Fiscal Year:	FY 2011	**Task Last Updated:**	FY 10/03/2011
PI Name:	Dulchavsky, Scott A. M.D., Ph.D.		
Project Title:	Ultrasound Fracture Diagnosis in Space		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Operational and clinical research		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **ExMC**:Exploration Medical Capabilities		
Human Research Program Risks:	(1) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures (2) **Renal Stone**:Risk of Renal Stone Formation		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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PI Web Page:			
City:	Detroit	**State:**	MI
Zip Code:	48202-2608	**Congressional District:**	13
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2007 Crew Health NNJ07ZSA002N
Start Date:	08/15/2008	**End Date:**	09/20/2011
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/20/2011 (from 8/14/2011) per NSSC information (Ed., 9/23/2011) NOTE: change in Gaps per HRR information (Ed., 9/23/2011)		
Key Personnel Changes/Previous PI:	None		
COI Name (Institution):	Amponsah, David (Henry Ford Hospital) Hamilton, Douglas (Wyle) Sargsyan, Ashot (Wyle)		
Grant/Contract No.:	NNX08AV74A		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Crew members on long duration space missions are at significant risk of decreased strength of bones despite counter-measures. The radiographic capabilities of future spacecraft are unknown; however, ultrasound is currently operational on the International Space Station (ISS). Preliminary investigations have shown that ultrasound can reliably diagnose long bone fractures. This proposal will evaluate the accuracy of ultrasound in the diagnosis of bony fractures and develop just in time, training methods to allow astronauts to perform and interpret skeletal ultrasound to answer the specific aims: 1. Evaluate the diagnostic accuracy of ultrasound for bony fractures and fracture healing in ground based studies. 2. Develop training programs to facilitate skeletal ultrasound to exclude fracture. 3. Develop pattern recognition algorithms to allow astronauts to autonomously diagnose skeletal fracture. Methods: Specific Aim 1: The accuracy of ultrasound will be evaluated against X-ray in a large cohort of acutely injured patients at the Level 1 trauma center at Henry Ford Hospital. Ultrasound examinations will be performed by experts in parallel with astronaut equivalents on patients with a history and exam consistent with bony fracture to assess sensitivity and specificity and optimize technique. The randomized trials will include patient groups with probable long bone, axial skeletal, and hand/foot fractures to allow statistical conclusions about exam accuracy to be determined. Specific Aim 2: A computer based ultrasound training program will be developed for astronauts to allow skeletal ultrasound to be performed for axial and extremity fractures based on a successful Onboard Proficiency Enhancement (OPE) program. Specific Aim 3: Autonomous ultrasound diagnostic capabilities will be developed for astronauts by combining cue card reference images, topographic ultrasound guides, and normal/anticipated pathologic images to allow pattern recognition diagnosis by the operators. Significance to NASA: This proposal will develop training and techniques for autonomous/remote guidance of in-flight fracture diagnosis using crew performed skeletal ultrasound.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	A large scale analysis of our data has demonstrated that point of care ultrasound is a rapid, accurate, and reproducible test to diagnose acute injury to the musculoskeletal system. This technique can be used by non-experts to rapidly diagnose injuries to the upper and lower extremities, chest, and hands/feet to guide therapy. This technique can be expanded for use in the pre-hospital setting, in military conflicts, and in natural disasters to aid triage decisions. The intuitive Fracture Catalog developed in this proposal is currently being used to train medical students in ultrasound and is a valuable tool for military and under served locations worldwide.
