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Pros and Cons of Computer-Assisted Rehabilitation

Pros y contras de la rehabilitación asistida por computadora

Prós e Contras da Reabilitação Assistida por Computador

Norbert Ferenčík[1], **Radovan Hudák**[1], **Miroslav Kohan**[1], **Viktória Rajťúková**[1]

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Abstract

This article summarized the knowledge obtained from exercises with patients using computer-assisted rehabilitation. Working with a wide base of healthy individuals and patients with various problems yielded the results to summarize. This work utilized several rehabilitation devices using computer games and uncovered positive and negative aspects of contemporary rehabilitation procedures. we conclude in this research computer-assisted rehabilitation is the future of modern rehabilitation, so it is necessary to know all factors affecting patients' health.

Keywords: computer-assisted rehabilitation; motivation; self-injury; computer games

Resumen

En este artículo resumimos los conocimientos adquiridos a partir de ejercicios con pacientes que utilizan rehabilitación asistida por ordenador. Durante varios años, tuvimos la oportunidad de trabajar con una amplia base de personas sanas y pacientes con diferentes problemas. Observamos los aspectos positivos y negativos de los procedimientos de rehabilitación en la rehabilitación moderna en varios dispositivos destinados a la rehabilitación mediante juegos de computadora. Se concluye en este documento que la rehabilitación asistida por ordenador es el futuro de los procedimientos de rehabilitación modernos, por lo que es necesario conocer todos los aspectos que afectan a la salud del paciente.

Keywords: rehabilitación asistida por computadora; motivación; autolesiones; juegos de computadora

Resumo

Neste artigo resumimos os conhecimentos adquiridos a partir de exercícios com pacientes que utilizam a reabilitação assistida por computador. Durante vários anos, tivemos a oportunidade de trabalhar com uma ampla base de pessoas saudáveis e pacientes com diferentes problemas. Observamos os aspectos positivos e negativos dos procedimentos de reabilitação na reabilitação moderna em diversos dispositivos destinados à reabilitação através de jogos de computador. Conclui-se, neste documento, que a reabilitação assistida por computador é o futuro dos procedimentos modernos de reabilitação, por isso é necessário conhecer todos os aspectos que afetam a saúde do paciente.

Palavras-chave: reabilitação assistida por computador, motivação, automutilação, jogos de computador

Norbert Ferenčík, norbert.ferencik@tuke.sk, https://orcid.org/0000-0002-9648-5799
Radovan Hudák, radovan.hudak@tuke.sk, https://orcid.org/0000-0003-1060-0539
Miroslav Kohan, miroslav.kohan@tuke.sk, https://orcid.org/0000-0003-4162-4306
Viktória Rajťúková, viktoria.rajtukova@tuke.sk, https://orcid.org/0000-0002-7180-2874
1 Department of Biomedical Engineering and Measurement, Faculty of Mechanical Engineering, Technical University of Košice, Košice, Slovakia

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Introduction

Under the term computer-assisted rehabilitation can be imagined a rehabilitation process during which the patient is in cooperation with a computer or other programmable device. For the rehabilitation itself, feedback from the exercise process was used. Feedback can be obtained in two ways: the first is the results or scores achieved in a computer game; the second is the initial output from the sensors. An example of a goal may be reaching a selected boundary or target.

The use of intelligent algorithms in computer-assisted rehabilitation is the appropriate step to improving classical rehabilitation procedures. The problem is that not every hospital or patient has access to such technologies. Another issue with these systems is a lack of complexity and, therefore, poor patient engagement, according to Miettinen (2003). Scrolling a black dot over the white area to reach a specific target is not motivating enough; so it is necessary to find something that patients enjoy and have them easily captivated. Perhaps the most effective way to keep people entertained, help them learn quickly and develop new skills is by linking rehabilitation with computer games, according to Wiemeyer (2016).

In this article, we will not mention the background work that inspired us to continue research in computer-assisted rehabilitation. This paper aims to show negative aspects that need to be considered in rehabilitation using computer games.

Rehabilitation equipment

We chose a computer game we developed for assisted rehabilitation. It should be noted at the outset that we used the RepaiR device according to Ferenčík (2018, 2019), which was developed in 2016 at the Technical University of Kosice. RepaiR (Rehabilitation Platform Improvement) is a device designed for computer-assisted rehabilitation and, at the same time, as a diagnostic device for measuring forces in flexion, extension, ulnar, and radial deviation, according to Viegas (1993). The device contains eight strain gauges, which are housed in a handle. During rehabilitation or exercise, the patient develops force on the handle on each strain gauge. The signal from the strain gauges is adjusted by a 24-bit transducer Hx711 with a frequency of 80 Hz. The device can measure the force developed in the range of 0-40 kg. The accuracy of each strain gauge is 0.05 % of sensitivity from the maximum range ±0.02 kg. The output from the converters is then processed by the Arduino Mega microcomputer, which is part of the device and is protected from damage. Device can be seen in Figure 1.

