Research on Rehabilitation Exercise Based on Virtual Reality Technology

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Abstract: This study applies Virtual Reality Technology to the rehabilitation treatment of patients who suffered from dyskinesia caused by brain diseases. First, samples of patients who suffered from acute stroke are randomly divided into a control group (traditional rehabilitation) and an experimental group (VR rehabilitation). Then, Participants are examined and evaluated from physical dyskinesia, body balance capacity and daily living skills before rehabilitation, at rehabilitation 4 weeks and 12 weeks respectively. Finally, statistical analysis of related data is made. According to the study, before rehabilitation, at rehabilitation 4 weeks and rehabilitation 12 weeks, the physical motor Furg-Meyer indicating gage score, Fugl-Meyer body balance functional score and daily living skill Barthel index of the experimental group are all higher than the control group. Thus, VR rehabilitation therapy can be effective in improving the physical dyskinesia caused by cerebrovascular disease and the daily living skill of the patient.

Keywords: virtual reality technology; motor rehabilitation; dyskinesia; motor training

1 Introduction

Virtual Reality Technology, based on the use of computers, is to create a virtual environment which simulates real life situations that a user is in and is interacting with through a variety of sensing devices[1]. Virtual Reality has the characteristics of immersion, interaction and imagination[2]. According to the degree of immersing, it can be divided into non-immersive, partial-immersive and complete immersive. According to its function of realizing virtual environment, it can be divided into desktop-like, immersive, distributive and mixed environment[3].

The scientific principles and advantages of the application of VR technology in rehabilitation treatment involve three key factors which are duplication, feedback and motivation[3]. Practice again and again is the initial factor of acquiring a motor skill. But only continuous practice is not enough. Patients must acquire feedback and experience of success gradually. Feedbacks provided by visual sense and sense of identity may enhance the correct behavior of the practicer in trying a mistake practice and maintain his motivation and enthusiasm and acquire pleasant emotional experience, thus encourage him to practice continuously until the acquaintance of this behavior. VR technology provides technological devices for the three key factors: repeated practice, achievement feedback and maintaining motivation. The advantage of the application of Virtual Reality to the rehabilitation training lies in that it can provide the patients who accept rehabilitation training with two feedbacks: RT feedback of each practice and group feedback. It will strengthen patients' sense of result-consciousness[4]. Moreover, through creating virtual environment, the tasks will be more entertaining and motivate the patients to practice repeatedly and maintain the motivation with various forms of feedbacks. A large amount of studies demonstrate that patients are able to learn the motor skills in the virtual environment and transfer these skills to the real environment in the real world.

At present, many foreign research groups have begun to apply Virtual Reality Technology in this field to conduct various studies and achieved certain clinical data and treatment effect. Holden, etc. first successfully applied Virtual Reality to the rehabilitation training of the patients who suffered from stroke. They developed a set of virtual rehabilitation system which enables the patients to consciously learn various physical movements through imitating the movements of the virtual teachers. A number of studies of Holden indicate that patients tutored by "virtual teacher" rehabilitated much faster. Burdea etc developed programs of rehabilitation training of the ankle. Several studies of theirs show that with the application of Virtual Reality Technology, the rehabilitation speed of ankle motor function of the patients is increased. In China, the application of Virtual Reality Technology to motor rehabilitation has also been practiced. Hebei University of Technology independently developed a program which applies Virtual Reality and Ectoskeleton Technology to the rehabilitation treatment of arm ectoskeleton. The virtual body building bicycle developed by Tsing Hua University can be used to train in the way of bicycle-driving and recover the damaged motor functions of the lower limbs[5].

Hemiplegia is one of the most common sequelae of stroke. It refers to reduction of muscle strength of one side of the body, motor inconvenience or complete disability, usually accompanied by sensory disturbance of the same side of the body. Based on the principle that

sensory stimuli and exercises will promote the recovery of the physical functions and strengthen the plasticity of cerebral cortex, the traditional stroke rehabilitation mainly adopt the therapy of physical functional training which promotes the establishment of normal motor posture, control the abnormal of the disease and recover the normal physical motor function. In the field of motor rehabilitation, the most important function of VR technology is the rehabilitation training of damaged motor functions. Whether the amount of exercise is suitable, whether the exercise is balanced, or whether the exercising style fits general living custom determines whether the rehabilitation training will succeed or not. Virtual reality can offer accurate measuring, aiding, supervising and training skills and guarantee the effect of motor rehabilitation training. Yet, up to now, the application of VR technology to the motor rehabilitation treatment after acute stroke has never been found.

