Fiscal Year:	FY 2023	**Task Last Updated:**	FY 04/04/2023
PI Name:	Lan, Li-i		
Project Title:	Ultra-Compact Urinary Calcium Measurement Device: Refinement and Application		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **ExMC**:Exploration Medical Capabilities		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	03755	**Congressional District:**	2
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2020 HERO 80JSC020N0001-FLAGSHIP, OMNIBUS1 Human Research Program: Crew Health Appendix A; Omnibus1-Appendix B
Start Date:	03/28/2022	**End Date:**	09/27/2024
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:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: End date has been changed to 09/27/2024 per NSSC information (Ed., 11/15/23). NOTE: End date has been changed to 09/27/2023 per V. Lehman/JSC (Ed., 3/24/23). Original end date was 03/27/2023.		
Key Personnel Changes/Previous PI:	None.		
COI Name (Institution):	Buckey, Jay M.D. (Dartmouth College) Devoy, Clive (Creare LLC) Phillips, Scott Ph.D. (Creare LLC) Knaus, Darin Ph.D. (Creare LLC)		
Grant/Contract No.:	80NSSC22K0847		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Slowing bone loss and preventing kidney stone formation are critical for successful spaceflight. The capability to track bone loss and kidney stone risk while in space would allow these risks to be monitored directly and would enable individualized countermeasure programs. At present, post-flight measurements are used to establish the effectiveness of the in-flight bone loss/kidney stone prevention program. A preventive approach would offer much greater operational flexibility, where ongoing in-flight measurements of countermeasure effectiveness would allow for adjustments in the countermeasure program during the flight. This approach could also be used during times when countermeasure equipment is broken, or when scheduling impacts the countermeasure program, to assess how this is affecting bone loss and kidney stone risk. In a previous NASA Omnibus project, we developed a prototype compact, low-power system to make urinary calcium measurements in space. This approach has proven to be feasible, but further development is needed to advance toward flight use. The objective of the current project is to improve this ultra-compact, robust, urinary calcium measurement system. This study will further a technology that may offer a personalized, preventive approach to bone loss and kidney stone prevention in space.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This research benefits life on Earth by developing a low cost, portable, and simple way to test urine calcium concentration in a remote setting or from the comfort of one's own home. This can be used for early detection of kidney disease. At-home testing of urinary calcium biomarkers allows individuals to monitor their kidney function regularly. This can help detect kidney disease at an early stage, thus enabling timely treatment and preventing further damage. A device with this portability and form factor promotes convenience. At-home testing of urinary calcium biomarkers is quick, easy, and can be done in the privacy of one's own home. This convenience can encourage more individuals to monitor their kidney function regularly. The simplicity of this device can also be cost-effective. At-home testing of urinary calcium biomarkers is less expensive than going to a healthcare provider for the same test. This cost savings can increase access to kidney health testing for individuals who cannot afford traditional healthcare services. This in turn has public health benefits. Regular monitoring of urinary calcium biomarkers can help identify populations at risk for certain health conditions, including kidney disease, and allow for targeted public health interventions. Overall, a low cost, simple, and portable device for measuring urinary calcium biomarkers can promote early detection of kidney disease, provide convenience and cost savings, and have significant public health benefits.
Task Progress:	In a previous award, we built a device that measures urinary calcium concentration using a disposable optrode to sample small amounts of urine and a handheld reader. The optrode was coated internally with a solid reagent consisting of calcein and sodium hydroxide (NaOH) buffer. The calcein binds with calcium in the urine and can produce a fluorometric signal when excited by the blue light in the reader. Our prototype worked but in this new project, we are refining the system to elevate the device technology readiness level for eventual spaceflight use. The project has achieved multiple milestones. 1) Variations on the reagent recipe were tested and finalized. 2) Several new optrode designs were explored, and one design was chosen. 3) Manufacturability of the redesigned optrode tubes was explored and finalized and three hundred tubes were produced for human urine testing. Regarding each: 1) Our reagent recipe consists of calcein with a buffering agent and the optional inclusion of potassium citrate. We tested whether NaOH or KOH was the preferred buffering agent and whether the inclusion of potassium citrate improved our reagent recipe. After preparing these four different reagent recipes, we created calcium standards (calcium dissolved in DI water) at several concentrations between 0 and 800 mg/L. We plotted the output voltage from our reader for each concentration of calcium standard mixed with each reagent recipe. We favored the recipe with the widest linear response. Calcein with KOH and potassium citrate was the favored recipe. 2) Several optrode concepts were explored. The concept we ultimately chose was a syringe-like design that could be preloaded with 18 microliters of reagent and an additional 2 microliters of urine could be drawn into the optrode. Once the urine was drawn into the tube, it would diffuse and mix with the reagent, producing the fluorescent signal that was detected by our reader. 3) To create a repeatable syringe optrode, we flared a polystyrene rod to create a seal with an outer tube. This formed the syringe. A manufacturing jig was created to ensure repeatability in flaring. With these three objectives accomplished, we will compare the performance of the prototype device in measuring urinary calcium concentration against the urine chemistry analyzer at Dartmouth Hitchcock Medical Center (DHMC). The evaluation will use both calcium standards as well as human urine collected from 100 volunteers per our Institutional Review Board/IRB-approved protocol.
Bibliography Type:	Description: (Last Updated: 05/24/2023)
Abstracts for Journals and Proceedings	Lan M, Knaus DA, Devoy C, Fergusson K, Phillips SD, Fellows AM, Buckey JC. "Ultra-compact urinary calcium measurement device: Refinement and application." 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 7-9, 2023. Abstracts. 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 7-9, 2023. , Feb-2023
Articles in Peer-reviewed Journals	Buckey JC Jr, Thamer S, Lan M. "Bone loss and kidney stone risk in weightlessness." Curr Opin Nephrol Hypertens. 2023 Mar 1;32(2):172-6. https://doi.org/10.1097/MNH.0000000000000863 ; PubMed PMID: 36683542 , Mar-2023