

Medical Devices Assess, Treat Balance Disorders

Originating Technology/NASA Contribution

You may have heard the phrase “as difficult as walking and chewing gum” as a joking way of referring to something that is not difficult at all. Just walking, however, is not all that simple—physiologically speaking. Even standing upright is an undertaking requiring the complex cooperation of multiple motor and sensory systems including vision, the inner ear, somatosensation (sensation from the skin), and proprioception (the sense of the body’s parts in relation to each other). The compromised performance of any of these elements can lead to a balance disorder, which in some form affects nearly half of Americans at least once in their lifetimes, from the elderly, to those with neurological or vestibular (inner ear) dysfunction, to athletes with musculoskeletal injuries, to astronauts returning from space.

Readjusting to Earth’s gravity has a significant impact on an astronaut’s ability to balance, a result of the brain

switching to a different “model” for interpreting sensory input in normal gravity versus weightlessness. While acclimating, astronauts can experience headaches, motion sickness, and problems with perception. To help ease the transition and study the effects of weightlessness on the body, NASA has conducted many investigations into post-flight balance control, realizing this research can help treat patients with balance disorders on Earth as well.

In the 1960s, the NASA-sponsored Man Vehicle Laboratory at the Massachusetts Institute of Technology (MIT) studied the effects of prolonged space flight on astronauts. The lab’s work intrigued MIT doctoral candidate Lewis Nashner, who began conducting NASA-funded research on human movement and balance under the supervision of Dr. Larry Young in the MIT Department of Aeronautics and Astronautics. In 1982, Nashner’s work resulted in a noninvasive clinical technique for assessing the cooperative systems that allow the body to balance, commonly referred to as computerized dynamic posturography (CDP). CDP employs a series of dynamic protocols to isolate and assess balance function deficiencies. The technology was based on Nashner’s novel, engineering-inspired concept of balance as an adaptable collaboration between multiple sensory and motor systems. CDP proved useful not only for examining astronauts, but for anyone suffering from balance problems. Today, CDP is the standard medical tool for objectively evaluating balance control.

The effects of space flight on astronauts’ ability to balance has long been a focus of NASA research. This 1964 photo shows a NASA scientist testing astronaut John Glenn’s inner ear balance mechanism by running cool water into his ear and measuring the effect on Glenn’s eye motions.



Partnership

In 1984, Nashner founded NeuroCom International Inc., headquartered in Clackamas, Oregon, and continued his research to refine the clinical role of CDP. Within 2 years, the company had developed the EquiTest, the first commercially available CDP device. NASA has employed NeuroCom’s CDP systems for its research and continues to use EquiTest for the routine evaluation and balance rehabilitation of its astronauts at Kennedy Space Center and Johnson Space Center. NeuroCom’s EquiTest and Balance Master systems—the latter created based on CDP concepts to meet increasing demand from physical therapists—were first featured in *Spinoff* 1996.

“When I joined NeuroCom in 1988, the concepts of a systems approach to balance and vestibular rehabilitation were basically unknowns,” says Jon F. Peters, Ph.D., NeuroCom’s vice president and general manager. “Researchers were keen on the ideas, but it wasn’t common practice. Out of Dr. Nashner’s work grew a whole new approach for looking at these problems.”

Product Outcome

NeuroCom now has over 2,000 systems in use around the world in a variety of medical fields including neurology, geriatrics, otolaryngology (ear, nose, and throat specialists), orthopedics, and sports medicine.

Under the Balance Manager concept, NeuroCom’s products are cast into two broad categories: systems based on either dynamic or fixed force plate technology. NeuroCom’s dynamic models, which include EquiTest, SMART EquiTest, SMART Balance Master, and PRO Balance Master, offer the ability to control the support surface as well as the visual surround. The patient stands on the system’s dynamic force plate, a platform that shifts while recording the vertical forces applied by the feet as the patient attempts to maintain balance. Supported by a safety harness to prevent falls, the patient faces into the booth’s three-sided visual surround, which also tilts to

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test the visual component of the patient's balance mechanisms. The system provides comprehensive reports that identify sensory and motor impairments and allow for comparison to normal data for the patient's age range. The information gathered can be teased apart, says Peters, to help understand where the patient's balance problems lie. The same

system can then be used in a biofeedback mode (a video screen provides visual biofeedback), retraining sensory and motor systems to regain balance control.

NeuroCom's fixed force plate models include the Balance Master and Basic Balance Master systems, which have a physical therapy focus and help identify specific daily performance issues and possible underlying sensory and motor impairments affecting balance. A stroke patient, for example, can be examined using a fixed force plate system to see what movements (getting up from a chair, for example) are contributing most to the patient's difficulty. After therapists identify the problem, they can then use visual biofeedback to help the patient learn new cues to perform tasks more safely.

All of NeuroCom's systems can be enhanced with optional protocols and capabilities. Among these is the *inVision* package, which measures changes in a patient's visual acuity as a function of balance and head motion. The electromyography option analyzes the response of a patient's gastrocnemius and tibialis muscles (both located in the lower leg) to unexpected external balance challenges. The NeuroGames package provides video games like Solitaire and NeuroPong that offer a fun way to rehabilitate balance control. Patients play the games on a Balance Master or SMART EquiTest system by shifting their center of gravity to control the action.

The versatility of the technology is essential; even patients with the same diagnosis, like Parkinson's disease,

can suffer from different balance impairments with different immediate causes. The same applies to the elderly. While about one-third of Americans over 65 experience falls each year according to the National Safety Council, the impairments that lead to these falls vary. The balance analysis and therapy offered by NeuroCom's NASA-developed technology can help reduce the Centers for Disease Control and Prevention's estimate of over \$19 billion spent each year to treat fall-related injuries.

The company continues to push its technology into new clinical realms, says Peters. "Applications have gone well beyond patients with vertigo and dizziness," he notes. The company is exploring the relationship between balance disorders and cognitive issues like learning problems and attention deficit disorder. Peters says NeuroCom looks to sources like NASA as "guideposts for our efforts."

"Because NASA has to deal with the complex problems of flying people in space," he says, "their research tends to be more applied and closer to what we need to take hold of and put into general medical practice." ❖

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Developed from balance assessment research supported with NASA funding, NeuroCom's systems provide a versatile range of balance analysis and therapy options.