Journal of Scientific & Industrial Research
Vol. 79, September 2020, pp. 794-797

Virtual Reality based Therapy Modules for Rehabilitation of Upper-limb Movements of Stroke Patients: A Trial Study

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Received 06 September 2019; revised 29 March 2020; accepted 28 May 2020

Traditional physical therapeutic sessions for stroke inflicted patients include- mobilisation, strengthening and stretching exercises of the affected limb. These methods proved to be advantageous in regaining lost strength, but seemed to be boring and less engaging. Virtual Reality techniques of rehabilitation are involving and excite patient's interest to participate. This research is based on improving upper extremity functions of left or right hemiplegic patients using Virtual Reality based therapy modules. The system was tried upon 5 stroke patients who were regular visitors in the occupational therapy department of the hospital, between age group: 25–50 years whose upper limb motion was restricted. After practicing on a regular basis, the subjects attained easy arm movement and reduced shoulder flexion.

Keywords: Feedback, Hemiplegic patients, Occupational therapy

Introduction

Rehabilitation helps stroke patients to regain lost functions of the body to perform activities of daily living with ease.[1,2] In virtual reality therapy sessions, a virtual environment scene is created that is similar to a real environment, using software tools.[3–5] Patients practice rehabilitation activities in that environment. There are various interaction devices that aid in performing activities or accomplish various tasks. The developed system aims to provide therapy to patients whose upper limb motor movements are affected due to stroke.

System Description

Principle

The attainment of motor skills involves a process of motor learning, whose principle is to integrate information from psychology, neurology, physical education & rehabilitation research. Expertise in attaining a motor skill is achieved by rehearsing repeatedly. In the rehabilitation program, the affected arm is made to do numerous repetitions of various tasks. Results from this type of program have been showing that intense structured practice leads to improvement in function, quality of movement, timing & even changes in neuro substrates of the brain, which leads to improving capabilities.

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Therapy Modules

Alphabets, Skywriting & Piano

All three therapy modules (Fig. 1) focus on improving cognition & range of motion of shoulder in stroke patients. In alphabet VI (*virtual instrument*), the LEDs are arranged in the shape of alphabets. It analyses with how much fineness patient is able to move his finger over adjacently placed LEDs. For skywriting, LEDs are arranged in the form of seven segment display. In this, cognition of patients is also improved as he has to remember which LED to glow next on the basis of number to be formed. The timer will calculate the time taken by the participant to complete the shape of the alphabet, number and to glow all the notes of the piano. Also, it improves the stability of hand in space without any support. In the piano VI, as the patient brings his finger on each chord, the corresponding chord glows and produces sound. In this way, patients learn to quickly switch from one chord to another.

Methodology

Case Descriptions

Trials on the three activities were carried out by five stroke patients (1-female and 4-males) aged between 25–50 years who were either left or right hemiplegic. These activities require fine movements of hands and fingers. Hence, patients whose individual finger's and hands' movements were

