PROFESE ON-LINE
peer-reviewed journal for health professions

ISSN 1803-4330

volume V/2 • October 2012

Game-Based Physical Therapy for Patients after Stroke

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ABSTRACT

This pilot study aims to verify the impact of positive emotions on motor learning by means of visual feedback in the form of virtual reality games in patients after stroke. In the pilot study, we evaluated 3 stroke patients, who completed a two-week virtual reality game-based therapy. Postural stability and gross motor status of the paretic upper limb were assessed in every patient before and after the therapy, using standardized clinical (Berg Balance Scale, Action Research Arm Test) and instrument-based (Computerized Dynamic Posturography) tests. The evaluation of patients showed a significant positive impact of game-based therapy on postural stability and coordination. Virtual reality games are likely an appropriate complement to a comprehensive physiotherapy approach in selected patients after stroke. In accordance with our pilot measurements, an extension of this study might be useful.

KEY WORDS

motivation, motor learning, game, visual feedback, virtual reality, stroke, hemiparesis

INTRODUCTION

With many diseases that require long-term treatment, both the therapist and the patient need a lot of patience and focus. This also applies to the rehabilitation of serious motor deficits. The success of a therapy within a comprehensive physiotherapy approach is the positive motivation of the patient during the treatment (Chang et al., 2011, p 2566; Nishimura et al., 2011, p 4). Despite its fundamental significance, motivation is often overlooked (Betker et al., 2011, p 1,146). In general, emotionally charged data is easier to remember than data void of emotions (Lewis et al., 2011, p 453; Véle, 1997, p 77. If the patient enjoys the therapy, he or she will submit to the therapy for longer and repeatedly.

The fundamental preconditions for effective learning in physical therapy also include movement repetition (especially in a changing environment) and preference for an active rather than passive range of motion (Lotze et al., 2003, p 871). The patient should also identify with the goal he or she wants to reach with the motion (Henderson et al., 2007, p 53). Optimal execution of the motion also depends on having an adequate idea of it, which is formed by afferent sensory information regarding the nature of the internal and external environments and by feedback of the course of the motion (Ehrsson et al., 2003, p 3,304; Gentili et al., 2010 p 774). Likewise, motion training is more effective when accompanied by visual feedback (Perez et al., 2006, 851; Banz et al., 2008, p 1,142).

All the above aspects (motivation, positive emotions, active range of motion, repetition of movement, the idea of the motion, and visual feedback) are incorporated in the therapy via video gaming, where the patient moves their entire body with the view to achieving a positive score (e. g. the Nintendo Wii or Kinect systems). While playing, the patient ceases to pay attention to the execution of individual movements but focuses on how to best fulfil the new task (Lange et al., 2009, p 147). Playing a game helps to maintain interest, improves motivation, and introduces fun but also hard work to the activity (Lange et al., 2010, p 347).

From the neurophysiological point of view, greater demands on cognition and motivation in the game lead to e. g. increased activation of the prefrontal cortex, limbic system, and cerebellum (Sun et al., 2012, p 573).

Incorporating a game into the therapy of patients with motor deficits is original precisely for the need of higher cognitive and emotional processing of afferent information, which positively potentiate the resulting motion.

Our pilot study focused on the use of virtual reality games as possible supplementation to comprehensive physical therapy.

OBJECTIVE

The study aimed to use the pilot monitoring to evaluate the impact a therapy in the form of a game based on visual feedback had on stroke patients and to assess the test methods for a possible larger study.

PARTICIPANTS AND METHODS

Three patients participated in the pilot study: proband 1 (male, age 41, height 165 cm, weight 78 kg), proband 2 (female, age 42, height 180 cm, weight 89 kg), and proband 3 (male, age 45, height 172 cm, weight 70 kg). All the patients had suffered an ischemic stroke in the left middle cerebral artery, followed by right-sided hemiparesis. Probands 1 and 3 suffered the attack one month before the launch of the study and Proband 2 six months before the launch. The sole criteria for inclusion in the study were the ability to stand and walk without support equipment and absence of cognitive impairments and other associated{MQ} motor disorders unrelated to stroke. Patients who did not meet these criteria were excluded from the study. At the time of the study, all the probands were hospitalized in the inpatient rehabilitation department of the Olomouc University Hospital, where they underwent standard rehabilitation therapy including individual physical therapy based on neurophysiological principles, with two sessions a day, each 45 minutes long. All the probands were familiarised with the measurement process and signed the Informed Consent to participating in the study. The research was approved by the Ethical Committee of Faculty of Health Sciences, Palacký University in Olomouc

Before and after the 14-day game-based therapy, all the tested patients were evaluated for:

a) Postural stability by means of a standardized clinical examination – Berg Balance Scale (BBS) and an objectification instrumental method – computerized dynamic posturography (NeuroCom).
   BBS assesses the patient's balance in 14 defined functional tasks. The evaluation centres on how self-sufficient the patient is in performing the monitored task. The maximum final score is 56 points. The posture testing included the Sensory Organization Test (SOT) – it evaluates the effectiveness of the processing and integration of peripheral afferent sensory information for the stabilisation of the standing position. A total of 6 situations are assessed. The final assessed parameter is a composite score for all the test situations, which quantifies the degree of postural titubation in percentage. The higher the final score is the better the postural stability.
b) Deliberate activity of the upper extremities by means of standardized clinical examination – Action Research Arm Test (ARAT). The test assesses the fine and gross motor statuses of the arm.
   During the examination, the patient performs a total of four types of arm movements. The execution of each movement is qualitatively differentiated. The more difficult the performed movement is the higher the score. The maximum final score is 57 points. The probands completed the visual feedback game-based therapy under the supervision of a physiotherapist, while receiving standard rehabilitation treatment at the same time. The video gaming therapy was held daily for two weeks, 30 to 60 minutes per session, depending on the patient's current schedule. The therapy utilised the Xbox 360® game console and the Kinect® sensor. The wireless sensor detects the movements of the whole body, which are immediately displayed on the TV screen in front of the player as avatar movements. Thus the patient interacts with the game environment. As part of the therapy, all the probands played a game (20,000 Leaks – Leaks Ahoy!) that required comprehensive active involvement of the upper and lower limbs, sufficient standing balance, and an adequate reaction speed in order to achieve a good score. Players are instructed to use their arms or legs to "prevent water from flowing in the water tank by covering holes" that randomly appear on the screen. The difficulty level of the game was gradually increased during the therapy.

