PhD of industrial Engineering
Research activity of interest for medicine

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« Neuropsycology and postural disease as marker of early diagnosis of dementia »

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The maintenance of balance, rhythm and stability, which are necessary for good-quality ambulation, requires a complex control-system, based on the cooperation of several sensory systems (visual, vestibular, sensitivity systems).

Multi-sensory integration supports improved perception and choice of appropriate movements and promotes motor-responses that are consistent with each situation.
ELDERLY:

- Reduced muscular strength;
- Inability to rapidly respond to postural changes.

Balance-disorder:

- Cognitive aging
- Sensory/motor-system impairment
Executional functions and attention are critical for postural control and are a main cause of the instability.

Cognitive aging

Cognitive-postural dual task

Primary postural task

Secondary cognitive task
If both tasks are enough difficult and require complete control, the attention-ability of the individual is over-challenged and the latter is therefore unable to complete the two tasks simultaneously.

Elderly patients = Priority to postural tasks  
(posture first)

Young patients = Priority cognitive task  
(cognitive first)
Could cognitive training, aimed at improving some cognitive functions, improve posture?

Cognitive training:

- Complex memory or attention-based tasks
- Combined memory and attention tasks

...Involving executional functions
Functional training based on dual tasks improves:

- The ability to complete dual tasks
- The attention-control in advanced age

... Benefits may also regard other cognitive processes (ADLs)

This mechanism is probably due to the fact that faster information-processing and faster cognition-experiences like focusing, inhibition and divided attention-management, which is achieved through cognitive-cognitive dual task, can positively influence the sensory processes which are necessary to maintain balance.
Because of the positive impact of cognitive training on cognition and executional functions and, consequently, on ambulatory performance, we believe that cognitive training can positively influence postural control.

Cognitive training and the related measurements are based on the use of methods like the Quali Gate Analysis, static and dynamic baropodometry, feedback systems etc. which can be further improved with the help of engineers in view of more specific goals.
Posture and feedback systems: Parkinson's disease

The rehabilitation program of the motor disturbances induced by the Parkinson’s disease always includes a series of exercises concerning the control of postural changes.

The posture in Parkinson's is characterized by:

- Decline in dorsal portion
- Rigidity of the neck
- Reduction of the lumbar lordosis
- Reduction of the respiratory capacity
- Hypertonicity, rigidity and bradykinesia
- Postural instability
In recent years, thanks to the strong contribution of biomedical engineering, postural re-education has been integrated with the administration of sensory stimuli (both visual and acoustic) that are beneficial to patients in terms of attention- and cognitive improvement in the postural and proprioceptive field. To this purpose feedback-tools play a useful role.

**POSITIONAL BIOFEEDBACK**

Therapeutic instrument designed to control motion through acoustic and visual information. The purpose is to instruct the patient to recognize incorrect posture and to correct it. This because bfb provides the patient with information on already adopted trunk-compensation and will help them become aware of proper position.

**COMPUTERIZED PLATFORM**

An evolution of the Freeman’s tablet. It generates information on the degree of impairment of the proprioceptive sensitivity of the patient.
POSITIONAL BIOFEEDBACK

The patient is exposed to a preliminary positional BFB session, which is useful to learn the exercise and also to evaluate the spinal range of emotion of the patient and the compensation already achieved. The patient sits at the table with the laser pointer on their sternum and gas-inclinometer on their forehead. Both devices must be parallel to the ground. The sound-feedback is given by the inclinometer, while the patient keeps the laser beam on a predetermined point of the whiteboard. If the inclinometer does not activate the sound it means that the position is correct and that the patient must keep and learn it. Subsequently, the patient is trained to perform breathing exercises with synchronous movements of flexion and dorsal extension. Later on, advanced exercises with the tablet for the lumbosacral junction and the antenna periscope are administrated.

A table with a whiteboard, a periscope antenna, a laser pointer, gas-inclinometer and an electrical device with a feedback detector is connected to the laser pointer, that features inputs for cables that activate the sound or visual feedback (LED).
We carried out a study on PD patients graded 1.5 and 2.5 on the Hoen and Yahr scale. Each patient completed 3 cycles of 20 sessions respectively, with a daily frequency, for 25 minutes per treatment with follow-up at 4 months.

The results were:
• Improved ADLs and motor activities;
• Improved low back pain;
• Increased patient-self-correction ability.
COMPUTERIZED PLATFORM

The postural rehabilitation program must also be integrated with a training for the recovery of proprioception.

The monitor shows the pathways that patient has to follow. Visual feedback helps the patient make a comparison between what they feel and what is seen on the monitor. The platform provides us with information on the proprioceptive sensitivity of the patient, the percentage of load on each half of the body or on the pelvis and also on the perception of the degree «0» defined as «position-center»

The tool is able to electronically transduce even the slightest movements made by the platform into electrical impulses, that are then sent to a computer which processes the data and projects them on a monitor in the form of a chart.
We carried out a study on PD patients using the computerized platform. A group of ten patients graded 2-3 Hoehn and Yehar. Each patients completed a cycle of 20 sessions with a frequency of 5 days per week, with a follow-up between the 45th and the 55th day after the end of the treatment.

The results of the study were:
• Reduction of vertebral pain, from a scale vas average of 6.6 to 2.8;
• Improved perception of the center;
• Improved vertical alignment between the spine and pelvis;
• Improvements to the BBS: better stability, turning pelvis, and transfers.
Our studies emphasize the importance of feedback systems, as well as of the integration of bioengineering-and rehabilitation-sciences, and how efforts in this direction can positively affect the lives of millions of patients who every day fight for their autonomy. Engineering and rehabilitation-medicine travel on parallel paths that, we hope, will intersect more and more.
Thanks for your attention!