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LSAH

THE LONGITUDINAL STUDY OF ASTRONAUT HEALTH

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Body Mass Changes in Phase I Astronauts

International Space Station (ISS) Phase I, more commonly known as Phase I, served as a precursor to the ISS experience. In this program, the existing resources of the US Shuttle orbiters and the Russian Space Station Mir were used to test the challenges facing the international partners in the areas of cooperation, data gathering, and logistics. As part of Phase I, seven NASA astronauts served as Mir crewmembers between March 1995 and June 1998. Physiological data gathered on these NASA astronauts can give insight on the effects of long-term weightlessness on individuals, which in turn is important for ISS considerations.

Changes in body weight during periods of prolonged weightlessness were examined for six of the seven US astronauts who have flown on Mir. Figure 1 presents the mean body weight and standard deviations (SD) at four intervals: the annual examination in the year prior to flight (Preflight Annual), inflight on approximately Flight Day 90 (FD 90), the third day after return to Earth (R+3), and the annual examination in the year after flight (Postflight Annual). Mean weight was 77.2 kg at the preflight annual examination, 73.8 kg at FD 90, 77.3 kg at R+3, and 78.1 kg at the postflight annual examination. There was a downward shift in mean weight inflight, with return to preflight mean weight occurring by R+3. However, inflight mean weight was not statistically significantly different from the preflight and postflight mean weights.

Another way to look at this type of data is to calculate and examine the percent change between preflight and inflight values. Figure 2 (on page 4) presents inflight data, comparing weight on FD 30, FD 60, and FD 90 to weight at preflight annual examination. Percent of change is calculated by the difference between the preflight annual examination weight and the inflight weight divided by the preflight weight multiplied by 100. The resulting negative value indicates that weight decreased early in the mission (-3.5% by FD 30) and then remained relatively constant at

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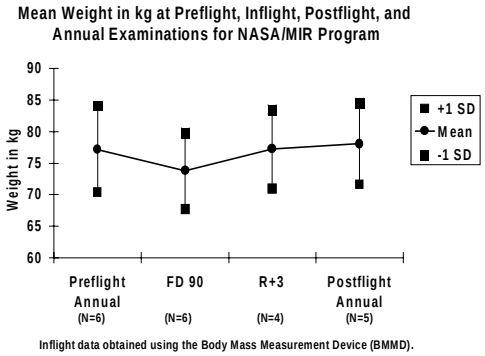

Figure 1

The 1998 Astronaut Class

Twenty five individuals have been selected to be in the latest astronaut class, with women comprising 16% (4 out of 25) of the total. The men have a mean age of 36.5 years, with an average Body Mass Index (BMI) of 26.0 (Table 1). The mean age for the women is 36.0 years, while their mean BMI is 20.3.

When compared to previous astronaut classes, the new male astronauts have a comparatively higher mean age, continuing the trend started with the 1992 selection class of mean age higher than 35 years. These new astronauts also possess the highest value for mean BMI.

As compared to the astronaut classes after 1969, this new class falls in the middle of the range (from 11% to 22%) in terms of its representation of women. These new female astronauts also display a typical mean BMI value. However, this group is notable for having the highest mean age of all female astronaut groups. ■

Table 1

Selection Yr	Selected M	Selected F	Mean Age M	Mean Age F	Mean BMI M	Mean BMI F
1959	7	0	34.7	n/a	23.9	n/a
1962	9	0	33.0	n/a	23.3	n/a
1963	14	0	31.5	n/a	23.4	n/a
1965	6	0	31.9	n/a	23.5	n/a
1966	19	0	33.3	n/a	23.6	n/a
1967	11	0	32.0	n/a	25.6	n/a
1969	7	0	33.2	n/a	23.1	n/a
1978	29	6	33.2	29.2	23.7	22.4
1980	17	2	33.3	31.9	23.4	19.3
1984	14	3	34.9	31.9	23.7	19.8
1985	11	2	32.7	29.5	23.5	20.6
1987	13	2	34.1	32.3	23.5	21.6
1990	18	5	34.7	32.2	23.6	21.0
1992	16	3	36.7	31.6	24.0	22.3
1995	16	5	36.9	34.3	24.7	21.1
1996	27	8	37.1	33.7	24.8	21.8
1998	21	4	36.5	36.0	26.0	20.3
Total	**255**	**40**	**34.1**	**32.2**	**24.0**	**21.1**

The Association between Aging and Specific Physiological Measurements

As part of the process of examining data to separate the effects of space flight from the background effects of aging, a comparison is made of the age-specific values for certain physiological measurements among both the astronauts and the comparison participants. A number of physiological measurements have recently been examined in this manner and a few have been selected for inclusion in this newsletter. In the general population, aging is associated with weight gain and increased serum lipids, increased blood pressure, and hearing loss. Similar associations were found among the LSAH population and the differences between the astronauts and the comparison participants, in general, were not dramatic.

