Fiscal Year:	FY 2007	**Task Last Updated:**	FY 02/01/2008
PI Name:	Buckey, Jay C. M.D.		
Project Title:	Improved Bubble Detection for EVA		
Division Name:	Human Research		
Program/Discipline:	NSBRI Teams		
Program/Discipline--Element/Subdiscipline:	NSBRI Teams--Technology Development Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **DCS**:Risk of Mission Impacts and Long-Term Health Issues due to Decompression Sickness		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	03756-0001	**Congressional District:**	2
Comments:	Address updated 9/2008		
Project Type:	Ground	**Solicitation / Funding Source:**	2003 Biomedical Research & Countermeasures 03-OBPR-04
Start Date:	07/01/2004	**End Date:**	06/30/2009
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**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:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 6/30/2009 per NSBRI (5/2008)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Magari, Patrick (Creare, Inc.) Knaus, Darin (Creare, Inc.) MacKenzie, Todd (Dartmouth College) Phillips, Scott (Creare, Inc.)		
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Performance Goal Text:			

Task Description:	Assembly of the International Space Station (ISS) and lunar exploration require extensive and unprecedented extra-vehicular activity. Current spacecraft and suit designs force astronauts to move between different pressure environments, making decompression sickness (DCS) a potential risk. Current DCS risk mitigation strategies, which are highly time consuming, reduce operational efficiency. The objective of this effort is to improve EVA efficiency and safety by developing and validating new bubble detection technology using dual-frequency ultrasound. The Creare dual-frequency instrument (CDFI) can detect and size bubbles through the chest wall as they move through the heart. Also, stationary microbubbles can be detected in tissue. Potentially, this technology could be used to: (a) characterize bubble dynamics during decompression sickness (DCS), (b) detect the earliest stages of DCS, (c) develop and evaluate non-compressive countermeasures for DCS, (d) diagnose DCS in tissue or joints, and (e) mitigate DCS risk by improving preventive strategies such as oxygen pre-breathing and limiting activity at particular times. Detecting and sizing bubbles intravascularly (a new and unique capability) allows for bubble size histograms to be constructed during the development and treatment of DCS. The change of bubble size distribution during decompression stress may indicate DCS severity. Before using the device either for quantitative research or operations, the sizing ability needs to be quantified in optimal in-vitro conditions. The calibration system developed for this project can create monodisperse distributions of microbubbles at the sizes likely to occur during decompression stress. Work in the past year has focused on resolving technical problems in the calibration setup and the calibration is moving forward. Tissue bubble detection is also a unique capability. The CDFI potentially can detect very small bubbles (the possible precursors of larger bubbles in tissue or blood) and identify larger bubbles in areas with symptoms of pain or discomfort consistent with DCS. Last year, a significant accomplishment was the demonstration of the ability to detect ultrasound contrast bubbles (Definity®) injected into tissue (in anesthetized swine). This work has been extended significantly. In a series of studies, the power levels needed to detect bubbles in tissue were established and the concentration of injected bubbles that could be detected was determined. Also, we validated that the CDFI was specific for bubbles and did not detect ultrasonic reflectors the same size as injected bubbles. Microspheres of the same size as the bubbles were also injected into tissue and were not detected by the CDFI. For the coming year, the plan is to: (a) complete the in-vitro calibration, (b) track bubble sizes during decompression stress in anesthetized swine, (c) determine if signals consistent with bubbles can be detected in swine muscle before or after decompression stress and (d) assess if these signals change after exercise or immobilization.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The results from this study are also applicable for divers, aviators, high-altitude parachutists and others who are exposed to the risk of decompression sickness. Another application for this technology is bubble monitoring during coronary artery bypass surgery or valve replacement surgery. Patients who have coronary artery bypass surgery are at risk for having solid and gaseous emboli reach the brain when they are on the "pump" (the cardiopulmonary bypass circuit). The Creare dual-frequency ultrasound unit could be used to monitor for bubbles in the bypass circuit and could distinguish between solid and gaseous emboli. A collaboration with Dr. Donny Likosky is underway to advance this work. The cavitation approach can be used to determine to assess the gas saturation in fluids such as hydraulic fluid, which is important for industrial and aviation applications. Creare is currently developing an instrument based on this concept for the U.S. Air Force. Creare is also applying the knowledge gained on the bubble acoustics knowledge and expertise gained in this effort to a Department of Energy project to mitigate cavitation damage in the Spallation Neutron Source (SNS) being developed at Oak Ridge National Laboratory. In this facility, a large acoustic wave is produced in the mercury spallation target when proton pulses very rapidly and repeatedly enter the mercury. The acoustic wave reflects off the vessel walls and causes the mercury to cavitate which results in severe damage to the vessel when the SNS is operated at the desired full power level. Creare is characterizing the ability of various stabilized bubbles to dampen the large acoustic wave and, thereby, mitigate the resulting cavitation damage.
Task Progress:	Bubble sizing calibration Efforts continued to calibrate the sizing capability of our dual-frequency ultrasound bubble-sizing device. Previous work has shown that bubbles can be detected and sized intravascularly in-vivo, but a careful in-vitro calibration is essential for future work with the device. Performing this calibration is technically challenging. We continue to make enhancements to the device and the experimental setup to aid in the completion of this calibration. The main challenges are producing and measuring monodisperse streams of bubbles in various sizes, and removing or understanding sources of non-linear signals that can mask bubble signals. We currently believe that the main source of non-bubble, non-linear signal is due to non-linear ultrasound propagation, which is the basis for harmonic imaging. Predicting the magnitude of this masking signal is confounded by the presence of standing waves, which are very difficult to eliminate from a calibration setup. Efforts were made to understand ultrasonic standing waves in both the tissue phantom and water tank experimental setups, and the impact that they may have on the production of sum and difference signals that indicate the presence of bubbles. In addition we have made adjustments to the calibration setup to minimize the interaction between the transmitted pump and image signals. Calibration of the sizing capability of the device is ongoing and should be completed by the end of the year. Stationary microbubble detection in-vivo This was the main effort of the year. Several dilutions of ultrasonic contrast agent were injected into the thigh of an anesthetized swine. The ability of the device to detect stationary microbubbles at different ultrasonic pressures and concentrations was demonstrated and characterized. The results of this effort have been submitted for publication. Decompression Studies Decompression studies using a swine model have been performed to detect decompression-induced bubble formation in tissue. Swine were pressurized at 4.5ATA for 2hrs and decompressed over 5 minutes. Each swine was monitored with clinical and dual-frequency ultrasound for 1-2 hours post-dive (depending on conditions). Results to date are as of yet inconclusive. It is widely speculated that bubbles form in tissue following decompression, but detecting native tissue bubbles is difficult since the concentration, locations and sizes of normally-occurring microbubbles in tissue is

	unknown. Current efforts to detect decompression-induced stationary bubbles in tissue are focused on determining the correct frequencies and pressures to use.
Bibliography Type:	Description: (Last Updated: 05/20/2025)