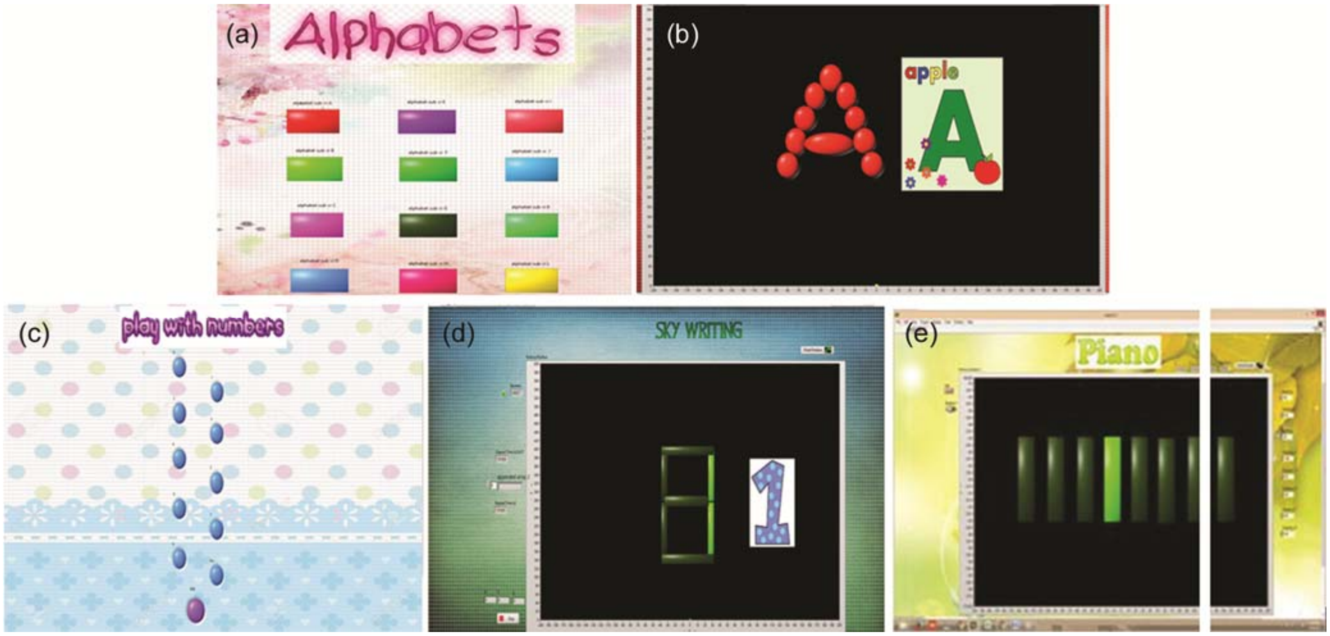

Fig. 1 — Graphical user interface of therapy modules (a & b) Alphabets; (c & d) Skywriting;(e) Piano

restricted were made to practice these activities. They were analyzed on regular basis for at least an hour per day, at least thrice a week for one month. Patients' consent was taken before carrying out trials. Doctors too were consulted. All patients had a different history of stroke. Demography of patients' was noted, as mentioned in supplementary file.

Procedure (Trials on Patients)

The trials for each patient were divided into three phases- the initial phase, middle phase and the final phase. In the initial phase, as the patient was novice to the VR based activities, so they took more time completing the shapes of alphabets and numbers. During middle phase the patients got accustomed to the activities, hence their timing improved. During the final phase of trials- patients showed significant improvement in activity performance when compared with initial phase timings as shown in Fig. 2 & 3. The time taken into consideration for plotting the bar graphs was the highest timing taken during first phase of trial for performing alphabet or number and least time taken during last phase of trials.

Results and Discussion

Overall the system proved to be beneficial in terms of improving shoulder flexion and hand stability. The graphs in Figs 2 and 3 showed that the overall effective timing of performing the individual activities improved.

Due to time constraints for conducting trials, we did not expect the results to show significant changes. However, 4 out of 5 patients improved their range of motion of the shoulder and were able to move their finger as per will in order to form the shape of alphabets and numbers, thereby reducing the tremoring effect. Subjects' degree of impairment varied from severe to moderate to mild. Usually, the patients gave all trials in continuity without any break which was quite tiresome and it led to patients taking more time than expected. Patients found the activities simple, user-friendly and playful. A questionnaire was prepared to consider patients' opinion about the VR activities**.** Majority of patients' response were in favour of the activities on which they performed (Table 1). These activities do not require any external hardware to wear, making the system economical and also allows free movement of hands. Hence, patients were motivated to perform the activities, unlike traditional occupational activities which patients find monotonous and uninteresting.

The activities in this system can be performed independently without constant supervision of the therapist. This possesses an advantage as patients can continue the therapy even at home. The system also has the merit of providing biofeedback in terms of time.

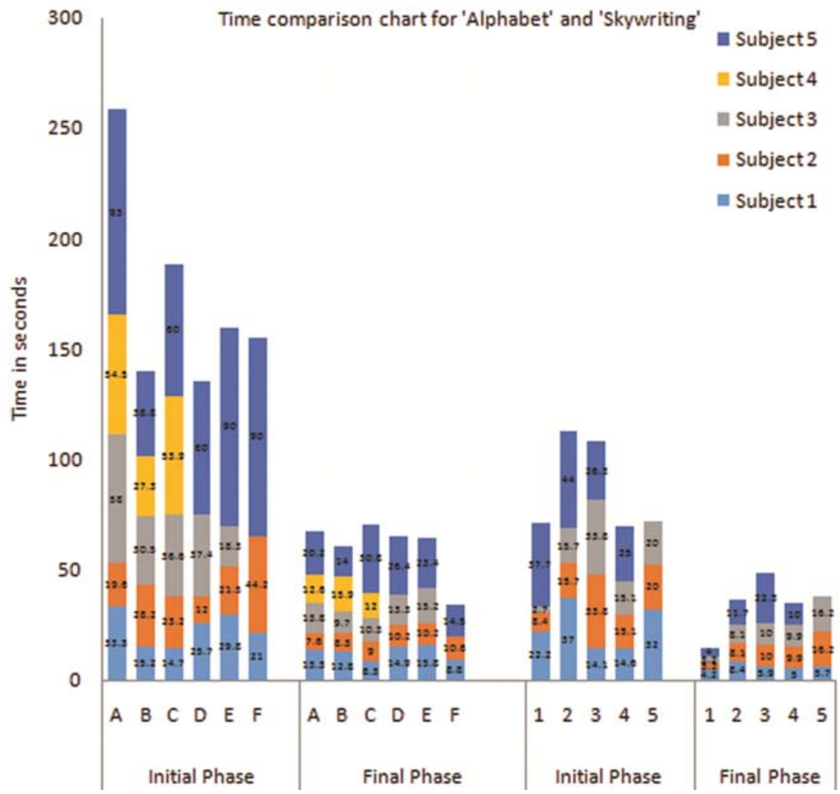

Fig. 2 — Comparison of time taken by five subjects on 'Alphabets' and 'Skywriting' therapy module from initial phase to final phase of trials