In recent years, cerebrovascular diseases are becoming more popular each year. Its sequela is the complication commonly seen by patients of neurology and neurosurgery. In addition, after treatment, it is often accompanied by dyskinesia and affects the living quality of the patients. This study plans to apply virtual reality technology the treatment of patients who suffered from dyskinesia caused by brain diseases, and thus examine the rehabilitation effect of dyskinesia caused by cerebrovascular disease with the application VR rehabilitation.

2. Methods Applied

2.1 Examinee

The examinee chosen by the author are in-patients of Zhengzhou No.2 Renmin Hospital and the Fifth Affiliated Hospital of Zhengzhou University from April, 2008 to January, 2009 who suffered from angiocardiopathy and cerebrovascular diseases. All the participants are patients who suffer from stroke for the first time and who are diagnosed by the Diagnostic Criteria passed by the Fourth Cerebrovascular Disease Seminar in 1995 and whose illness are confirmed through brain CT or MRI. They all suffer from motor dysfunction, but no severe cognitive impairment and mental illness. Their illness has lasted for no more than 3 weeks, GCS≥8 points, and their vital signs are stable. Those who suffered from mental illness or dementia before stroke, or who suffered from severe cognitive impairment and aphasia accompanied by serious disease of the heart, lung, liver, kidney and other important organs, or who suffered from skeletal neuromuscular diseases affecting the functional recovery and could not corporate with the treatment are excluded. Sixty samples are selected randomly from the in-patients who meet the inclusion criteria and then randomly divided into control group (conventional rehabilitation) 30 samples and experimental group (VR rehabilitation) 30 samples. Among the 30 samples in the control group, there are 17 males and 13 females whole average age is (56.23±10). Among the 30 samples in the experimental group, there are 16 males and 14 females whose average age is (55.98±8.43). The statistical analysis shows that the differences in age, gender, pathological changes and muscle strength (before rehabilitation) of the patients make no significant difference. Thus, the two groups are comparable.

2.2 Experiment Procedures

The two groups are both treated with the medical treatment of Department of Neurology as the basic treatment, and then treated respectively with motor rehabilitation therapy and VR therapy when they have stable vital signs.

In this study, motor rehabilitation therapy is implied to the control group (conventional rehabilitation) patients. Its treating methods include：1) the display of good limbs on the bed; 2) posture change from time to time; 3) passive movements and active movements of joints of the affected limb; 4) turning over and sitting up exercises; 5) bridge-pattern exercises; 6) sitting and standing balance training; 7) getting up and standing exercises; 8) walking exercises; 9) ADL exercises. The key is that the motor functional rehabilitation should adopt different measures at different stages and should be done one to one by the therapeutist. Treatment will last 12 weeks, five days each week, twice a day and 45 minutes each time. VR therapy is implied to the experimental group (VR rehabilitation) with the use of desktop virtual reality biofeedback system. The implied rehabilitation equipments for the treatment are MyoTrac Train Miriam and Sunlight Tetrax Balancing Instrument. While MyoTrac Train Miriam selects corresponding rehabilitation program with the support of the MyoTrac Clinical software, Sunlight-Tetrax Balancing Instrument, with the same working principle of MyoTrac Train Miriam, adopts corresponding treatment according to the different balancing status of the patients. Treatment will last 12 weeks, five days each week, twice a day and 45 minutes each time.

2.3 Evaluating Criteria

Furg-Meyer motor function scale is applied to evaluating the recovery of the motor function of the hemiplegic limb of the patients before and post rehabilitation, and the Barthel index score (BI) score is used in the evaluation of the daily living skills ADL: the total is 100. The higher the score is, the more independent. Participants scored above 60 are nearly able to accomplish ADL. Those who scored 60-40 need help while those scored 40-20 need much help. Participants who scored less than 20 completely depend on help. The data of both groups are collected respectively before rehabilitation, at rehabilitation 4 weeks and rehabilitation 12 weeks.

2.4 Statistical Analysis

Statistical analysis is made in the database established by SPSS13.0 software package.

3 Results and Analysis

Table 1. Furg-Meyer Motor Function Scale Score of the Control Group and Experimental Group Comparison (x±s)

Group	Samples	Pre-rehabilitation	Rehabilitation 4weeks	Rehabilitation 12weeks
Control Group	30	120.56±3.12	131.69±3.75	160.43±4.09
Experimental Group	30	123.84±2.81	159.58±3.46	197.87±3.93

Note: Compared with the same group before rehabilitation， after rehabilitation 4 weeks，p<0.01；after rehabilitation 12weeks，p<0.01；compared with pre- and post-rehabilitation of the control group，p<0.05.

