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How Can Space Travel Affect Our Heart Health?

Dr. Sorrentino:
As recent advancements have made space travel increasingly possible, we need to consider how this type of exploration can affect our health. How does the long-term absence of gravity impact our hearts? And is there anything we can do to protect our cardiovascular health in outer space? And what insights can this research teach us about how our heart health here is on earth?

Welcome to Heart Matters on ReachMD. I'm Dr. Matthew Sorrentino, and joining me to discuss how we can help protect heart health in long-term space travelers is Dr. James MacNamara, an advanced cardiography fellow and first author of a recent research paper published in Circulation studying the cardiac effects of extreme duration space flight. Dr. MacNamara, welcome to the program.

Dr. MacNamara:
Hi, thank you for having me.

Dr. Sorrentino:
Can you first tell us how did you get this idea of studying heart health in long-term space travelers?

Dr. MacNamara:
My primary research mentor is Dr. Ben Levine. He's the founder of the exercise institute where I do my research, and he has been one of the international leaders in addressing this issue over the last twenty or thirty years. The cardiac effects of space flight has been of interest to NASA since we first started sending astronauts to space for prolonged periods of time, and we had two very unique circumstances in which we were able to study the effects of weightlessness, both from Captain Kelly's year-long mission as well as Mr. Lecomte's extremely impressive swim.

Dr. Sorrentino:
So let's go into a little bit more detail about both of those individuals. Why comparing somebody who did a long-distance swim to somebody in outer space?

Dr. MacNamara:
We send people to space and we have a lot of research from the people who've gone to space, and even more, research planned in the people that are going to, but as you can imagine, it's a limited data set. It's not something that happens every day. So there's been a lot of focus over the last few decades on ground-based simulations of weightlessness. We've done studies, including here in Dallas, the Dallas bedrest study where you just have healthy people lay flat for weeks, and three weeks in bed replicates thirty years of aging and simulates the effect of weightlessness, that it takes away that effect that gravity has on our circulation. One of the best simulants for space flight is water immersion because the buoyancy as you float in the water, it really takes away that gravitational gradient, that gravity that pulls two-thirds of our blood volume down into our lower body. The hard part with water immersion is that it's just not well-tolerated for extremely long periods of time. You can lay in bed, and we're very grateful for the people who do because even that's not easy, but being immersed in water, we don't have studies for extreme periods of time, so when Mr. Lecomte, who we've had a working relationship with over the years because he's a famous endurance athlete, has previously swam the Atlantic Ocean and was preparing to swim the Pacific. We had the idea of can we take pictures of his heart as he does this? He is going to have potentially the most water immersion plus he'll be swimming, so he'll also be horizontal to the ground so he'll actually have two mechanisms to eliminate the gravitational gradients. And we approached him, and he agreed, and his team agreed to take pictures of his heart as he progressed through his swim, and the same arrangement had been established with Captain Kelly to actually do pictures of his heart in space while he was on the space station. The type of exercise is different, but Mr. LeComte was doing a lot more exercise. I mean, he was swimming from anywhere from two to three hours, but upwards of nine hours, and about an average of six hours a day, which is much

more exercise than an astronaut can do. They have other responsibilities. So what this lets us do is it (A) it let us compare to see if the adaptations were similar and to see if there would be a prevention of that adaptation the heart shrinking as a response to weightlessness. If you were to do low-level exercise all day long, would it reverse that?

Dr. Sorrentino:
So just some technical questions about the study. I presume this was all using echocardiography. What were some of the measurements you were making to observe changes in heart structure and function?

Dr. MacNamara:
Yeah, it's great. So these all were echocardiograms. As an echocardiographer myself, it's my favorite part of the study because we worked with Dr. Romjin, who was on the boat with Mr. Lecomte,–he's an extreme medicine provider. He provided the medical care for Mr. Lecomte along with Loren Farnard. And we trained him to do these echos, and he was able to do them on the boat itself, and then Captain Kelly got his echos on the space station with remote guidance from David Martin, who's the stenographer at NASA. He would actually be on ground and provide real-time feedback to get adequate pictures. There is still some limitations, especially with echo. So the measurements that we primarily looked at were the linear measurements of the left ventricle. So we looked at the left ventricular diameter to get a sense of heart size, and then we measured left ventricular mass using echo by looking at the wall thickness as well as the ventricular diameter using the Tycolt equation; this is the standard for using echo to determine left ventricular mass.

Dr. Sorrentino:
So I would have expected, if an individual is exercising at a high level, certainly with the gentleman swimming across the Atlantic Ocean, but even with our astronauts in space – I know they're doing exercise – I would expect, like any muscle, the muscle would tend to thicken. What were some of your findings? What did the echos show, both with the astronaut and with our swimmer?

Dr. MacNamara:
Yeah, so for Captain Kelly, the results were actually what we expected. We expected him to lose some heart mass. It's interesting with astronauts because it really depends on their baseline level of fitness. There's clearly an effect of exercise. So in a different setting, when you look at the very, very fit astronauts, they lost heart mass, but the astronauts that weren't as fit – the ones that got back to earth and were like, that is the most exercise I've ever done in my life, their hearts got larger. So the baseline fitness does affect how you respond in space. But Captain Kelly's decline in heart mass without any adverse effects on his heart function were what we expected for a space flight of that duration with an exercise countermeasure, so he did do exercise when he was up on the space station.
For Mr. Lecomte, we were shocked. We thought that swimming for that length of time, every day for so frequently, would have caused his heart to get larger and his heart muscle mass to get larger as well. And it didn't. The adaptation to a lack of gravity was the dominant effect, so his heart lost mass at essentially the exact same rate as Captain Kelly's. Similarly, the heart size decreased initially, and then kind of leveled out, but this was not what we were expecting. We were expecting that level of exercise to overcome the lack of gravity.

