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## 2012 Bone and Muscle Risk Standing Review Panel

### Status Review for:

*The Risk of Intervertebral Disk Damage,  
The Risk of Renal Stone Formation,*

*The Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance,  
and the Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity*

### Comments to the Human Research Program, Chief Scientist

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#### I. Introduction and Overview

The 2012 Bone and Muscle Risk Standing Review Panel (from here on referred to as the SRP) met for a site visit in Houston, TX on October 24 - 25, 2012 to review the Research Plan for the two bone risks (Risk of Bone Fracture and the Risk of Early Onset Osteoporosis Due to Spaceflight) in the Human Research Program's (HRP) Integrated Research Plan (IRP Rev. D) and to receive a status update on the Risk of Intervertebral Disk Damage, the Risk of Renal Stone Formation, the Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance, and the Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity.

The SRP thought that the presentation by Lori Ploutz-Snyder, Ph.D., Lead Exercise Physiology Scientist at the NASA Johnson Space Center and Musculoskeletal Alterations Team Leader for the National Space Biomedical Research Institute (NSBRI), was very well done. The general plan was to update the SRP on progress made since the last review in November 2011, present results from recently completed projects, discuss current projects underway and to interact with members of the SRP regarding future plans and the vision for future studies related to the IRP Rev. D gaps and tasks.

The general theme of the presentation succinctly identified that “**in-flight studies**” were progressing slowly, but had the greatest impact on operational objectives. Current studies on the International Space Station (ISS) have excellent crew response rates, but the number of crewmembers is limited and the times available for studies are limited. **Bed rest studies**, used as flight analogs performed in a 1G environment are easier to complete and address relevant flight information gaps. **Laboratory studies** address more basic and applied questions that do not easily transition to a microgravity environment. The approach taken, as a framework to discussion, was realistic and the translational approach focused on the needs of the astronauts.

#### II. Exercise Flight Studies

- In-flight evaluation of maximal aerobic capacity is progressing to completion at the end of 2012. Preliminary outcomes suggest the need for new in-flight medical tests but no specifics were provided. It was not surprising to the SRP that in-flight sub-maximal testing did not validly or reliably predict  $VO_{2max}$ .
  - Evaluation of treadmill kinematics and reaction forces at the treadmill surface at various speeds is also near completion indicating reaction forces increase with speed and reach
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values comparable to walking in 1G at speeds greater than 7 miles per hour. This is useful information in the development of training interventions to maintain bone and muscle integrity in future exploration missions.

- The Functional Task Test study is also near completion and was felt to be useful in providing insights to sensorimotor interface and strength related to specific task demands.
- The SPRINT/Standard Care assessments of fitness are ongoing and the SRP felt the large number of outcome measures, covering bone, muscle and cardiovascular measures, was good. The potential data set could be used in further studies designed to integrate the three major areas mentioned above which should be “value added” to program development. Also, implementation of the SPRINT training protocol although not as complete as the kinematics protocol, suggests there is a practical in-flight method of assessing fitness and guiding the development of a high intensity, low duration exercise prescription of maintaining fitness.
- One question posed by the SRP was “Can assessments of muscle and bone health using ultrasound technology be made on the remaining subjects?” The SRP concluded that the in-flight studies remain valuable and progress toward completion is being made.

### **III. Bed Rest Analog Studies**

- The initial 14-day six-degree head-down tilt bed rest feasibility study was completed between November 2010 and April 2011 and identified minimum fitness standards, medical monitoring plans, logistics of implementation, diet and rehabilitation needs and effectiveness of an exercise program in combating the effect of a microgravity environment on for example, muscle size and function and maintenance of body weight.
- Improvements in exercise hardware were also achieved to include, for example, modifications to the squat machine and vertical treadmill support system.
- The exercise prescription countermeasure and functional testing 70-day six-degree, head-down bed rest study is underway and contains a unique complement of three large multi-unit and multi-investigator studies. Additional outside disciplines in these studies include vision experts, testosterone studies, and neuroimaging of brain function related to learning. The study at the University of Michigan represents an additional effort to include neural control issues in astronaut performance. The exercise countermeasure used in all aspects of this large study is the SPRINT in-flight exercise treadmill training protocol.
- Finally, the SRP felt this comprehensive study would lead to at least two important outcomes. One is related to the effort to replace all exercise devices with one small device. Testing in this regard is ongoing and directly related to the needs/ requirements of a manned mission to Mars (i.e., payload limitations). The second is the opportunity to use the ISS to validate the fidelity of a ground analog (i.e., bed rest) to evaluate countermeasure effectiveness during long-duration space flight (i.e., greater than six months). These last two considerations are important and represent the vision of the muscle and aerobics risks team for future exploration missions.
- In conclusion, the SRP suggests that the small unit multi-function flywheel exercise device be evaluated as soon as possible. Furthermore it would be advantageous in the 70-

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day bed rest study to incorporate muscle and bone health using ultrasound technology and function testing on a subset of subjects.

