-related behaviors during painful medical procedures [25], medication intake for young people with a serious chronic illness [34, 41], and the like.

Based on the reviewed papers and the grouping presented in Fig. 1 we will list a number of examples of where games were used for analysis, and papers where scientific contributions were presented. The analytical approach is identified in games dealing with disease and risk prevention, while the scientific approach is more present in games focused on attention distraction, self-management, as well as games related to medical education.

4.1 Scientific Approach

Attention Distraction and Self-Management. As mentioned earlier, serious games are used as distractions to decrease pain, distress and anxiety in children during wound care. An Open source game Tux Racer and a Wiimote (a remote control) were used with children who visited a specialized wound care nurse 2–7 days after the injury occurred. The game involves a penguin that has to collect as many fish as possible on the slalom path. The study involved 62 children in the period from May 2008 and June 2010. The results showed lower observed behavioural pain values in children playing the serious game compared to other groups [41]. The use of serious games in such procedures requires fewer staff resources and less training time for children. Although formal evaluations of such studies are lacking, researchers hypothesize that “playing video games could block pain to some extent by consuming part of the attentional capacity that would otherwise be devoted to perceive the stressful event” [45].

The European Union’s Horizon 2020 iManageCancer project (http://imanagecancer.eu/) uses two proprietary developed serious games, one for adults and one
for children and adolescents, to “manage the impact of the disease on their psychological status, such as negative emotions, anxiety or depression, and motivate them to stay positive and to participate in social life” [26]. Within the project, researchers developed a platform that uses a personalized approach to each patient group. The personalized approach means providing services tailored to the characteristics of individual users. The games used in this project were developed separately and hence differ in purpose and game-play aspects. The serious game for adults promotes health habits that authors want their patients to apply in real life by delivering relevant knowledge and shifting unhealthy attitudes. The purpose of the serious game developed for children and adolescents is to distract young patients from the disease by killing cancer cells in a virtual environment. The narrative elements of each game are diminished due to research results that indicate their counter-productive effects [26].

Re-Mission (https://www.re-mission2.org/) is another serious game developed for children with cancer and their family members. The game consists of 20 stages with different cancers developed by a multidisciplinary team consisting of game developers, animators, cancer experts, biologists and psychologists, and a total budget of 4.6 million dollars. Similar to the iManageCancer game for children, children are also asked here to kill cancer cells using weapons such as chemotherapy, antibiotics and natural body defenses. In doing so, patients have improved treatment adherence and increased a sense of power and control over the disease itself.

Serious games can also be used to improve self-management skills for dealing with certain chronic illnesses, such as asthma, diabetes, and the like. Bronkie the Bronchiasaurus is a relatively old but still interesting serious game with an asthmatic dinosaur as its main character. Children play the dinosaur and help him avoid asthma triggers such as dust and pollen while saving his homeland. Furthermore, managing diabetes by monitoring blood glucose, taking proper amount of insulin, reviewing a diabetes logbook, and finding appropriate food was enabled through the serious game Packy & Marlon [45].

Medical Education. Games are used for training and educating medical staff and students—for example, applying specific procedures in stressful situations [53]. The text-based game Breast Cancer Detective Game was developed as a web-based learning tool for senior medical students. The students receive points by answering problem-based questions. SimCity is also used to help nursing students practice thinking, planning, and evaluation in a simulated environment focusing on community issues with various environmental problems such as flooding [45]. Video games also have their place in the education of cardiologists and intervention cardiologists, both in terms of clinical skills and in theoretical training [11, 13]. The Serious game Pulse!! (http://www.sp.tamucc.edu/pulse/) represented a new approach to the development of such games as it was developed in collaboration with Texas A&M University-Corpus Christi and the game development company BreakAway. The team used cutting-edge technology and delivered a very life-like and complex virtual clinical environment. Using this game, medical students and trainees were able to experience various rare and life-threatening scenarios and through repetitive prac-
tice test their knowledge, practice skills and correct errors without compromising the patient’s life.

In addition, in the light of the current pandemic, we are witnessing a justified possibility of a transformation of future medical education. Information technology assistance in the process of providing international support to most affected areas of the pandemic is invaluable: we observed international collaborators as they shared their knowledge either in person or by using digital platforms. This trend could continue in the future to align with the WHO goals of addressing the shortage of trained medical professionals. Digital platforms, as such, could be a great resource in this endeavor.

### 4.2 Analytical Approach

**Disease and Risk-Prevention.** Obesity among young adults is an increasing world health problem associated with harmful effects on health and general well-being. *Squire’s Quest* is a children’s serious game designed to increase the consumption of fruits, juice and vegetables by preparing recipes for a king and his court so that they have the energy needed to defeat invaders [4]. The evaluation involved 1578 children over a period of five weeks. The children in the treatment group increased their consumption of fruits, juice and vegetables. *Farm* is another game that encourages a child to move using Kinect motion sensors [3]. In the preliminary stage, the authors evaluated the effect of pleasure and user satisfaction.

