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Body Mass Changes During Long-Duration Spaceflight

Dear Editor:

The authors of the recent article by Zwart et al. (6) should be commended for determining body mass during spaceflight with reliability and precision. They found the "crewmembers lost 2-5% of their body mass in the first month of flight and subsequently maintained the lower body mass during flight." However, the authors make several assumptions and conclusions that are difficult to support. They make the statement that loss of body mass during spaceflight is due to "insufficient caloric intake" and is "associated with increased muscle loss. ... Body mass loss can generally be explained by the subjects not consuming WHO-recommended caloric requirements." Further weight loss after 1 month is explained as "the occurrence of a consistently lower energy intake throughout the flight that is not accompanied by additional loss of body mass indicates that subjects were in energy balance during the mission." The authors down play the role of fluid shifts since previous studies "did not detect increased diuresis." Plasma volume was not measured or addressed in this study.

Weightlessness has a potent effect on fluid volume shifts. There is a rapid loss of plasma volume during the first day of spaceflight (17%) which causes an increase in the hematocrit, but does not cause an immediate diuresis. There is some adaptation that occurs which adjusts this to a 10% reduction at 12 days (1,2). This plasma volume loss is associated with fluid shifts cephalad from the lower extremities. The 84-day flight of Skylab 4 found that in-flight body mass decreased by 2.5 kg (3.8%) and leg volume decreased by 12.5%. Astronauts, however, became adapted after 4 weeks to the orthostatic stress provided by in-flight LBNP (5). Detailed leg volume studies on the Shuttle showed that up to 2 L of fluid was lost from the lower extremities within 10 hours of flight (4). I will note that it has been found that the loss of plasma volume is not the sole cause of orthostatic intolerance post-spaceflight. There are also changes in the total peripheral resistance, blunting of the carotid baroreceptor-cardiac reflex, and a lack of responsiveness to catecholamines combined with a hypo-adrenergic response.

The body mass loss during spaceflight found in this study is entirely consistent with plasma volume loss due to the cephalad shift of fluids from the lower extremities which occurs during the first weeks of the mission. Although deconditioning and muscle loss undoubtedly occurs, it would be expected to be gradual throughout the mission duration (3) and of much less magnitude than the fluid losses. This is supported by the rapid return to normal of subject body mass after landing as found in this study.

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REFERENCES
1. Diedrich A, Paranjape SY, Robertson D. Plasma and blood volume in space. Am J Med Sci 2007; 334:80–5.
2. Leach CS, Alfrey CP, Suki WN, Leonard JI, Rambaut PC, et al. Regulation of body fluid compartments during short-term spaceflight. J Appl Physiol 1996; 81:105–16.
3. Matsumoto A, Storch KJ, Stolfi A, Mohler SR, Frey MA, Stein TP. Weight loss in humans in space. Aviat Space Environ Med 2011; 82:615–21.
4. Moore TP, Thornton WE. Space shuttle inflight and postflight fluid shifts measured by leg volume changes. Aviat Space Environ Med 1987; 58(9, Pt. 2):A91–6.
5. Thornton RE, Moore TP, Pool SL. Fluid shifts in weightlessness. Aviat Space Environ Med 1987; 58(9, Pt. 2):A86–90.
6. Zwart SR, Launius RD, Coen GK, Morgan JL, Charles JB, Smith SM. Body mass changes during long-duration spaceflight. Aviat Space Environ Med 2014; 85:897–904.

In Response:

We appreciate Dr. Campbell's letter, interest, and kind words regarding our recent paper (4). He nicely and succinctly highlights many aspects of the fluid shifts that occur during spaceflight, and their documentation over several earlier space programs. However, shifting of fluid among compartments or regions (e.g., from the legs to the upper torso) will not result in loss of body mass. Diuresis of fluid is required for a loss of body mass and, as he notes, this has not been observed during flight (1-3). In an attempt to document fluid changes in Mir astronauts, Drummer et al. came to conclude that "loss of body mass during space flight is rather a consequence of hypocaloric nutrition."

Research on the Spacelab Life Sciences flights of the early 1990s indeed documents reductions of up to 17% in plasma volume in the first hours of flight, with some repletion in the following days (3). However, in those same subjects, neither total body water nor body mass changed from preflight levels (3). Ignoring those facts for a moment, the plasma volume loss averaged 0.58 L on flight day (FD) 2 and 0.4 L on FD 7/8. Thus, for those same subjects, if all of the plasma volume missing on FD 7/8 (0.4 L) had been lost (excreted), it would represent less than 0.5% of body mass on average.

Regarding Dr. Campbell's comments on the "rapid return to normal" body mass after flight, we noted in the paper (on page 902) that the initial mass determinations after landing are confounded by many factors. Although body mass measurement around 30 days after landing is (on average) back to preflight levels, this timeframe (4-6 weeks postflight) is similar to that of recovery of muscle and red blood cell mass.

We concede that we are not able to draw definitive conclusions of causality and that we did not measure fluid volumes or collect other data that might help to clarify these findings further. Nonetheless, on the basis of the dietary intake data and the body mass loss data, we maintain that the body mass losses can "generally be explained" by crewmembers not consuming enough energy. Might other factors, including fluid loss, also contribute in part to this phenomenon? Absolutely.

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DOI: 10.3357/ASEM.4148.2014