The current mean age of the study population is slightly lower for the females, 41 years, than for the males, 49 years. The age range is from the late 20s to the middle 70s. The cumulative follow-up time is 4057 person years for the astronauts and 12874 person years for the comparison participants.

For the purposes of looking at the association of aging, cross-sectional data for specific age groups were examined. The data were organized by age of examination for all annual examinations for all study participants. The first examination was selected for each participant when he/she entered a new age group. An individual is included in every age group that he/she has achieved but is represented only once in any age group.

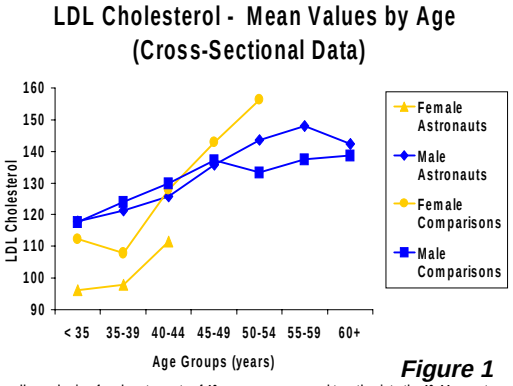

Figure 1

* Due to small sample size, female astronauts of 40+ years were grouped together into the 40-44 yrs category

Low-density-lipoprotein (LDL) cholesterol is the component of cholesterol that is most closely associated with risk of heart disease. The ratio of LDL to high-density-lipoprotein (HDL) cholesterol appears to be more important than the raw values of either type of cholesterol. The trend frequently observed in the general population is an increase in LDL and a decrease in HDL as aging occurs. The trend among the LSAH population for LDL is also an increase with age (Figure 1). However, the trend for HDL is relatively flat (not shown). HDL is associated with exercise and it can be speculated that the LSAH population is more active than the general population. As the numbers of individuals in the upper age groups increase, this flat trend for HDL may or may not continue. The values for both of these variables are noticeably different for the females compared to the males. This difference is consistent with the lower risk of heart disease for

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Physiological Variables of EVA Participants

Placing a human into free space, outside the protective confines of the space vehicle, has become an important component of space travel and exploration. An Extravehicular Activity (EVA) is a protocol that requires the astronaut to leave the aircraft to perform various duties such as repairs, observations, and experiments. One of the most important aspects of preparing for an EVA is to determine the physical requirements of the participants. Although the astronaut corps consists of individuals with specific skills, not everyone may be suitable for EVA activity. It is important, therefore, to determine whether the astronauts who perform EVAs differ from the general astronaut population in particular physiological variables. For comparability purposes, only data from Shuttle astronauts were used in these analyses.

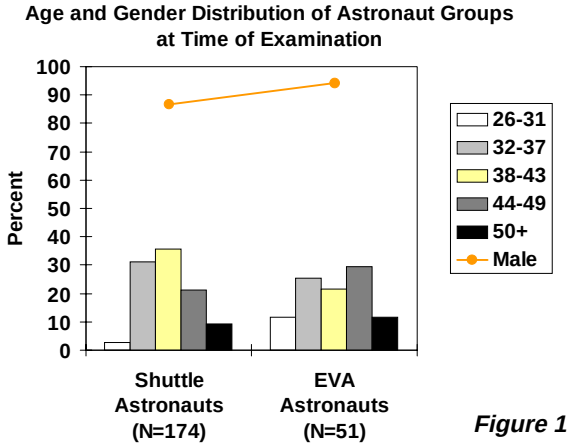

Figure 1

There have been 270 United States astronauts selected into the NASA astronaut

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corps from 1959 until 1998. Of the 270 astronauts, 225 have flown through the January 23, 1998 launch of STS-89, with 183 of this group flying on the Shuttle. A total of 114 EVAs have been performed, with approximately 83 performed during the Shuttle program.