Table 2. Barthel (BI) Index Score of the Control Group and Experimental Group (x±s)

Group	Samples	Pre-rehabilitation	Rehabilitation 4weeks	Rehabilitation 12weeks
ControlGroup	30	28.97±12.10	50.45±13.97	68.21±17.49
Experimental Group	30	27.13±11.85	59.26±15.08	74.37±19.84

Note： Compared with the same group before rehabilitation， after rehabilitation 4 weeks，p<0.01；after rehabilitation 12weeks，p<0.01；compared with pre- and post-rehabilitation of the control group，p<0.05.

The statistical analysis shows that the differences in age, gender, pathological changes and muscle strength (before rehabilitation) of the patients make no significant difference. Thus, the two groups are comparable. The fact that the two groups reveal no significant difference in the initial evaluation of the Fugl-Meyer motor function score and daily living ADL-Barthel Index (BI) score indicates that as far as motor dysfunction and daily living abilities are concerned patients of the two groups are basically on the same level. But after the same period of rehabilitation treatment, the statistical analysis reveals that there are significant differences in the results（p<0.05）.Compared with the same group before rehabilitation, after rehabilitation 4 weeks, p<0.01；after rehabilitation 12weeks, p<0.01. The differences are significant. Compared with the control group after the same period，p<0.05, there are significant differences as well. The key theoretical basis of the rehabilitation of diseases of the nervous system is that the central nervous system has the capacity to reorganize structurally and/or functionally, i.e. the central nervous system has a high degree of plasticity. If the rehabilitation treatment is carried out at a early stage, it will promote bypass cycle, give full play to capacity of restructuring of the central nervous system, develop the plasticity of the cerebral cortex, promote the restore of the lost functions and reconstruct the normal motor model.

The fundamental purposes of rehabilitation training are to maximumly restore the damaged functions of the patients and improve the quality of independent living of the patients. Daily activities are an indispensible training program of motor rehabilitation. This demands that rehabilitation training environment as well as content and the real life should be closed connected so that the patients are able to transfer what they learned in the training to the real life activities. Virtural Reality Technology has its own merits in simulating real-life environment and providing daily living skill training.

The experiment and study also reveals that the application of virtual reality to motor rehabilitation training has its own un-comparable advantages. Compared with the rehabilitation training results in the real environment, the effect of motor skill learning and motor rehabilitation is much better. Virtual reality has the following advantages when it is applied in motor rehabilitation. Firstly, it provides a strong sense of active participation and creates a feeling of being immersive, thus, participants will naturally react with the objects in the virtual environment. Secondly, with exercise requirements being described through established process, or standard movements being demonstrated by virtual coach, the computer can be more patient and consistent than human coach, thus, patients can practice by imitating repeatedly through observation according to their own situation. Thirdly, virtual reality may simplify the training task, thus, reduce the danger caused by wrong operation in the real environment. Fourth, virtual reality may provide various forms of feedback, and offer encouragement, indication or recommendation to the patients according to their own state, thus, makes the boring and monotonous process of rehabilitation training easier and more interesting. Fifth, virtual reality allows the user to set the individual settings and combines the motor training, psychological treatment and functional evaluation better, thus, the patients' rehabilitation training plan is appropriately made in view of their actual situation.. Sixth, because the virtual environment and the real environment are quite similar, the motor skills acquired in the virtual environment may be easily transferred to the real environment.

4 Conclusions

This study finds that the application of virtual reality to the treatment of patients with acute stroke may effectively resolve the limitations of the conventional rehabilitation therapy. It not only provides the patients with realistic virtual environment to perform themselves, but also increase their motivation for treatment and rehabilitation. Compared with conventional rehabilitation treatment, it will be of great significance in improving the physical motor function and daily living abilities of the patients.

References

[1] Xu Maoyun,Lu Zhaotong,Liu Shijun. The progress of application of virtual reality technology in medicine. Practical Journal of

Medicine & Pharmacy, 2007, 24(11):1379-1381.
[2] Yang Yilu, Hu Ying, Liu Jihong, Xu Xinhe. Virtual reality technology and its application in modern medicine . Information and Control, 2003, 32(3):251-254.
[3] Tao Weidong, Sun Hongjin, Tao Xiaoli, Liu Qiang, Wu Lingdan, Luo Wenbo. Application of immersed virtual reality technology in psychology study. Progress in Modern Biomedicine, 2006, 6(3):58-62.
[4] Mou Changjun,Tong Zhiwei. The summarization of virtual reality technology and its application. Equipment Manufacturing Technology, 2007, 1:64-65.
[5] Zhou Liu, Wang Yinghua, Liu Qiang, Sun Hongjin. Application of virtual reality in motor rehabilitation. Journal of Clinical Rehabilitation Issue Engineering Research, 2007, 11(5): 957-960.