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New: the Maastricht SLS

Restoring balance and posture in patients severely handicapped by loss of vestibular function

M.J.A.Janssen[1,7],A.F.J.Aarts[6],A.J.Pas[5],R.v.Lummel[8],S.A.T.v.Pinxteren[2,7],Y.Janssen[3],R.J.Stokroos[2,7],J.S.H.Vles[4,7], H.Kingma[1,2,3,5,7]
[1]Dept. of Biomedical Engineering, [2] Division of Balance Disorders, [3] Movement Laboratory, [4] Dept. of Neuropediatrics, University Hospital Maastricht, [5]Faculty of Biomedical Engineering, BIOMIM, Eindhoven University of Technology, [6] Instrument Development Engineering & Evaluation, [7]Research Institute Brain & Behaviour, University Maastricht, [8]McRoberts sensor technology, the Hague

Aim of the study

Development of an artificial sensor to replace the function of the human labyrinths in case of an acquired complete vestibular areflexia.

Background

The vestibular labyrinths in the inner ear (two 3D accelerometers for translations and rotations) are by far the most sensitive organs to detect head motion and head orientation relative to gravity. Similar to the loss of either eyes or ears, the loss of both labyrinths leads to severe impairment and reduced quality of life. Patients fall frequently and are afraid to fall especially when walking on uneven ground, in shimmer or dark. All other senses are too slow to restore functionality by sensory substitution.

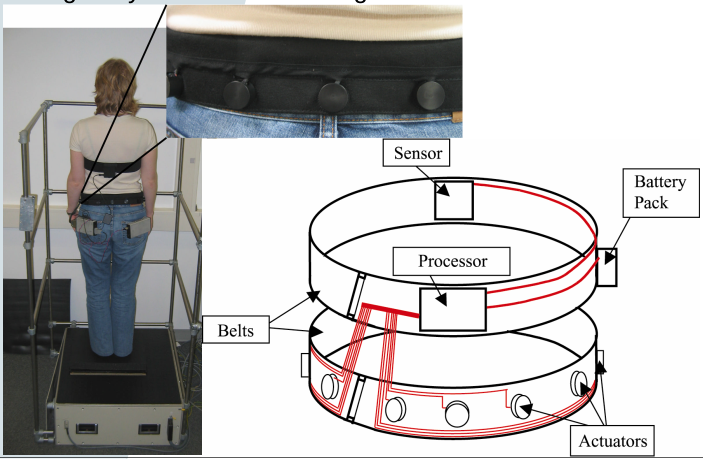
Substitution of labyrinths

At current no treatment is available. Replacement of the failing labyrinths by an artificial sensor and facilitating neuroplasticity in the vestibular system seem to be the sole option for treatment of these severely impaired patients. The electrical output of an artificial sensor can be decoded into a stimulus for other sensory modalities (e.g. tactile or visual) or directly connected to the labyrinth or vestibular nerve (a vestibular implant).

SLS

A Somato-sensory Labyrinthine substitution System (SLS) is engineered by modeling the vestibular system and developing an artificial sensor and vibro-tactile belt [1].

- Sensor: 3 linear capacitive accelerometers
- Actuators: 12 equally distributed eccentric vibrators
- Processor: translates sensor output into vibrations, thus coding body tilt and rotation angles



Method

The impact of the SLS on balance control is analyzed in 18 patients with vestibular areflexia or severe hyporeflexia by stabilometry (static posturography, on a force platform) and video recording of slow tandem gait.

Results

In 8 patients with the most severe complaints static body sway in an unstable situation is significantly ($p < 0.05$) decreased using the SLS with the sensor mounted on the trunk. The first results of the detailed gait analysis confirm a striking improvement in performance too.

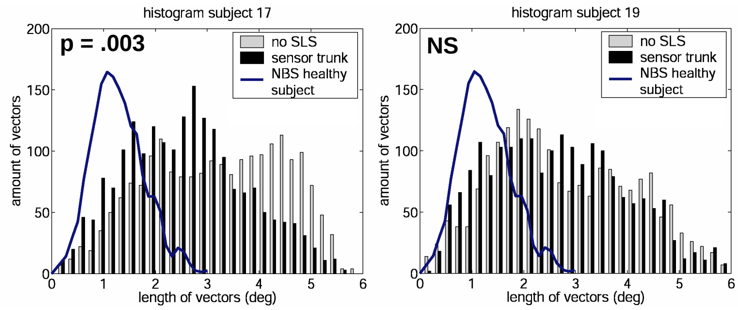


Figure 2: Static body sway quantified using length of vectors, which indicate movement from midpoint compared to the natural body sway (NBS) of healthy subjects. The SLS significantly decreases static body sway for subject 17, not for subject 19.

Discussion

The impact of the SLS varies among individuals, most likely due to differences in neuroplasticity. Therefore, the usefulness of the SLS differs per patient.

Conclusion

The SLS clearly improves balance in stance and during walking in severely vestibular handicapped patients. This non-invasive prosthesis is now being optimized for regular use in patient care. Based on these promising results we also decided to continue the development of a vestibular implant where the electrical output of the artificial sensor after decoding can be directly connected to the labyrinth or vestibular nerve. Regarding the latter option we recently developed a special technique to monitor the remaining sensitivity of patients to electrical stimulation necessary to select patients for a possible implantation [2].

References:

[1] Pas AJ et al. (2005) *De SLS, een kunstmatig evenwichtsorgaan*, Klinische Fysica
[2] Balter SGT (2004) *Galvanic-induced Body Sway*, ISBN 90-5278-415-9

/department of biomedical engineering

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