#### **IV. Laboratory Studies**

- The data from standardized pre-flight exercise tests to predict performance during extravehicular activity in a lunar environment should be compared to data from the Passmore, R. and Durnin, JVGA study (Passmore, R. and Durnin, JVGA (1955). Human Energy Expenditure. *Physiological Review*, 35: 801-840) as a means of comparative validation of similar tasks.
- The study (Integrated Regulation of Bone and Muscle Metabolism by Simulated Microgravity) by Henry Donahue, Ph.D. (Penn State College of Medicine) was felt to be a good example of the link between muscle and bone albeit in rodent hindlimb unloading. The SRP continues to emphasize the need for new studies integrating the various sub-disciplines.
- The study (Modulation of Muscle Function by Lower Limb Loading during Spaceflight) by William Paloski (University of Houston) was felt to be good as it might provide data related to the time course of muscle atrophy as well as the effect of foot pressure on muscle activation (i.e., the effect of force-dependent input on muscle activation patterns and neural control).
- The completed study (Development of a Submaximal Cycling Protocol to Identify the Ventilatory Threshold in Astronauts: Application to Monitor Changes in Endurance Capacity in Response to Long-Duration Spaceflight Missions) by Richard Simpson (University of Houston) on development of an algorithm identifying the ventilation threshold (VT) needs to be evaluated in comparison with the 1972 published work of B. J. Whipp and K. Wasserman *J. Appl. Physiol.* 33:351-356, 1972.
- NASA's Digital Astronaut Project continues to be a challenge. Given the current state of musculoskeletal modeling the questions posed by the muscle discipline are appropriate. One example is the need for magnetic resonance imaging characterized input parameters (good idea) and the second is the limitations of the current model as exemplified by the discussion on kinematic differences in the Advanced Resistance Exercise Device exercise between microgravity and 1g and the failure of the model. The muscle discipline group is very aware of these problems.
- Consideration of Small Business Innovation Research (SBIR) proposals, improvements on the treadmill harness and the improved collaboration between NASA and the NSBRI are all positive indications of improvements in the overall muscle discipline research plan.

#### **V. Summary and Conclusions**

In the SRP's opinion, the muscle discipline appears to be well managed and remains focused on the objectives initially established by the SRP in 2009. Good progress has been made; short-term goals have been reached (i.e., projects completed); long-term objectives are clear with necessary projects underway, and the vision regarding future challenges is clear and appropriate.

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The SRP concludes there is a need for the ISS to remain operational as a test bed for the development of the next generation exercise equipment, especially the testing required for the development of a single exercise device that can achieve the same results as the currently used “set” of exercise equipment.

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## **VI. 2012 Bone and Muscle Risk SRP Status Review: Statement of Task for the Risk of Intervertebral Disk Damage, the Risk of Renal Stone Formation, the Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance, and the Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity**

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The 2012 Bone and Muscle Risk Standing Review Panel (SRP) will participate in a Status Review that will occur via a site visit meeting with the Human Research Program (HRP) Chief Scientist, Deputy Chief Scientist and members of the Human Health Countermeasures Element. The purpose of this review is for the SRP to:

1. Receive an update by the HRP Chief Scientist or Deputy Chief Scientist on the status of NASA's current and future exploration plans and the impact these will have on the HRP.
2. Receive an update on any changes within the HRP (for example, each of the Elements rewriting their gaps) since the 2011 SRP meeting.
3. Receive an update by the Element or Project Scientist(s) on progress since the 2011 SRP meeting.
4. Participate in a discussion with the HRP Chief Scientist, Deputy Chief Scientist, and the Element regarding possible topics to be addressed at the next SRP meeting

The 2012 Bone and Muscle Risk SRP is not required to produce a report from this status review, but the HRP Chief Scientist welcomes any written comments from the SRP within 30 days of the 2012 update. Any comments that the 2012 Bone and Muscle Risk SRP provides to the HRP Chief Scientist will be made available to the public on the Human Research Roadmap website (<http://humanresearchroadmap.nasa.gov/>).

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## VII. 2012 Bone and Muscle Risk Standing Review Panel Roster

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