IMPROVING WEIGHT BEARING ASYMMETRY IN UNILATERAL LOWER LIMB AMPUTEES BY USE OF AN INSOLE PRESSURE SENSOR-BASED ELECTRO-TACTILE BIOFEEDBACK SYSTEM

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The upright stance of persons with unilateral lower limb amputation is characterized by weight bearing asymmetry with more weight on the non-affected limb (e.g. [1]). Over the long term, asymmetric weight bearing can lead to complications, such as pain and premature arthrosis of the non-affected limb [2,3], as well as additional blood flow deficits in persons with vascular disease [1]. Within this context, training for symmetrical weight bearing represents an important issue in the rehabilitation of unilateral lower limb amputees. The purpose of this study was to assess the effectiveness of an insole pressure sensor-based electro-tactile biofeedback system in improving weight bearing asymmetry in lower limb amputees. To achieve this goal, the limb load asymmetry, representing the ratio of body weight fraction put on the more loaded limb to the less loaded limb, was measured in 20 unilateral lower limb amputees (10 transtibial and 10 transfemoral) and 10 able-bodies persons, when standing upright with their eyes closed in two conditions of No-biofeedback and Biofeedback. The No-biofeedback condition served as a control condition. In the Biofeedback condition, participants used an insole pressure sensor-based electro-tactile biofeedback system. This system comprised two major components: (1) a plantar pressure data acquisition system (FSA Inshoe Foot pressure mapping system, Vista Medical Ltd.), consisting of a pair of insoles instrumented with an array of 8 × 16 pressure sensors per insole, as the sensory unit; (2) a tongue-placed electro-tactile tactile output device (Tongue Display Unit) [4], comprising a 2D electrode array (1.5×1.5 cm)of 36 electro-tactile electrodes arranged in a 6×6 matrix, maintained in close and permanent contact with the front part of the tongue dorsum (e.g., [5,6]), as the tactile output unit. The underlying principle of the biofeedback system consisted of supplying users with supplementary information about their weight-bearing distribution through the Tongue Display Unit. The following coding scheme was used: (1) when weight bearing was determined to be equally divided between the two lower limbs, no electrical stimulation was provided in any of the electrodes of the matrix; (2) when weight bearing was not determined to be equally divided between the two lower limbs, electrical stimulation of either the left or right zone of the matrix (2×6 electrodes) (i.e. stimulation of left and right portions of the tongue) was provided, depending on whether more body weight was loaded on the left or right lower limb, respectively. Without the provision of biofeedback, results showed larger limb load asymmetry in lower limb amputees than able-bodies persons. Conversely, when the Biofeedback was available, lower limb amputees were able to drastically reduce their limb load asymmetry to reach a level similar to that observed in able-bodies persons. What is more, the biofeedback was shown to induce a greater effect in reducing the limb load asymmetry in individuals (transtibial amputees, transfemoral amputees and able-bodies persons) exhibiting the greatest limb load asymmetry in the No-biofeedback condition. The present findings evidence the effectiveness of an insole pressure sensor-based electro-tactile biofeedback system in improving postural asymmetry in unilateral lower limb amputees. Based on the encouraging results, this biofeedback system is currently being evaluated in more functional tasks, for the rehabilitation of pathologic gait pattern.

References

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