Fiscal Year:	FY 2009	**Task Last Updated:**	FY 12/09/2009
PI Name:	Buckey, Jay C. M.D.		
Project Title:	Improved Bubble Detection for EVA		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Smart Medical Systems and Technology 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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City:	Lebanon	**State:**	NH
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:**	1
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.) Pawelczyk, James Ph.D. (Pennsylvania State University)		
Grant/Contract No.:	NCC 9-58-TD00402		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Decompression sickness can be a significant operational issue for NASA during extravehicular activity (EVA). Improved bubble detection and sizing technology could enhance safety and promote understanding of decompression sickness. The goal of this project is to develop and demonstrate a novel bubble detection and sizing technique—dual-frequency ultrasound (DFU). In this project we (1) demonstrated the ability of the DFU to detect stationary microbubbles in tissue, (2) performed a comprehensive calibration of the sizing capabilities of the device using bubbles of known size, and (3) performed a mix of human and animal experiments to explore the usefulness of tissue bubble detection. First, we demonstrated that DFU could detect both ultrasonic contrast agent and decompression bubbles in tissue. This demonstrated the ability of DFU to detect small bubbles in tissue. The next step was to assess whether bubbles could be detected after exercise in normal humans. Exercise has been postulated to create small bubbles in tissue, and these bubbles are thought to increase bubble formation and decompression sickness risk during subsequent decompression stress after exercise. But, these small bubbles had never been directly detected in tissue. To do this, in the past year we surveyed for bubbles in the legs of human subjects before and after cycle ergometer exercise using DFU. Six normal human subjects aged (28-52) were studied. Eleven marked sites on the left thigh and calf were imaged on each subject using standard imaging ultrasound. Subjects then rested in a reclining chair for 2 hours prior to exercise. For the hour before exercise a series of baseline measurements were taken at each site using DFU. A minimum of 6 baseline measurements was taken at each site. The subjects then exercised at 80% of their age-adjusted maximal heart rate for 30 minutes on an upright bicycle ergometer. After exercise, the subjects returned to the chair and multiple post-exercise measurements were taken at the marked sites with the CDFI. Measurements continued until no further signals consistent with bubbles were returned or one hour had elapsed. All the subjects had signals consistent with bubbles at a least one site after exercise. The most likely explanation for these results is that exercise does produce gas-filled micronuclei (bubbles). This is the first demonstration that these micronuclei can be detected after exercise, and these results have important implications for decompression sickness diagnosis and treatment.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The results from this study are applicable to 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. 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:	The bubble detection technique exploits the resonance properties of bubbles to detect and size them using two ultrasound frequencies. Over the years, several approaches have been used to address the various tasks of the project. * Micropipette-generated bubbles of optically-verifiable sizes were used as a standard with which to calibrate and validate the intravascular bubble sizing capability of the instrument. This work has been completed and presented in abstract form. It is being prepared for publication. * Definity® stabilized bubble-based ultrasound contrast agent were used as a known source of nonlinear bubble mixing signal for tissue bubble detection validation. Solid polymer microspheres were used as comparative standard since they reflect ultrasound but do not produce nonlinear mixing signals characteristic of bubbles. Solutions of known concentrations of ultrasound contrast agent and solid polymer microspheres were injected into the thigh of an anesthetized swine and imaged using the dual-frequency ultrasound bubble detection and sizing device. These results have been published in the journal Undersea and Hyperbaric Medicine. * A swine model of decompression sickness was used to produce nitrogen bubbles in tissue and blood. Anesthetized pigs weighing 20 kg were exposed to 4.5 ATA for 120 minutes and then brought to 1 ATA. This work has been completed and presented in abstract form. It is being prepared for publication. * Exercise was used as a mechanism to increase levels of pre-existing extravascular bubbles in human subjects. This work has been accepted for publication in the Journal of Applied Physiology.
Bibliography Type:	Description: (Last Updated: 05/20/2025)
Abstracts for Journals and Proceedings	Bollinger BR, Phillips SD, Donoghue TG, Wilbur JC, Knaus DA, Magari PJ, Buckey JC. "Dual-frequency ultrasound detection and sizing of 20-200 micron bubbles for studying decompression sickness." 79th Aerospace Medical Association Annual Scientific Meeting, Boston, MA, May 12-15, 2008. Aviat Space Environ Med. 2008 Mar;79(3):317. , Mar-2008
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Articles in Peer-reviewed Journals	Bello JW, Rickrode GA, Harlan NP, Buckey JC Jr. "Systemic prostacyclin analogues for frostbite require careful monitoring." J Burn Care Res. 2022 Nov 29;irac178. https://doi.org/10.1093/jbcr/irac178 ; PMID: 36444642 , Nov-2022