Table 1 — Questionnaire based observation by five patients

Features	Score
Activities: presentation	
• Presentation of activities appeared interesting	3
• Response of activities was good	3
• No delay in illuminating indicators	4
• Movement of cursor was flexible	3
Activities: level of difficulty	
• Activities were difficult	1
• Rehearsals were needed before performing	1
• Activities were too easy	4
Player: motivation	
• Activities required less of labour	4
• Activities were time consuming	1
• Activities were user-friendly	1
Player: Cognition	
• Activities required concentration	3
• It required hand-eye coordination	4
Player: physical effort	
• Found it hard because it required constant hand movements	2
• Activities were tiring, as compared to other physiotherapy exercises	1
• Range of motion increased after practicing the activities regularly	4

(1-disagree, 2-neutral, 3-agree, 4-completely agree)

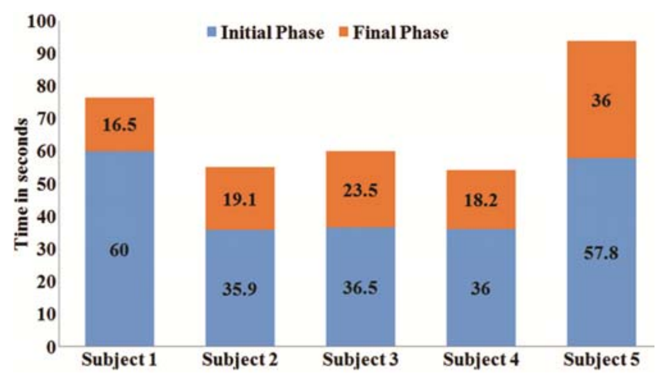

Fig. 3 — Comparison of timing taken by five subjects on 'Piano' therapy module from initial phase to final phase of trials

Conclusions

From the study, it is concluded that individual finger dexterity and stability of hand is required to carry out activities of daily living and to improve the quality of life. This system has an edge over other Virtual Reality therapeutic systems in the way it doesn't require any hardware to wear or sensors attached to body surface making the system simple and easy to perform. As per patient's feedback, the activities helped to improve shoulder flexion in patients. Shoulder's range of motion also increased as they have to move their hands or fingers from top to bottom in order to form the shape of alphabets or numbers. In the piano activity, the patient needed to move their fingers sideways from extreme left to extreme right. The abduction of the affected arm also enhanced, in the way patient could move it from body's median plane to different positions. After subsequent multiple trials, they could voluntarily move their fingers to the desired position. Patients felt satisfied for they were now using their stroke-affected upper limb more often in order to perform the activities.

Future Scope

The current status/version of the game targets the rehabilitation of upper extremity, affected due to stroke with a special focus on improving individual finger dexterity, the range of motion of hands and reducing the stiffness of arm and shoulder.

The future course of action could be to design the system in such a way so that it improves fine motor skills that are involved in activities of daily living like, grasping an object, placing it from one place to another, holding an object, etc. Patients having trouble stretching their finger can be provided finger splints to perform the desired action. Besides treating the stroke patients, these activities are helpful for learning the purpose of cerebral palsy affected kids. For them, it will serve the dual function of learning through fun and improving their upper-limb motor functions.

References

1 Levin M F, Weiss P L and Keshner E A, Emergence of virtual reality as a tool for upper limb rehabilitation: incorporation of motor control and motor learning principles, *Phys Ther*, **95(3)** (2015) 415–425.

2 Wang Y and Aimin W, Augmented reality based upper limb rehabilitation system, *13th IEEE International Conference on Electronic Measurement & Instruments (ICEMI)*, IEEE, 2017, pp. 426–430.

3 Perez-Marcos D, Bieler-Aeschlimann M, and Serino A, Virtual reality as a vehicle to empower motor-cognitive neurorehabilitation, *Fron Psychol*, **9** (2018).

4 Maier M, Rubio Ballester B, Duff A, Duarte Oller E, and Verschure P F M J, Effect of specific over nonspecific vr-based rehabilitation on poststroke motor recovery: a systematic meta-analysis, *Neurorehabil Neural Repair*, **33(2)** (2019) 112–129.

5 Huang Q, Wu W, Chen X, Bo Wu, Wu L, Huang X, Jiang S and Huang L, Evaluating the effect and mechanism of upper limb motor function recovery induced by immersive virtual-reality-based rehabilitation for subacute stroke subjects: study protocol for a randomized controlled trial, *Trials*, **20(1)** (2019) 104.