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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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DETERMINING RESPONSE DIFFERENCES TO MICROGRAVITY IN MALE AND FEMALE BIOENGINEERED CARTILAGE TISSUES

Abstract

As humanity pushes further into the unknown, astronauts will be faced with heightened risks of physiological issues during long-term missions. Bone mass loss seen in astronauts is proportional to the time spent in zero-gravity, and increases the chance of osteoarthritis (OA), a disease that affects around 240 million people worldwide. OA occurs when the protective cartilage cushioning the joints degrades over time, and interestingly presents itself in women almost twice as much as in men. Knee osteoarthritis (KOA) is the most common form of OA and is used to study its pathogenesis. Several studies involving astronauts have already shown that prolonged periods of zero-gravity contribute directly to cartilage degradation in various measurable fashions. Others have investigated cartilage tissue behaviour inside artificial biological environments and centrifuges. The next step is to explore minute changes in cartilage tissue in microgravity, such as during a parabolic flight, to generate a deeper molecular and genetic understanding of OA pathogenesis.

Flying aboard the Canadian Space Agency's Falcon-20 parabolic aircraft in summer 2021, this experiment evaluated the molecular differences between female and male bioengineered cartilage samples when exposed to microgravity, while also for the first time specifically exploring the role of metabolites (the intermediate products of metabolism) in KOA pathogenesis. Metabolite activity responds to gravitational changes on a per-second basis and thus shows exact variations in cartilage tissue metabolism and degradation over time more accurately than before. Until now, such a focus on metabolites has not been conducted in this context. Sample groups were subject to set parabola quantities to determine the effect of repeated microgravity exposures. Hydraulic systems to promote the transfer of nutrient solution (to maintain sample health) and RNAlater reagent (to freeze the samples' molecular activity in time) were implemented, operated by two mission specialists. Upon return, all samples were mRNA-sequenced and molecularly analyzed with OA markers.

At this time, early analysis has shown a difference in male and female sample response, and has validated the experimental setup. Through further research, a novel understanding of the metabolite role in cartilage degradation will help in the identification of drug-targetable pathways, leading to more robust OA treatment in astronauts and the public alike. With crewed missions projected to increase in duration, the results will be extremely beneficial in ensuring the long-term prevention, mitigation and treatment of OA in the remote space environment. As a result, astronaut recovery time may be shortened, and mission

readiness increased.