MOBILE REHABILITATION DEVICE FOR BALANCE TRAINING WITH VISUAL FEEDBACK

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Abstract

The use of modern technologies for the rehabilitation of patients with brain damage is a popular addition to conventional procedures. An interactive mobile system for the treatment of stability disorders was developed in Prague at the Department of Rehabilitation Medicine of the First Faculty of Medicine of Charles University and General Teaching Hospital in Prague in cooperation with the Joint Department of Biomedical Engineering of the Faculty of Biomedical Engineering at the Czech Technical University. The system may be used for the training of stabilizing mechanisms on an outpatient basis. It is particularly suited to practice in the home environment.

Keywords

balance training, stabilometry, visual feedback, home rehabilitation, brain damage

Objectives

According to the permanently increasing incidence of brain damage: 46000 patients with stroke and 23000 patients after traumatic brain injury (mostly young men between 18 to 35 years of age) in Czech Republic per year, the rehabilitation of these patients becomes more and more important.

Epidemiologic studies have shown that survivors of stroke are at high risk for falls in all poststroke stages. In the etiology of falls, stroke-related balance and gait deficits play an important role. [1]

Methods based on biological feedback are appropriately supplementing conventional rehabilitation procedures. Depending on the functioning of the natural senses that contribute to balance control, i.e. the vestibular, somatosensory, and visual systems, the biofeedback may be used as a substitute or as an augmentation in the central nervous system’s sensorimotor integration. [2]

Patients after brain damage often face situations (e.g. using escalators, orientation in city traffic, crossing the street) that can be possibly dangerous or even impossible to manage. For this reason we develop a stabilometric system with a set of training scenes so that patients can experience these situations without any risk. Commonly used gaming systems are not suitable for this purpose due to limited adjustability of difficulty and absence of diagnostics of current patient's health state.

Fig. 1: Example of training scene – crossing the street

Methods

The system consists of a stabilometric platform and a tablet or a console connected to a display device.

The stabilometric platform Wii balance board (WBB) contains 4 transducers, each in one corner of the plate. It is a portable, light weight device, primarily developed for gaming purpose. Nevertheless the WBB is applicable in the rehabilitation of patients and for objective evaluation of postural reactions. [3, 4] The sampling rate of the WBB is 80 Hz. It uses a wired connection to the base console (6-pin DIN connector). The weight limit is 150 kg.

Fig. 2: Stabilometric platform

The software contains the basic diagnostics and a set of therapeutic scenes. The device is based on the principle of using biological feedback. A patient standing on the stabilometer (platform) interacts by transferring their weight in front of a therapeutic scene on the display, on which he performs tasks according to instructions. The results are displayed immediately after the end of a therapeutic session, and it is possible to monitor these over the short- and long- terms. The patient will improve the mechanisms maintaining an upright, correct posture in an entertaining way, and find new limits to their stability within which they are able to move safely.

Before and after the therapy a diagnostics is made, the patient is examined by FootScan (FS) and Synapsys Posturography System (SPS) devices. In addition, BBS (Berg Balance Scale) and TUG (Timed Up and Go) tests are carried out.

The examination on SPS consisted of stance on a firm surface with open and closed eyes, stance on a foam surface with open and closed eyes. We used the standard stance with feet under 30 degrees angle. The examination on FS consisted of wide stance with opened eyes and stance with feet together with open eyes and closed eyes.

The postural response was characterized by displacement of the center of pressure. These stabilometric parameters were evaluated from the measured results: Amplitudes of stabilogram, length and area of statokinesiogram, root mean square of statokinesiogram and amplitude spectra of stabilograms. These parameters were statistically compared.

The therapy itself takes place in the patient's home environment daily and lasts four weeks. The participation of therapist is therefore no longer necessary. Each patient has the same exercise unit, so the exercise takes 15 – 30 minutes, according to their abilities. Every day, an indicative stabilometric examination is also conducted.

Results

The examined group of patients shows improvement, especially in dynamic stabilometric parameters. A survey has shown in the majority of patients an improvement of their condition in connection with the stability disorder which they reported before the treatment. An improvement of static stabilometric parameters is not conclusive.