The pregnancy prevention games such as *The Baby Game!* and *Romance!* were designed to educate youth about contraception options, practice communication skills in dating situations and experience a simulated life of a teenage parent. The results indicate that participants significantly improved their knowledge of contraception, pregnancy risk, and cost of birth and child care [45].

*Heart Sense* is another role-playing risk-prevention game where the player (hero) encounters many virtual characters who need help because they have symptoms of a heart attack [27]. The player has to make a decision on how to respond to each case and thus save a life.

### 5 Discussion

A growing body of research is focused on developing serious health games. Such games are developed primarily for patients, but also for medical professionals. Most of these games involve diving into the human body, visualizing the impact of the disease and the value of a cure. Usually the patients are the superhero who beats the enemy in their own body. In most of these games, the superhero never dies. According to comprehensive research conducted by Peng et al. [45], social learning theory is one of the most cited theories used in the development of serious games for health.
According to this theory, having a role model within a game influences children’s behavior as they pay more attention. In conclusion, within self-management games a player is always engaged in helping the main character control symptoms in various settings. Compared to traditional learning methods, serious games are interactive, more engaging and provide unlimited chances to practice.

Unfortunately, evidence of the effectiveness of such games is lacking [12, 33, 45]. According to Kato 2013, “there are far more games for health that have not been evaluated scientifically than those that have”. However, effectiveness studies do exist and the results are promising. They show that patients who have played games in specific studies and conditions “show increased health-related knowledge, greater self-efficacy to engage in health-related behaviors, and improved adherence to medical recommendations and regimes” [33]. The purpose of such validations is not to determine whether the patient or doctor likes the game and its design, but rather to verify that there exists a measurable effect after playing the game [33]. Otherwise, we are simply talking about a usability study.

Evaluating serious games for health can be time consuming especially if we are working with a small sample or the evaluation requires monitoring over a longer period of time. Such evaluations require significant funding. Furthermore, it takes time to develop a serious game. When ready for testing, “there is a risk that the technology and hardware used on the game will become outdated” [33]. Going further, “the technology may be “old” by the time the world knows that your serious game for health is actually highly effective at improving health outcomes!” [33].

When it comes to medical staff, research has shown that playing games improves the fine motor skills associated with surgery and skills relevant to emergency situation [32]. What is imperative is the collaboration of the medical professional and the person involved in the video game making process. An EG based on evidence-based medicine and subsequently validated by a competent healthcare authority could certainly have a wider application. Video games have become a daily routine in medical clinical practice, and their potential is enormous, but with adequate supervision of the development process and their usage.

5.1 Future Study Recommendations

As we stated earlier, the serious game concept itself should be a symbiosis of the work of a medical professional and software engineer, where a multidisciplinary approach would produce results that can be useful in clinical practice. Currently, in all health care institutions, initiatives remain local and are addressed locally. Furthermore, the SG should be based on information that has been verified (preferably evidence-based) with the source and background necessary information provided. The next step would be to validate the SG under clinical conditions to justify the credibility of the SG itself. It is likely that each SG should also be certified by a validation body (on regional or country level), and as such should be safe to use, which is the aim of the process itself. It is important that the validation of games be faster than the validation
of medical devices because of their immediate use on patients but also from the aspect of technology used, which may be considered obsolete due to the long wait.

Serious games also provide assistance in the education of medical personnel, and their development has been primarily directed in this direction [24, 63]. However, their use has expanded and become increasingly important in assisting with therapeutic treatment [17]. The lack of specialist, especially sub-specialist staff, and the increasing number of needs for healthcare services, has forced medical professionals to seek options for more frequent and close contact with patients, where SG have been imposed as a good option as a supportive therapy, from which the patient, but also the physician, may benefit [2, 14, 54]. With the development of information technology, and advances in the development of SG, they also received broader indications in the treatment of internal and surgical pathology, the management of tobacco addiction, psychological and psychiatric disorders, obesity, but also epidemiological crises, where they can be of help in treatment and social supervision [15, 16, 19, 38, 54, 56].

6 Conclusion

This paper has a descriptive character and presents a narrative review that describes the potential use and benefits of SG in everyday clinical practice, whether in diagnostic or therapeutic algorithms. More comprehensive and rigorous study evaluations will result in a significant contribution to the field of serious games and specifically health interventions. Doctors themselves will want to prescribe such games to their patients. As shown in a number of studies investigated here, serious games provide patients with a sense of control. They are able to shift their attention between “playing the game and watching the wound dressing” [41].

In the recent past, the media industry connected violence in games with violence in real life. Unfortunately, similar implicit assumptions could happen with serious games for healthcare. However, it is important to understand that serious games are not the first line of therapy, but rather a more supportive therapy that can help the therapeutic modality.

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