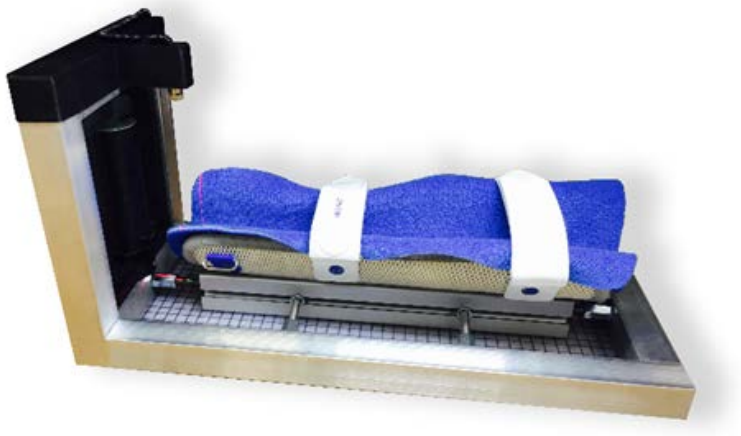

Figure 1. *RepaiR device with a measuring part and splint for placing the hand manufactured from low-temperature thermoplastic material LTT. Note:* derived from research.

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These components are used for communication with the protocol and feedback at the same time. Intensive training delivered by a therapist soon after the injury can effectively restore motor functions needed for independent living. However, even top hospitals only devote a limited amount of time to the rehabilitation of motor functions, according to Baumgartner (2009). Since the original protocol for obtaining maximum strength data was not motivating enough, we developed the game called Flying with Friends.

During the game, the patient is trying to control the flying plane. Throughout the game, targets are randomly generated on the map, where the patient's task is to claim an imaginary goal. At the beginning of the measurement, it is necessary to obtain achievable patient values for all directions of wrist movement. In a special interface, it is necessary to develop the maximum force in all directions in order to be able to determine the maximum range of forces. We will discuss this issue in the next section of this article. This data is then stored for further development of the game. From the beginning, the target generation algorithm uses only this measured data to calculate the position of the next target. However, the patient's movement is not fully developed, but a maximum of 75 % of the range (δ = 75 %) in each direction is used to reduce frustration and increase motivation.

This means that if the patient develops a force in any direction under wrist pressure, for example, 40N in any duction, the goal that will need to be achieved in the next session will be generated so that the maximum force to be developed is 30N. All these forces come from strain gauges located in the handle of the instrument. After 5 attempts to reach the goal, the first stage of the exercise ends. After the end of the first phase, the following targets are generated according to the mentioned algorithm.

If the patient has achieved enough goals (more than 80 %) in the previous exercise and thus met the expectations, the following goals will be generated more difficult by the constant α = 2 %. For example, after a successful exercise, $\delta + \alpha$ = 77 % of the maximum values for next stage (thus new δ n = 77 %). If the patient achieves results between 45 % and 80 %, δ n = δ in that case. But if the score is less than 45 % during the exercise, the scale is δ n = $\delta - \alpha$, even if the exercise is very problematic and the rate is less than 20 %, then δn = $\delta - 3 * \alpha$. The game score is created based on the number of captured targets. We can see a sample exercise in Figure 2.

Figure 2. *Exercise demonstration of a patient in a rehabilitation facility under supervision. Note:* derived from research.

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Results from exercises

The study was focused on practicing patients with various problems who participated in playing the game Flying with Friends. A sample of surgical outpatient patients during routine post-traumatic surgery was selected to test the device. Ten volunteers (6 men with an average age of 45 years and 4 women with an average age of 33 years) attended the exercise. The most common problems of patients enrolled in the RepaiR exercise included a fracture of the triquetral bone of the wrist (4 cases), a fracture of the radial bone of the hand (2 cases), damage to the phalangeal part of the hand (2 cases) according to Goršič et al. (1991), soft tissue damage (2 cases) according to Ganel (1979), and others. None of the patients had any other health problems that would affect the exercise.

All exercises were performed under the supervision of a physician and all patients were acquainted with the game before the exercise. They could also see a demonstration of the game. The patient's score was monitored, patient feelings while playing and the $\Delta\delta = \delta l - \delta$, where δl is last δ after last session and δ is 75 %. Table 1 shows the results of measurements at the surgical outpatient clinic. Ratings on a scale of 1 to 5 mean 1 is low and 5 is the highest.