Of the Shuttle astronauts, 174 had available data from annual examinations conducted in the six years prior to their flights. Their gender distribution (Figure 1, page 2) shows that 86.8% are males. Fifty seven percent of these astronauts were between 38 and 49 years of age, with 62.6% of individuals within this age group younger than 43 years of age. More than 90% of the entire group was younger than 50 years of age.

Table 1 shows the means of the following variables for the Shuttle astronauts: age (at time of examination), percentage of body fat (%Body Fat), mean VO_{2max} and maximum heart rate (MHR). BMI is a surrogate measure for fatness which is more accurate for a group of people than for an individual; it is calculated using the weight in pounds and the height in inches. A BMI between 22-26 is about standard. Percentage of body fat is an estimation of fatness based on the sum of three skin-fold measurements and age at last birthday. Values of 10%-15% for men, and 20%-25% for women, are considered to be the norm for the general population. VO_{2max} and MHR are estimations of cardiovascular fitness that are measured during an Exercise ECG test. VO_{2max} is measured by the volume of oxygen, in milliliters per kilogram of body weight, expired per minute, and is an indicator of an individual's maximal aerobic capacity. The normative values of VO_{2max} for men and women in good aerobic condition in the 30-49 years age group are 41 ml/kg/min and 37 ml/kg/min, respectively. The MHR is the maximum heart rate, measured in beats per minute. For individuals in the 38-49 years age group the expected MHR is 179.7 beats per minute.

Table 1. Shuttle Astronauts*

Age Group	Total N=174	BMI (N)	% Body Fat (N)	VO_{2max} (N)	MHR (N)
26-31	5	22.5 (2)	10.9 (2)	48.9 (5)	179.0 (5)
32-37	54	23.5 (44)	14.4 (45)	46.0 (52)	177.0 (52)
38-43	62	23.9 (50)	15.5 (49)	45.4 (60)	171.6 (61)
44-49	37	24.2 (33)	16.6 (33)	42.4 (37)	170.1 (34)
50+	16	24.7 (10)	18.1 (9)	41.6 (16)	169.4 (14)
38-49	**99**	**24.0 (83)**	**15.9 (82)**	**44.2 (97)**	**171.0 (95)**

**Measurements have different totals (N) because examination data availability varies from individual to individual.*

As expected, the Shuttle astronauts showed better fitness than the general population; the majority of the astronauts, those in the 38-49 year age group, had higher VO_{2max} and lower MHR values than the previously mentioned norms.

In analyzing EVA data, each EVA per mission is accounted for, so that an astronaut is included for every EVA mission and the age group he/she has achieved. Fifty one EVA participants had data available from examinations (Table 2). The majority (51%) of the EVA participants were under the age of 43, and 94.1% of them were male (Figure 1, page 2). The small number of female participants precludes data analysis of this group.

All of the parameters varied only slightly between EVA participants and Shuttle astronauts. The largest age group representation of EVA participants is in the 44-49 years age group (29.4%), while that of the Shuttle astronauts is the 38-43 years age group (35.6%). In comparing the majority of each group's subjects (38-49 years age group), there is very little difference in the BMI or VO_{2max} between the two 38-49 years age groups, but the average percentage of body fat for the EVA participants was slightly lower than that of the Shuttle astronauts. However, the EVA participants also have a slightly higher mean MHR (172.5 versus 171.0 beats per minute). The trend of decreasing VO_{2max} and MHR seen in the older population of the astronaut corps could not be detected in the EVA participants, possibly due to the small sample size in those age groups. Therefore, EVA participants were slightly older, but might be slightly more fit, than the total group of Shuttle astronauts at the time of their examination.

These results are preliminary; further analyses of EVA participants should include all participants and examination data within one year of flight. Through such data availability, a more comprehensive analysis may yield some criteria for EVA participants during the International Space Station implementation.■

Table 2. EVA Participants*

Age Group	Total N=51	BMI (N)	% Body Fat (N)	VO_{2max} (N)	MHR (N)
26-31	6	23.3 (3)	17.5 (3)	49.6 (6)	182.5 (6)
32-37	13	24.6 (13)	15.2 (13)	43.2 (13)	172.7 (13)
38-43	11	23.1 (9)	13.2 (9)	48.1 (11)	173.2 (11)
44-49	15	24.1 (14)	15.6 (14)	41.7 (14)	172.0 (15)
50+	6	22.5 (6)	15.1 (6)	43.4 (6)	172.3 (6)
38-49	**26**	**23.7 (23)**	**14.7 (23)**	**44.5 (25)**	**172.5 (26)**

**Measurements have different totals (N) because examination data availability varies from individual to individual.*

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women during pre-menopausal years than for men of the same ages. The sharp increase seen in LDL for women at age 40-44 is associated with an increase in risk that is more like the risk men have for heart disease.

