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Spc. Heath Isome is scanned for bone density and geometry on the peripheral quantitative computerized tomography machine in the bone health lab. Photo by Sarah Underhill

Army Lab Tackles Problem of Military Stress Fractures

By Curt Biberdorf
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NATICK, Mass., May 19, 2004 – Stress fractures caused by repetitive pounding activities of physical training take a toll on enough of the military population, specifically recruits, that a major research program called "Bone Health and Medical Military Readiness" was started in 1997 to solve the problem.

With a collection of the latest research tools acquired in the past year, the U.S. Army Research Institute of Environmental Medicine's bone health and metabolic laboratory at the U.S. Army Soldier Systems Center here is ready to examine its piece of the puzzle.

"The goal of the whole program is to ultimately eliminate stress fractures," said Maj. Rachel Evans, a research physical therapist and director of bone health research. "Stress fracture cases have been reported since the late 1800s, and today are one of the most common and potentially debilitating overuse injuries seen in military recruits, particularly in women."

Stress fractures are overuse injuries that occur when muscles transfer the overload of strain to the bone, most commonly in the lower leg, and cause a tiny crack. They're tricky to see on X-rays, and they disrupt physical training, sidelining troops while costing the Defense Department as much as $100 million annually in medical costs and lost duty time, according to Evans.

Funded in part by Congress through the advocacy efforts of the National Coalition for Osteoporosis and Related Bone Diseases and the American Society for Bone and Mineral Research, and managed by USARIEM, overall research is multi-faceted, examining factors such as gait mechanics, impact attenuation and genetics. USARIEM research physiologists are studying specifically how exercise and nutrition influence stress fractures.

"A systematic approach to the study of stress fracture was needed, but hadn't been done," Evans said. "With this focused effort, and recent breakthroughs in technology, we're hoping to come up with science-based strategies to identify individuals at risk for stress fracture, and then prevent their occurrence through innovative training interventions."

Col. Karl Friedl, USARIEM commander, led a study on bone health earlier in his career at Fort Lewis, Wash., and said the understanding of bone physiology is significantly advancing and has widespread ramifications on health.

"There has been no program in the DoD that paid attention to bone health in the past," Friedl said. "Anything we can provide has the potential to save millions of dollars and enhance readiness through reduction in lost duty time, attrition from the military and medical cost avoidance. We want to avoid occupationally- induced stress fractures now, and osteoporosis and osteoarthritis later."

Noninvasive methods of studying bone health at USARIEM started in the early 1990s with the first dual energy X-ray absorptiometry machine to measure bone density. Still in the lab, the older DEXA machines have been superseded by the superior software and scanning times in a new Prodigy fanbeam bone densitometer, according to Robert Mello, a research physiologist and the lab director.

The Prodigy scans total body bone density in 5-inch instead of 1-inch increments, increasing precision and cutting scan time from 30 minutes to six minutes. Improved software provides a clearer picture of total body composition and bone mineral density.

"We can look at regional areas of interest, such as sections of the tibia, forearm or hip," Mello said. "Before, you had to scan an entire area. Just to have that capability is a major advance."

The Prodigy also allows researchers to scan small animals for studies on bone health, Evans said.

While the Prodigy gives a front-to-back, two-dimensional view, the peripheral quantitative computerized tomography machine allows researchers to analyze 3-D cross sections of spongy and outer bone. It's designed to reconstruct a volumetric model of bone, from which bone density, and for the first time, bone geometry, can be determined, Evans said.

"We can now look at cross-sectional images where stress fractures are most common," she said. "There's also software to quantify muscle mass at that point."

Another scanning instrument is the handheld ultrasound bone sonometer, which examines bone quality by measuring the speed of sound of ultrasonic waves axially transmitted along the bone.

The results can then be used as an aid in the assessment of bone strength. "We can identify bones that may be at risk," Mello said. "The big thing is the portability so that it can easily be taken to the field."

To help understand the relationship between muscle mass and bone strength, the lab purchased an isokinetic dynamometer to assess muscle strength and endurance for the major joints of the body, except the neck.

Although research is focused on preventing stress fractures in the military, Evans said the information they learn can apply to any population of physically active people to help prevent stress fractures.

Four USARIEM studies are planned in the next year to try to answer how muscle structure and function relates to bone quality. Researchers will examine whether differences in bone density and geometry exist between the right and left tibia, and then look at how that changes through physical training.

One objective is to find out the proper training balance, to see where bone strengthening ends and weakening begins. A third study will look at the effect of three 12-week exercise programs -- aerobic training, strength training, and a combination of the two -- against a sedentary control group.

"We want to look at what factors might build up bone," Evans said. "Maybe we can give (recruits) a program before going to basic training to ward off problems."

Building on what they've learned in the experimental study, the plan is to transfer that information to actual basic combat training units to examine what risk factors, such as slender bones or low bone density, predispose trainees to injury.

Evans and Friedl gave examples of expected outcomes from current projects that USARIEM is managing. Soldiers with high risk for fracture may simply stand on a platform for 15-minute daily treatments of low-frequency vibration to stimulate bone development.

Recruits might benefit from specific guidance on physical training, and calcium and vitamin D supplementation resulting from studies now with Navy basic trainees.

Various studies at USARIEM could lead to new recommendations on zinc and protein content in operational rations to optimize bone health. Even basic biology studies, such as one that demonstrated a refractory period in response of bone cells after mechanical stimulation, may affect military training with science-based advice to break up physical training into more than one session per day to maximize the benefit to bone health.

(Curt Biberdorf is editor of Warrior magazine at the U.S. Army Soldier Systems Center.)