As we can see from the table, almost every patient had the motivation to continue such rehabilitation and practice with the help of assisted robotic rehabilitation. Even though the patients missed the goal only three times during the 7 sessions of the exercise, it was observed that they considered the game to be moderately demanding and had to exert a relatively large amount of effort to achieve the targets. The doctor who monitored the exercise concluded that some patients exerted excessive force during the sessions. A patient with a severe triquetral bone of the wrist fracture experienced pain several times during the exercise, despite having determined the maximum strength she could achieve on her own. The impact of such procedures will be assessed in the next chapter.

Observed effects of computer-assisted rehabilitation

As stated by Whitbourne (2013), rehabilitation using games can delay decay in age-related cognitive functions, especially

Table 1
Results of measurements at the surgical outpatient clinic.

Patient	Achieved score	Missed	Δδ	Difficulty
1.	23 (5 sessions)	2	6 %	3
2.	32 (7 sessions)	3	10 %	3
3.	27 (6 sessions)	3	10 %	2
4.	20 (5 sessions)	5	2 %	4
5.	13 (4 sessions)	7	0 %	5
6.	22 (5 sessions)	3	6 %	3
7.	28 (6 sessions)	2	10 %	2
8.	41 (10 sessions)	9	16 %	1
9.	22 (5 sessions)	3	6 %	2
10.	32 (7 sessions)	3	12 %	1

Note: Achieved score means the number of goals passed per number of sessions.
Note: derived from research.

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for the elderly. Playing video games is a popular leisure activity among children and adults and may therefore potentially influence brain structure, according to Kühn (2014). An advantage in combining of computer games and rehabilitation equipment (including console games) is the observed significant improvement in motor skills. With the help of games, an improvement in the movements of children with spastic cerebral palsy was also observed, according to Alsaif (2015). In our project, we also wanted to point out aspects of improving the health of patients and quality diagnostics, which we tried to achieve with the RepaiR device.

The three basic positive features of computer- or robot-assisted rehabilitation are:

-motivation triggering,
-repeatability,
-accuracy.

In connection with the first point of motivation, expectations were met. Almost every one of our patients said they would continue with computer-assisted rehabilitation. Systems such as RepaiR and the associated software also have high repeatability thanks to the exact parameters set for rehabilitation. We could consider reduced repeatability due to the adaptability of the system, according to Lima (2013). However, the parameters of the rehabilitation procedure can be set to a standard level, which can be the same with each repeated exercise. Thanks to high-quality strain gauges placed in the handle, the device for robotic rehabilitation also meets the requirement of accuracy.

When motivation is required for the patients, despite the adaptability of the system, the possibility for them to self-harm arises during robotic-assisted rehabilitation. Figure 3 shows the problem of the first point mentioned about self-injury of trained body part.

It is therefore necessary to pay attention to the correct process parameters when setting up robotic-assisted rehabilitation and, at the same time, to receive feedback from the patients. Feedback for a change in the conditions of the rehabilitation process can be a failure to achieve the goal of rehabilitation based on the maximum achievable values of the patients, or the limit at which they feel pain, according to Carr (2011). We used the first option to achieve feedback for a suitable adaptation of the game Flying with Friends. Nevertheless, we noticed that the patients themselves could establish the conditions for achieving the goal so high that they cannot achieve such conditions in the subsequent exercise.

Figure 3. *Equilibrium scales of accuracy for computer-assisted rehabilitation. In the case of a computer game or program intended for rehabilitation, the equality factor between motivation and self-awareness must supervise the setting of parameters.*
Note: derived from research.

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Conclusion

This article described our experience in the field of computer-assisted rehabilitation. An acquaintance with the main positive and negative effects of modern rehabilitation was developed during data acquisition and rehabilitation with patients. The procedure of playing the rehabilitation game Flying with friends and its results were also presented to better understand our rehabilitation process. This research was also intended to inspire and establish rehabilitation procedures in which the self-harm of practicing patients can occur. We believe that computer-assisted rehabilitation has a rich future, and the effects of negative influences will be eliminated as much as possible in modern research.

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Conflict of Interest

The authors declare no competing interests.

Author contribution statement

All the authors declare that the final version of this paper was read and approved.

The total contribution percentage for the conceptualization, preparation, and correction of this paper was as follows: N.F. 40 %, R.H. 20 %, M.K. 20 % and V.R. 20 %.

Data availability statement

The data supporting the results of this study will be made available by the corresponding author N.F. upon reasonable request.

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