Fiscal Year:	FY 2007	**Task Last Updated:**	FY 08/21/2007
PI Name:	Qin, Yi-Xian Ph.D.		
Project Title:	A Scanning Confocal Acoustic Diagnostic System for Non-Invasively Assessing Bone Quality		
Division Name:	Human Research		
Program/Discipline:	NSBRI Teams		
Program/Discipline--Element/Subdiscipline:	NSBRI Teams--Technology Development Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Bone Fracture**:Risk of Bone Fracture due to Spaceflight-induced Changes to Bone (2) **Osteo**:Risk Of Early Onset Osteoporosis Due To Spaceflight		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	11794-5281	**Congressional District:**	1
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2003 Biomedical Research & Countermeasures 03-OBPR-04
Start Date:	11/01/2004	**End Date:**	10/31/2008
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	4	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Gruber, Barry (SUNY- The State University of New York) Rubin, Clinton (Research Foundation of SUNY)		
Grant/Contract No.:	NCC 9-58-TD00405		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The bone loss which parallels extended space missions represent serious threat to astronaut health, both during flight and on return to gravitational fields. Early diagnosis of osteoporosis would enable prompt treatment and thus dramatically reduce the risk of fracture. Currently, the principal method used to diagnose osteoporosis is dual-energy X-ray absorptiometry (DEXA), which provides a 2-D representation of bone mineral density (BMD), but not bone's physical properties per se. Recent advances in quantitative ultrasound have enabled a true characterization of bone quality, including both BMD and mechanical strength. Currently funded by the NSBRI, we have developed a scanning confocal acoustic diagnostic (SCAD) system capable of generating acoustic images at the regions of interest (e.g., in the calcaneus). The objectives of this study are to further develop this unique diagnostic for use in the human, including an improved resolution, faster scan times (e.g., < 5 min for the calcaneus), the ability to scan multiple sites of the skeleton, and to validate image based characterization of bone's physical properties to true bone quality as based on material testing. In essence, this next phase of research will focus on developing the SCAD prototype as a real-time, high-resolution, and portable bone image modality for determining bone quality. A series of four interrelated specific aims are proposed: 1) Determining the surface topology for accurately measuring wave velocity; 2) Capable of extracting trabecular BUA and UV images at multiple skeletal sites, i.e., calcaneus, wrist, and hip, to provide direct assessment of bone loss and fracture risk; 3) Measuring bone's structural and strength properties, e.g., in the cadaver samples, using SCAD, microCT and mechanical testing for bone quality prediction; and 4) Performing clinical diagnostic assessment by comparing SCAD and DXA in osteoporosis and disuse subjects. In this year's research, a new generation of the prototype of scanning confocal acoustic diagnostic (SCAD) system was developed, including feature of bone surface topology mapping and the automatic region of interest identification in measured ultrasound imaging. The new development is capable of generating non-invasive, high-resolution quantitative ultrasound (QUS) attenuation and velocity maps of bone, and thus determining the relationship between ultrasonic specific parameters and bone mineral density (BMD), and bone strength and bone's physical properties (i.e., stiffness and modulus). The ultrasound resolution and sensitivity are significantly improved by its configuration. (1) Bone surface topology mapping and its role in trabecular bone quality assessment using scanning confocal ultrasound. The objective of this study was to identify 3D surface topology of bone for accurate calculation of ultrasound wave velocity. The irregular surfaces of calcaneus can be clearly depicted using surface mapping and SCAD parameters were highly correlated to bone mineral density (BMD), bone volume fraction and bone modulus. (2) Automatic region of interests based on the ultrasound broad band attenuation. This feature is capable of determining ultrasonic parameters through bone more accurately and automatically with friendly user-device interface, which can be easily incorporated into future in vivo clinical application. (3) Exploring the capability of ultrasound assessment for bone quality in bedresting subjects. QUS provides a method for characterizing the quality of bone non-invasively. The objective of this work was to evaluate bone mass changes in a longitudinal 90-day bed rest (UTMB, Galveston, TX). QUS