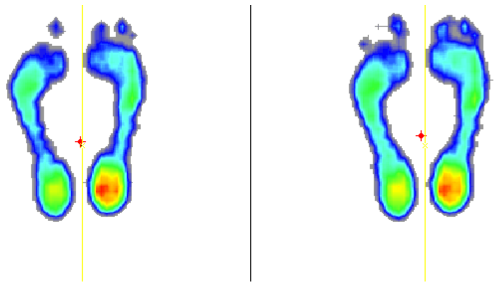

Fig. 3: The example of planograph before (left) and after (right) the 4 weeks home-based therapy shows a better weight distribution

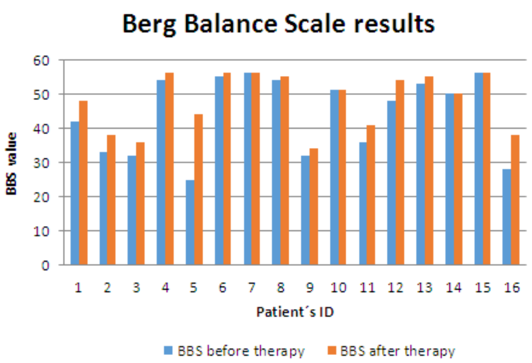

Fig. 4: Berg Balance Scale results

The mean improvement in BBS test in the examined group of patients was 12.3%. The mean improvement in TUG test was 7,1%.

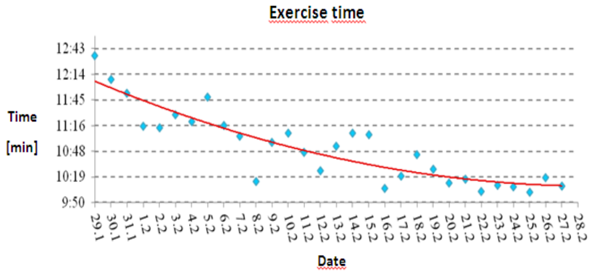

Fig. 5: Exercise time results in selected patient from the same training scene show acceleration of 2 minutes.

A system that allows the therapy of stability in the home environment has been used in a group of 16 patients after brain damage. Exercise at home is very comfortable. The patient practice daily at the appropriate time of day. The results are stored so that the therapist has control over the regularity of exercise. This form of exercise has its negatives. Therapist´s supervision is missing and there is a risk that the patient will practice incorrectly. Therefore, it requires a very thorough instruction before starting the whole therapeutic process. It is also important to consider for which patient is the home therapy suitable.

Conclusion

The use of the developed interactive system seems to be a tool suitable for treating patients with impaired stability. This system allows reducing frequency of outpatient therapy, increases the efficiency of rehabilitation, improves cooperation with patients, increases their confidence and activates the patient's normal daily routine. Patients get feedback on their current condition, which provides motivation for further stability training and also for the whole rehabilitation process, which is a long-term matter for patients with brain damage.

Acknowledgement

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References

[1] WEERDESTEYN, Vivian, et al. Falls in individuals with stroke. *J Rehabil Res Dev* 2008;45:1195-213.

[2] ZIJLSTRA, Agnes, Martina MANCINI, Lorenzo CHIARI a Wiebren ZIJLSTRA. Biofeedback for training balance and mobility tasks in older populations: a systematic review. *Journal of NeuroEngineering and Rehabilitation*. 2010, vol. 7, issue 1, s. 58-. DOI: 10.1186/1743-0003-7-58.

[3] BOHUNČÁK, Adam; TICHÁ, Marie; JANATOVÁ, Markéta. Comparative study of two stabilometric platforms for the application in 3D biofeedback system. In *ABSTRACTS OF THE 6 TH INTERNATIONAL POSTURE SYMPOSIUM*. Bratislava : Institute of Normal and Pathological Physiology, 2011. s. 21. ISBN 978–80–969544–9–0.

[4] CLARK, Ross A., et al. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. *Gait & posture*, 2010, 31.3: 307-310.

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