IS FOUNTA

The pendulum drop: could this new measurement technique revolutionize physical therapy?

THE IN OF YOUTH OBSOLETE?

(MAYBE NOT, BUT BIOMEDICAL ENGINEERS ARE MAKING IT EASY TO AGE GRACEFULLY)

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THE FIRST WAVE of baby boomers has now passed the over-fifty milestone. The majority are not going gently into that good night but instead are facing middle age with a certain defiance. The generation born between 1945 and 1962 will no doubt make significant changes in the way older adults live.

"Our demographics are changing very rapidly and the population is shifting. The percentage of people who are aging is increasing while the percentage of those under age twenty is decreasing," says Norbert L. Elliot, professor of the Department of Humanities and Social Sciences. "By 2025, worldwide life expectancy, which is currently at sixty-six years, is expected to be seventy-three years. Two out of three babies born in 2025 will live to be at least seventy-five."

PHOTOS: BILL WITTROP

Americans will fare better, according to the National Center for Health Statistics. Babies born in the United States in 1998 can expect to live to 76.7 years. By 2030 there will be seventy million people older than 65, or about 20 percent of the population.

To most people, these statistics are encouraging. Medical breakthroughs, advances in technology, social improvements and successful public health initiatives are responsible for our increasing life expectancy. Most of us would gladly accept a long life, if it were productive, fulfilling and healthy. What we fear is longevity fraught with debilitating mental and physical conditions and social isolation. To paraphrase singer Neil Young, most of us would probably rather burn out than fade away.

The challenge, then, for physicians, engineers, social scientists and architects is to find ways to make old age more comfortable and satisfying. Richard Olsen, director of the health and aging division of NJIT's Center for Architecture and Building Science Research, for example, has significantly improved the lives of people with Alzheimer's disease through Media Memory Lanes, a device providing people who have lost the ability to operate a CD player, tape deck or VCR with access to nostalgic music and videos. He and his collegue Lynn Hutchings, research architect at the center, have been instrumental in helping people adapt their homes to meet the needs of elderly loved ones. Most recently, he has focused on the needs of forty-five developmentally disabled aging adults living in group and supportive homes. His goal is to enable them to age in their current residences more safely and independently.

"Simple changes — such as providing better storage and lighting, fixing windows and furniture, and installing grab rails in the bathrooms — can go a long way," he notes.

At NJIT, biomedical engineers are also researching ways to improve the lives of people with acute and chronic illnesses associated with aging.

Beyond Your Grasp

Most of us take for granted the ability to perform our morning routines. When the alarm goes off, we get out of bed, stumble to the bathroom and jump into the shower, where blasts of water help start the day. Then it's back to the bedroom to get dressed and out to the kitchen for breakfast. But what if the simple task of buttoning your shirt were beyond your grasp? What if you could no longer bring a spoon to your mouth to eat your cereal?

For patients who have suffered a stroke, the third leading cause of death in the United States and one of the major contributors to disability, according to the American Heart Association, these tasks are no longer something to be done without thought. Instead, they are hurdles to overcome in the fight to retain one's dignity and independence. Although a person can suffer a stroke at any age, the majority of those who do are over sixty-five, a time when that fight has sometimes already begun.

Many patients know that physical, occupational and speech therapy will improve their ability to function. Getting them to perform the required repetitive actions, however, is one of the challenges of such traditional therapy, says Michael Recce, associate professor of biomedical engineering and mathematics and founding director of the university's Center for Computational Biology and Bioengineering. In order for a brain that has been damaged by stroke to improve functioning, exercises must be repeated over and over again. This can be difficult in a hospital or outpatient facility, where a typical physical therapy session might last only one hour per day for a limited number of weeks.

Could a Hand Game Help?

Recce has had success rehabilitating stroke patients as long as several years after they have completed physical therapy. By using a virtual reality system involving a device called a data glove, he and co-investigator Alma Merians, chairwoman of developmental and rehabilitative sciences at the UMDNJ School of Health Related Professions, have helped patients regain their ability to perform daily tasks.

"People love video games," says Recce. "That's why we believe that the data glove holds great potential for rehabilitating stroke patients. It replicates video games that people like to play over and over again."

The therapy utilizes a linen glove, into which thin sensors have been imbedded. A cable from the glove's wrist area is connected to a computer. "The patient puts his or her hand into the glove and performs a series of exercises that develop and strengthen the muscle groups needed to perform tasks," says Recce.