RESULTS

Table 1 shows the results of the evaluated tests.

All the probands reported an improved standing balance, as is apparent from the resulting values of both the BBS clinical test and the SOT test. However, findings of the test assessing the arm function are not equally unambiguous.

Probands 1 and 3, who had suffered stroke one month before the study, noted a much more significant improvement of the standing balance (BBS and SOT tests) in the therapy than Proband 2, who had suffered stroke 6 months prior to the measurements. Active motor status of the paretic upper limb (ARAT test) improved only in Proband 1.

All the probands evaluated the therapy positively. They subjectively felt their orientation in space, standing stability, and overall motor coordination had improved.

DISCUSSION

Tests that are routinely used for functional assessment of the upper limbs and tests assessing the standing stability were deliberately selected to evaluate the impact

of the visual feedback game-based therapy because the selected form of the game was comprehensive. To achieve a positive score in the game, probands had to effectively transfer their weight from one leg to the other and at the same time actively reach with both their left and right arm (in random order) the target point. The instrument-based and clinical examinations operated with tests that are designed to assess motor deficit in patients after stroke. The BBS and SOT tests reflect the impaired postural stability and its improvement/deterioration over time in stroke patients (Oliver et al., 2011, p 2,046). ARAT is a valid and reliable test designed to assess the arm function in stroke survivors (Nijland et al., 2010, p 694), while also verifying the effectiveness of the therapy (Wallace et al., 2010, p 475). The results show that all the monitored probands improved stability in both tests (BBS and SOT); one of the key goals of physiotherapy that focuses on the optimization of postural control is to achieve effective postural standing balance (Haart et al., 2004, p 760). Past research has shown that virtual reality training is effective in stroke survivors (Yang et al., 205), whom games help improve the symmetry and dynamic stability in their standing position (Ding et al., 2012, in press). The question remains whether comprehensive training within the selected virtual game therapy actually improves the active range of motion of the upper limb, because only one of the probands monitored reported improvement.

An advantage of virtual reality games, in addition to patient motivation, is the need to use comprehensive movements in order to perform the task effectively. Furthermore, instead of focusing on individual movements during the game, the patient concentrates on fulfilling each task. The tested form of the game also has a beneficial impact on spatial orientation, motor coordination, and improves the patient's notion of the body schema.

Moreover, the suggestive game environment composed of music, audience, and graphic background make this form of therapy highly captivating. Another advantage is that to some extent, the difficulty level can be regulated based on the patients' competence. Patients are thus motivated to perform activities that (unlike in the real environment) they can do in a virtual environment, and a good performance is rewarded with points.

The present pilot study has some limitations. The gaming therapy supplemented a rehabilitation process; it ran in parallel with daily intensive physiotherapy. It is therefore impossible to say to what extent the results were affected by the ongoing comprehensive rehabilitation care. In order to objectify the exclusive effects of the game, a control group needs to be selected, consisting of patients who will not be undergoing a similar therapy as part of their physical therapy. Another limitation was the insufficient number of monitored probands. Clinical studies of this type suffer from great time demands and difficulties with compiling a homogeneous sample, where all probands would meet the initial criteria. The pilot sample of three probands was chosen based on previous trial measurements. Another limitation to the use of virtual reality games as an additional form of rehabilitation is in the possible "overmotivation" and excessive efforts of the patient, which could become counterproductive. The patient may adopt inadequate motor patterns, which could consequently reinforce motor pathology. Therefore, this form of therapy should always be carried out under the supervision of an experienced therapist.

With respect to the findings of this pilot study, based on clinical practice and scientific research publications, we recommend a study is implemented with a larger sample and results compared against a control group. We expect that the results could be applicable to a wider group of patients.

CONCLUSION

Virtual reality game therapy with visual feedback is likely effective as a complement of a comprehensive physiotherapy approach in stroke survivors. The added values of the game are the patient's positive emo-

Table 1 Scores of clinical testing and instrument-based testing

	Clinical testing				Instrument-based testing	
	ARAT		BBS		SOT [%]	
measurement	1.	2.	1.	2.	1.	2.
proband 1	3	45	44	52	73	81
proband 2	57	57	54	55	77	80
proband 3	3	3	49	54	63	81

Note: Max score: ARAT – 57 points, SOT – 100%

tions and motivation. To verify the impact of the tested game-based method in stroke patients, a larger sample of patients needs to be assessed and results compared with a control group.

The study was developed with the help of the internal grant UP FZV 2011_002 titled "Objectiveness of Modified Sensory Input in Clinical Rehabilitation" and the project "Supporting R&D Human Resources of Non-Medical Nursing Programmes of Faculty of Health Sciences, UP Olomouc", reg. no. CZ1.07/2.3.00/20.0163.

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