scanning for the calcaneus region showed a unique pattern of acoustic image. Strong correlation was observed between pooled BUA in the heel region and pooled whole body BMD (determined by the DXA), R2=0.84. Longitudinal subtle changes were significantly predicted by the UV measurements at 0, 60, and 90 days, in which 1.5% UV reduction in 60 days bed rest. (4) Initiation of SCAD assessment in large and critical bone sites, e.g., proximal femur. These works will help to refine a non-invasive diagnosis for bone loss, and may potentiate the development of a flight instrument for the precise determination of bone quality during extended space missions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Musculoskeletal decay due to a microgravity environment has greatly impacted the nation's civil space missions and ground operations. Such musculoskeletal complications are also major health problems on Earth, i.e., osteoporosis, and the delayed healing of fractures. About 13 to 18 percent of women aged 50 years and older and 3 to 6 percent of men aged 50 years and older have osteoporosis in the US alone. One-third of women over 65 will have vertebral fractures and 90% of women aged 75 and older have radiographic evidence of osteoporosis. Thus, approximately a total of 24 million people suffer from osteoporosis in the United States, with an estimated annual direct cost of over $18 billion to national health programs. Hence, an early diagnosis that can predict fracture risk and result in prompt treatment is extremely important. Development of a low mass, compact, noninvasive diagnostic tool, i.e., ultrasound bone quality detector, will have a great impact as an early diagnostic to prevent bone fracture. This research will address critical questions in the Critical Path Roadmap related to non-invasive assessment of the acceleration of age-related osteoporosis and the monitoring of fractures and impaired fracture healing. The results have demonstrated the feasibility and efficacy of SCAD for assessing bone's quality in bone. We have been able to demonstrate that the bone quality is predictable via non-invasive scanning ultrasound imaging in the ROI, and to demonstrate the strong correlation between SCAD determined data and ?CT identified BMD, structural index, and mechanical modulus. These data have provided a foundation for further development of the technology and the clinical application in this research. Our principal goal is to continue the development and evaluation of the SCAD system for ground-based determination of bone's physical properties, and for determining even subtle changes of bone during extended flights.
Task Progress:	Musculoskeletal complications induced by age-related diseases like osteoporosis, and in long-term disuse osteopenia such as a lack of microgravity during extended space missions and long-term bed rest, represent a key health problem. Such a skeletal disorder changes both the structural and strength properties of bone, and the latter plays a critic role in ultimately leading to fracture. Early diagnosis of progressive bone loss or poor bone quality would allow prompt treatment and thus will dramatically reduce the risk of bone fracture. While most of the osteoporotic fractures occur in cancellous bone, non-invasive assessment of trabecular strength and stiffness is extremely important in evaluating bone quality. In this year's research, we are able to develop a scanning confocal acoustic diagnostic (SCAD) system capable of generating acoustic images at the regions of interest (e.g., in the human calcaneus) for identifying the strength of trabecular bone, in which the system is capable of generating non-invasive, high-resolution ultrasound (US) attenuation and velocity maps of bone, and thus determining the relationship between ultrasonic specific parameters and bone mineral density (BMD), and bone strength and bone's physical properties (i.e., stiffness and modulus). The ultrasound

	resolution and sensitivity are significantly improved by its configuration, compared to the existing technology. Developed prototype of SCAD is successfully used in the bedrest subjects (UTMB, Galveston, TX) and clinical test (Stony Brook University). A surface topology mapping technology using scanning ultrasound is developed and capable of determining calcaneus bone thickness accurately and hence enhancing the accuracy of UV measurement.
Bibliography Type:	Description: (Last Updated: 02/17/2021)
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Patents	Provisional Patent: 4/13/06 Serial No. 60/791,642. Patent. Apr-2006 Qin Y- X, Xia Y, Lin W. "Scanning Acoustic Topology Mapping for Determining Tissue Surface Features and Wave Transmit Thickness."