The patient's own hand controls the action on the screen. "Patients win 80 percent of the time, which makes it fun," he adds.

Once the patient dons the glove, a corresponding image of a hand appears on the computer screen. Certain fingers are highlighted in fluorescent green.

The patient moves the highlighted fingers in a prescribed manner.

For range of motion skills, as the patient's fingers move, they wipe away a curtain of solid color on screen to reveal a beautiful image. For independence of motion, the patient attempts to move fingers so that on-screen, they press the keys of a piano. Touch the wrong key and a discordant tone sounds. Speed in motion exercises include scaring away a butterfly on the screen in the same manner. Therapy to recover force of motion function requires patients to use four fingers (no thumb) to push buttons down.

"We expect that with the additional hours of therapy, patients will be rehabilitated more successfully," says Recce. "We have seen it in patients who are now able to perform daily tasks that they once couldn't do."

Recce's goal is to eventually design and build an inexpensive home-based system that patients can download into their computers, giving them the ability to follow a prescribed course of therapy in their own homes, at whatever hours suit them.

Shake It Up

The hand glove is not the only way that research at NJIT benefits people who have suffered strokes.

A stroke attacks one side of the brain, negatively affecting the other side. Typically, the patient experiences stiffness of the legs and arms that causes difficulty moving, including walking and reaching. This condition, called spasticity, interferes with the normal activities of the muscles.

In a healthy patient, the body has a feedback system that makes use of sensors in the muscles. When

Cyber rehab: computer games replace traditional therapy

ALUMNI WATCH

DESIGNING BETTER FRACTURE FIXERS

Many patients who fracture bones must undergo surgery to repair them, requiring an orthopedic surgeon to place plates, nails, screws or pins into the bones to help them heal. Because these devices can cause pain or stick out from under the skin, patients sometimes undergo a second round of surgery to have them removed. To avoid this, engineers have been experimenting with biomaterials.

Barbaro J. Perez, who holds a B.S. in mechanical engineering from NJIT ['92], an M.S. in biomedical engineering from NJIT ['95] and an M.D. from UMDNJ-New Jersey Medical School ['99], has conducted research at the Hospital for Joint Diseases in New York City to evaluate the mechanical properties of a new biodegradable composite material. It consists of a polymer made of a tyrosine-derived polycarbonate mixed with calcium phosphate fibers to increase strength. This composite material is absorbed by the patient's body, making surgery to retrieve the implant superfluous.

"We found that the composite material was fine for making pins, which are used to repair small bones, but lacked the necessary strength for the large plates and nails used for long bones," says Perez, who is now a third-year orthopedic surgery resident at Albany Medical Center. He selected his specialty in part because all of the implants used in orthopedic surgery are designed by mechanical engineers in concert with orthopedic surgeons.

muscles are stretched, these sensors send signals to the spinal cord that tell the muscles to contract. The muscle then pulls back to an erect position, a natural give-and-take that helps us stand and keep a sense of balance.

A stroke disturbs the sensors, resetting them to a higher sensitivity. The slightest movement triggers the sensors, causing them to overreact. This hypersensitivity causes stiffness and spasticity.

"Patients [with spasticity] have reported that they move better after horseback riding or boating, two activities that cause the body to go up and down," says Recce. He and a colleague, a fifty-year-old man with cerebral palsy who experiences spasticity, are collaborating at the A.I. DuPont Hospital in Delaware on a device called a vertical vertibular table that literally shakes a patient while he or she lies on it.

A larger issue with spasticity is measurement. In order to really treat spasticity effectively, the physician or therapist needs to know the degree of spasticity the patient experiences so that the treatment can be tailored properly.

That is where Richard Foulds, associate professor of biomedical engineering and associate chairman of research for the department, comes into the picture. He is the principal investigator of a team of NJIT researchers now completing studies at the Kessler Institute of Rehabilitation in West Orange, New Jersey, that may lead to a more accurate way to measure spasticity.

"Using a simple technique called the pendulum knee drop — where we hold a patient's affected leg out straight and let it drop and swing — we have developed a mathematical function that describes the spasticity of the movement that occurs during the drop and separates this from other movements that the patient's leg makes," says Foulds. His research associates include James Fee, a research engineer and doctoral candidate at NJIT, and Sue Ann Sisto, director of the Human Performance Laboratory at Kessler.

According to Foulds, this new way of measuring spasticity is a great improvement over the Ashworth Scale, used for many years. The Ashworth Scale subjectively measures the amount of resistance a patient's joint demonstrates when manipulated manually by a physical therapist.