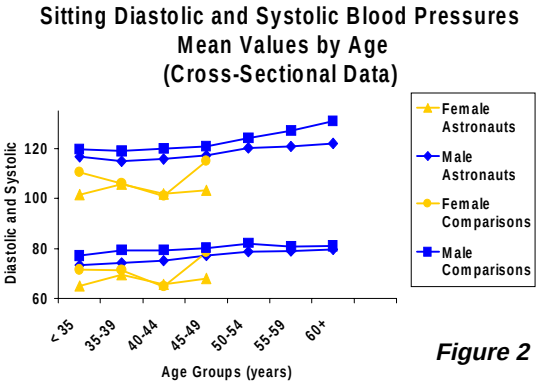

Figure 2

Relatively small increases in blood pressure result in increased risk of circulatory diseases such as stroke and heart disease. Figure 2 (diastolic pressures are shown in the lower part of the figure and systolic pressures in the upper part) shows an upward trend in blood pressure with age for both the comparison participants and the astronauts. Again, the number of females included in 40 and above age groups is small and results in somewhat erratic trend lines.

Hearing loss is associated with aging as well as with occupational exposures to noise. It would not be unexpected to see greater hearing loss among the astronauts than among the comparison participants. However, that is not evident in the current data. Figure 3 shows the results of one of the high frequency (6000 Hertz) tests completed in the standard audiometric test. The patterns were similar for all frequencies from 500 through 8000 Hertz. A hearing loss is seen in association with age, especially for males, but the difference between the comparison participants and the astronauts is negligible.

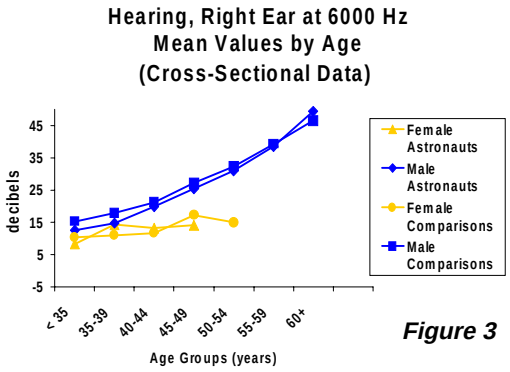

Figure 3

There are some differences between the astronauts and the comparison participants in the many physiological measures recently examined but the patterns seem to be very much alike for the two groups. The astronauts started this study from a point of selection based on a high standard of well being whereas the comparison participants started from a point of being a generally healthy working population. The occupational exposures of the astronauts have some high risks and are different from the comparison participants. However, the current data suggests that both groups are affected by age in the same ways. These data will continue to be monitored and shared with study participants through this newsletter. ■

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the next two inflight intervals (-4.0% by FD 60 and -4.25% by FD 90).

The method of measurement is different for inflight and on ground, which may contribute to the differences in weight reported here. These results suggest that during periods of prolonged weightlessness, astronauts may experience weight loss early in the mission. Inflight weight appears to stabilize at the new level, and return to preflight levels after return to Earth. Further research into nutritional status during long-duration spaceflight may reveal the causes and consequences of this temporal weight loss. ■

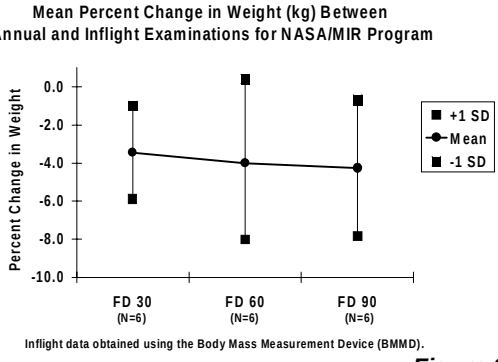

Figure 2

For your information

If you want a copy of your exam results, please complete and sign a release form while you are visiting the Clinic for your examination. The form is called *Privacy Act Disclosure Authorization and Accounting Record (DAAR)*, or NASA Form 1536.

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