Task Progress:	This ground-based proposal accumulated high-level clinical evidence on the sensitivity and specificity of point of care ultrasound performed by expert and novice users for the rapid diagnosis of musculoskeletal injuries. This proposal developed preliminary educational methodologies to provide just-in-time training of novice users by creating multi-media training tools and imaging procedures for non expert operators. Expanded diagnostic use of ultrasound is being substantiated for the diagnosis of specific musculoskeletal injuries deemed possible in Low Earth Orbit (LEO) and future exploration-class missions. This final report summarizes the sensitivity and specificity of non-expert performed musculoskeletal ultrasound to diagnose acute injuries. This Final Report covers Specific Aim I and II in the cooperative agreement: 1. Evaluation of the diagnostic accuracy of ultrasound for bone fractures, associated muscle trauma, and fracture healing in a ground-based study at an academic medical center. EXPERT OPERATORS: We identified patients with potential musculoskeletal injuries in an urban, Level 1 trauma center based on mechanism of injury and the presenting complaint. Potential subjects were given a summary of the study and invited to participate following informed consent. A GE Logiq-e portable ultrasound device with a 12 MHz linear probe was used for the ultrasound investigations in this study. The initial musculoskeletal (MSK) evaluations were performed and interpreted by ultrasound experts with extensive experience in MSK ultrasound. These examinations were also used to fashion cue cards and short video based educational aids to allow non-expert operators to perform complex ultrasound examinations for the later investigations in Specific Aim II. The examinations confirmed earlier investigations at our institution which have demonstrated a very high sensitivity and specificity for ultrasound when performed with a portable ultrasound machine by an expert. There were no false positive examinations in this study. There was one false negative in a non displaced, sub-capital fracture of the hip in an obese patient. This patient also had a negative X-ray and was found to have a fracture on a subsequent MRI for continued pain. There were a number of additional soft tissue ultrasound examinations in this patient subgroup which showed soft tissue edema, hematoma formation, tendon-ligament tears, and foreign bodies. The analysis of this data set obtained and interpreted by MSK ultrasound experts suggests that 2D ultrasound provides a high degree of sensitivity and specificity for the diagnosis of musculoskeletal trauma and that 3D or volumetric ultrasound is not necessary to obtain a correct diagnosis in experts' hands. NOVICE OPERATOR: Over 850 patients were screened for enrollment in the emergency room at Henry Ford Hospital. Initial patient screening was done by Trauma Surgery or Emergency Medicine staff based on mechanism of injury, history, and presenting signs and symptoms suggestive of significant musculoskeletal injury. Informed consent was obtained and a localized ultrasound examination was completed prior to radiographic evaluation by minimally trained personnel using a 10.5 MHz linear probe. The ultrasound examination was initially done on the contra lateral, non-injured side to obtain a reference image and to optimize visualization and focal zone. The entire length of the bone was visualized with special attention to the injured area. A positive scan consisted of identification of cortical disruption or discontinuity. Secondary hematomas and muscular injury were also recorded. Routine radiographic

	imaging was then completed for comparison against the ultrasound examination. Demographic, anatomic, and radiographic information was collected for correlation to the ultrasonographic findings. A diagnostic scoring sheet with patient and exam-specific data was filled out by the operator immediately following the examination. High fidelity ultrasound images/video loops were also archived for later blinded review. The sensitivity and specificity of the test was determined for the operator and the blinded reviewer. The majority (78%) of the patients entered into the study were male with an average age of 38 (range 18-84). The majority of injuries involved falls (72%), followed by motor vehicle accidents (19%) and assaults (8%). This study comprises the largest comprehensive investigation of the use of point of care ultrasound for the diagnosis of musculoskeletal injury by non-expert operators. Approximately 700 acute care examinations were performed by just-in-time operators with and average examination time of less than 10 minutes. There was no statistically significant difference in examination quality or diagnostic accuracy between expert and novice users in this trial. The overall sensitivity of ultrasound for the detection of fractures was 97% (confidence interval 0.38-0.46) and the specificity was 99% (confidence interval: 0.94-0.99) with a prevalence of 0.14. Subgroup analysis shows that the sensitivity is less for fractures in the hand and foot which is most likely related to the complexity of the examination in this area. There were a limited number of examinations of the femur, hip, and facial bones making statistical analysis impractical; however, observations of this technique suggest that it could be reliable if appropriate attention is given to technical factors including probe selection and depth in larger patients. We have also evaluated fracture healing in a limited number of patients with hand and rib injuries. Fracture callus formation is readily apparent at 3-4 weeks and the maturation of the bony healing can be followed over a more prolonged period with specific ultrasound findings.
Bibliography Type:	Description: (Last Updated: 02/23/2023)
Articles in Peer-reviewed Journals	Dulchavsky SA, Sargsyan AE, Garcia KM, Melton SL, Ebert D, Hamilton DR. "Intuitive ultrasonography for autonomous medical care in limited-resource environments." Acta Astronaut. 2011 May-Jun;68(9-10):1595-607. http://dx.doi.org/10.1016/j.actaastro.2009.08.024 , May-2011