"With a modest outlay of a personal computer and about two thousand dollars worth of software for the pendulum leg drop assessment, physical therapists can objectively measure spasticity, which in turn means better treatment for patients," explains Foulds.

The ultimate goal of Foulds' research, however, is to answer the question that has baffled researchers: Why does the simple motion of shaking up and down seem to reduce spasticity in some patients?

As Recce remarked, "If we can figure out what happens in the brain when spasticity occurs and why shaking helps, then maybe we can design something to stop the trigger and prevent spasticity."

Health Beat

Hand-in-hand with the fear of stroke is anxiety about heart healthiness. For the past twenty years, Stanley Reisman, professor of biomedical engineering, has been collaborating with researchers at the Veterans Affairs Medical Center in East Orange, New Jersey,

to explore the role of heart rate variability in health and disease.

Heart rate variability measures the variation in time between heartbeats. It is not constant and decreases with age and disease. Less variation in the time between heartbeats is called lower heart rate variability; more variation is called higher variability. Reisman and his co-investigators have been studying patients with various illnesses and conditions, including stroke, multiple sclerosis and spinal cord injuries. He is currently setting up a study to evaluate heart rate variability in patients at UMDNJ-University Hospital with heart failure and syncope.

A major study ten years ago by Columbia University researchers evaluated one thousand patients who had each experienced a heart attack. It measured their respective heart rate variabilities and the time lapse before a second heart attack. Patients with a lower heart rate variability enjoyed less time before the next heart attack.

"This goes against what you would think, that a steadier heartbeat is better," points our Reisman. "Yet the study proved that a higher heart rate variability is a measure of wellness."

Reisman has conducted several research studies since seeking ways to increase heart rate variability. His findings: relaxation techniques such as biofeedback and cyclical exercises work.

"Traditional exercises such as jogging on a treadmill for twenty minutes actually decrease heart rate variability," says Reisman. "Cyclical exercises, which build the heart rate up and then let it recover quickly when the patient stops cold, are a radical approach but they increase heart rate variability." The patient typically exercises for about one minute, then stops and lets the heart recover for about eight minutes. This technique is repeated four times in a forty-five-minute period.

Perhaps Reisman should spread the word among personal trainers at the local gym.

There's No Place Like Home

Whatever conditions and chronic ailments accompany aging, most older adults want to remain in their own homes for as long as possible. Richard Greene, Becton Dickinson Professor of Health Care Technology, may be their salvation. His role is to develop partnerships between the engineers at NJIT and physicians at UMDNJ-New Jersey Medical School so that they can bridge the gap between engineering and clinical health care.

An initial project is a tele-medicine system that will help nurse practitioners monitor patients with chronic diseases who have just been discharged from the hospital and are at risk of returning. Patients with congestive heart failure, a condition that routinely sends them back and forth to hospitals and emergency rooms, would be first in line to try this new technology.

"If these patients do not take their medications properly, monitor their salt intake or keep their clinic appointments, they are likely to be re-hospitalized," says Greene. "If we can keep abreast of their conditions, we can intervene with medical treatment before they end up back in the hospital. We would have an effective and cost-effective system to maintain patient health."

Greene's system features an inexpensively designed television monitor through which a nurse practitioner sees and talks with the patient. The patient wears a wristwatch connected to a device that transmits pertinent information, such as blood pressure and EKG results. The nurse could watch the patient take medications and observe his or her physical condition. The nurse could even have the patient step on a digital scale that would transmit the patient's weight.

Greene says such a monitor could be tailored to the individual patient's needs, adding glucose monitoring for a diabetic or a device to check blood clotting levels in someone on Coumadin, a blood-thinning medication. He points out that monitors similar to this design are used routinely in Germany, but that they are very expensive.

"Our challenge is to have NJIT engineers design a monitor in the five-hundred-dollar range so that it could be economically feasible for most," says Greene.

Taking the Lead

As the century progresses and the population ages, it's scientists like these, who bridge the gap between medicine and engineering, that will lead the breakthroughs and improve the health, and ultimately the lives, of people in their seventies, eighties and beyond.

"In biomedical engineering, it is essential that we work as a team with the health care professionals," urges Greene. "We can each focus on our areas of expertise, but we must come together to create the devices of the future. All of this is possible at NJIT because of the partnerships we have developed over the years and new ones we are pursuing with leading medical institutions." ■