

AUDIO BIOFEEDBACK AS A SOURCE OF BALANCE INFORMATION FOR VESTIBULAR LOSS SUBJECTS

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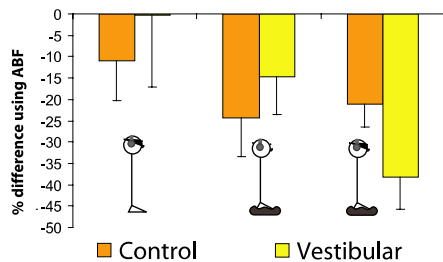
Although normal subjects maintain balance easily, balance is a critical task and involves interpretation and processing of complex information provided by vision, the somatosensory system and the vestibular system. In subjects with vestibular loss (VS), the lack of vestibular information makes every task in which stability is normally challenging extremely hard and makes balance challenging in many common life situations.

The purpose of this study was to investigate the possibility to give back to VS the movement information they are missing using a different sensory channel, the hearing. In particular, an audio-biofeedback (ABF) system able to represent anterior-posterior (AP) and medial-lateral (ML) body sway was developed and tested.

A portable sensor, measuring body trunk linear accelerations (along AP and ML directions), was mounted on the subjects' back at L5. A Matlab code was developed to acquire the information sensed by the accelerometers and to generate an appropriate sound in response to the body movements. Center of pressure (CoP) position was recorded using a force plate. ABF consisted of a stereo sound consisting of two different sine waves, modulated in frequency and volume. In particular, the frequency and volume modulation signaled the AP sway and the different balance between the two audio channels loudness signaled the ML sway. . The sound dynamics was processed as a function of anthropometric parameters. A 1 degree safety region around the natural posture of the subject was defined, where the sway was considered normal and the ABF consisted just of a pure tone with a very low volume. When the subjects were outside the safety region, the sound dynamics informed them about their movement and they were asked to correct it in order to find newly themselves inside the safety region.

The subjects, nine with profound bilateral vestibular loss function and nine control subjects (CS), gender and age matched, performed several trials standing on the platform with and without ABF. The effect of using ABF in different randomized conditions, such as eyes closed and standing on a foam surface, was investigated.

95 % confidence ellipse (Sway Area)



In conditions in which subjects stood on the foam with eyes closed, we found that, using ABF, subjects: 1) decreased their CoP sway area (23% CS, 38% VS, see figure); 2) increased the time that they swayed inside the safety region (103% CS, 196% VS); 3) decreased the mean displacement of CoP outside the safety region (16% CS, 25% VS).

In addition VS sway area was 67% larger than CS sway area without ABF but only 36% larger after using ABF.

Results with the same trend but quantitatively smaller were found in the other conditions mentioned above.

These results suggest VS take more advantage of the ABF than

do CS, probably because the ABF supplies them, at least in part, with the information they would have sensed if they had a healthy vestibular system.

Since using ABF VS behavior become closer to CS behavior the development of rehabilitation systems and balance prosthesis based on this ABF principle seems promising in the future.

References

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