

INSOLE PRESSURE SENSOR-BASED AUDIO-BIOFEEDBACK FOR BALANCE IMPROVEMENT

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INTRODUCTION

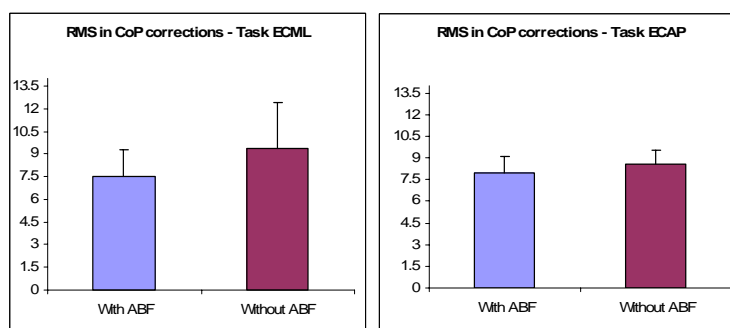
In motor rehabilitation, the use of biofeedback for improving postural sway and balance control is common. In most cases, the biofeedback is provided by a clinician or by an electronic system, and assists the subject with visual, oral or tactile information. Specifically, center of pressure (CoP) information has been used in many studies to provide visual biofeedback to patients with neurological diseases while standing on a force plate [1]. In this study, we recorded the pressure distribution beneath the subject's feet and provided CoP information to the subjects using audio-biofeedback (ABF). The final aim of this study was to evaluate the effect of CoP ABF in terms of sway reduction on healthy subjects.

MATERIALS AND METHODS

Four healthy subjects were asked to maintain balance on a wood roller with eyes closed in two conditions: with the roller tilting in (1) medial-lateral (ML) and (2) anterior-posterior (AP) direction. For each of the 4 subjects, we monitored the CoP position during 3 repetitions (48-s long) of each task performed with and without ABF in random order. Through a control application developed in LabView environment, we collected pressure data beneath the subjects' feet with a 100-Hz sample rate. Pressure data resulted from both compressive and shear forces which were acquired using a pair of flexible insoles with 24 embedded discrete piezoresistive sensors contained in a fluid-filled cell [Hydrocells, Paromed Inc]. Pressure data were stored and also real-time processed for calculating an estimation of the instant CoP. Finally, CoP was converted into a sound by means of the same algorithm used for the ABF system described in Chiari et al., 2005 [2]. In particular, this algorithm was able to feed back AP and ML CoP information to the subjects by modulating frequency, volume, and L/R balance of the stereo sound.

RESULTS AND DISCUSSION

Our initial analysis was based on the parameter root mean square distance (RMS) calculated on the CoP displacement in AP and ML direction combined. The Figure shows the RMS averaged values in the two tasks (left and right panel, respectively), with and without ABF. Error bars represent standard deviations. RMS values are reported in mm. ABF resulted in a 19.8% RMS reduction in the first task and a 7.3% reduction in the second task. We observed that in both tasks, using ABF, subjects were able to reduce their CoP displacement RMS. However, the ABF influence was higher in the first task than in the second one. These preliminary results suggest that this new-developed biofeedback pressure-insole-based system can be used to improve balance. Of course, an extended experimentation and a detailed statistical analysis using more CoP-based parameters will be necessary to further understand the influence of this ABF on subjects' balance.



REFERENCES

- [1] Shumway-Cook, A., Anson, D. and Haller, S., Postural sway biofeedback: its effect on reestablishing stance stability in hemiplegic patients, *Arch. Phys. Med. Rehabil.*, 69 (1988) 395-400.
- [2] Chiari, L., Dozza, M., Cappello, A., Horak, F.B., Macellari, V. and Giansanti, D., Audio-biofeedback for balance improvement: an accelerometry-based system, *IEEE Trans. Biomed. Eng.* 52 (2005) 2108-2111.