Dr. Sorrentino:
For those just tuning in, you're listening to Heart Matters on ReachMD. I'm Dr. Matthew Sorrentino, and I'm speaking with Dr. James MacNamara about how we can protect space travelers' hearts from the long-term effects of space flight and the lack of gravity.

So I guess I'm just as surprised as you are that the long-distance swimmer, who I would have expected would have had a significant increased thickness of the heart mass with that high level of exercise, actually lost heart mass. I'm also a little surprised that the astronauts who are still exercising also lose that as well. But does that change function? Does the heart mass bring about a change in function? Can you tell both with systolic or even diastolic function if there's changes that occur as well in these individuals?

Dr. MacNamara:
Yes, in this case, we were able to look at the ejection fraction while they were on their campaign, and we did not see a significant change. Ejection fraction isn't necessarily the best measure of systolic function, but it is what we are able to do. We have future plans to try to look at the longitudinal strain of Mr. Lecomte's echos to see what that does during his swim. But based on the data that we have now, we did not see any change, at least in global systolic function. And diastolic function is always a hard thing to pin down because filling is such a multifactorial process. But when we look at the Doppler measures, when we look at the e' velocity and the E/A ratio, we don't see a compelling change in either participant over the course of their campaigns.

Dr. Sorrentino:
Do you have any follow-up data? Do you know if after the astronauts come back to earth and normal gravity is again pushing down on their hearts, does the mass quickly come back? And, with the long-distance swimmer, once he's done with his swim, does the LV mass become restored back to the normal levels?

Dr. MacNamara:
Yes, astronauts, we do know that they return to normal levels. It's amazing how adaptive the heart is. It's able to lose this mass, maintain function, and then regain it after the effects of gravity are restored. For Mr. Lecomte, we don't have a lot of data in general for someone who does this level of exercise. We do have another analysis that we're working on finalizing right now, where we did cardiac MRIs before and after his swim. Now there's a time delay The nice thing about the study that we're presenting here in Circulation is we're able to do these echos while they're in the midst of their exposure to weightlessness, whereas the MRI was a few weeks later.

That data will be forthcoming soon, but it is interesting to kind of tease that we saw the left ventricle pretty much return back to normal, but there were persistent effects of the right ventricle that also may help us understand the effects of the left. So that will hopefully be forthcoming in the next few months after we finalize that data.

Dr. Sorrentino:
And I'm going to ask you to speculate a little bit about what actually happens with this decline in LV mass. Do you think there's actual loss of myocytes, or are we just seeing some shrinkage of normal myocytes that then bounce back, if you will, to normal when normal gravity is again restored?

Dr. MacNamara:
I would speculate that it's the latter. That this is more of a plasticity than it is an actual loss of muscle cells or damage to the heart. To use an analogy, with someone who has a myocardial infarction and they lose mass by scar, they don't get that back. This is more of a physiologic adaptation, and I think that it's actually quite encouraging that the heart is able to lose a quarter of its mass without any ill effects. You know, Captain Kelly felt great. He gave an interview where he said that if they'd let him go back, he'd absolutely go back. And while some astronauts have issues with what we call orthostatic intolerance, or they faint or feel like they're gonna faint when they get back to earth, that's one of the major drivers of performing this research is to prevent that. The actual adverse cardiac events are very, very rare and we think are related to either the coronaries or the atria. That, right now when it comes to actual pathology, is the focus of current and future research is atrial stretch leading to atrial fibrillation. Or is the exposure to space causing premature coronary disease? For the most part, we don't believe that with reasonable countermeasures this decline in mass is actually adverse event for these astronauts.

Dr. Sorrentino:
For my final question, I'd like to bring us back down to earth. You mentioned that one of the groups you've been studying is individuals who have prolonged bed rest, and how it can mimic some of this as well. It seems to me that that's a reason to get our patients out of bed as quickly as possible, at least getting them to sit up, that maybe it'll have less of an adverse effect on the heart. Is there any correlations you can draw from these two individuals on how we should be treating our own patients?

Dr. MacNamara:
That's a great question, and for these individuals, I mean these are people who are exceptional human beings; Mr. Lecomte is a world-class athlete, and Scott Kelly is an astronaut. But these findings are consistent with other studies. And the heart is a "If you don't use it, you lose it" kind of muscle. I referenced the Dallas Bed Rest study, where we put healthy people to bed for three weeks and saw the same effects of 30 years of aging, cardiac atrophy. So you do see this in otherwise healthy people. When you add on the effects of comorbidities, it is an incredible motivator to get our patients up out of bed. We see patients who have traumatic spine injuries who are unable to get in and out of bed. Their hearts get smaller as well. There is a floor, but when we have our patients who are hospitalized for sometimes two or three weeks, and as we're dealing with the COVID pandemic, where people are often on ventilators for weeks at a time, the effects of being in that supine position should definitely be considered by the patient's clinicians, and I'm a huge advocate of getting people up out of bed, in the chair, walking around as soon as it's safe to do so.

Dr. Sorrentino:
Well clearly, we're only just scratching the surface when it comes to understanding the effects of gravity on our heart health, and certainly, if we're ever gonna go to Mars, we need to understand this even further. I want to thank my guest, Dr. MacNamara, for joining me to discuss his very intriguing study of two unique individuals. Dr. MacNamara, it was great having you on the program.

Dr. MacNamara:
Oh, thank you so much for having me. It's been an absolute pleasure.

Dr. Sorrentino:
I'm Dr. Matthew Sorrentino. To access this and other episodes in our series, visit reachmd.com/programs/heartmatters, where you can Be Part of the Knowledge. Thanks for listening.