Characterizing fractures across the astronaut corps: Preliminary findings from population-level analysis

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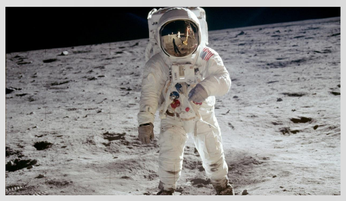
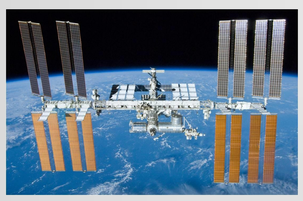
Introduction

Despite evidence of bone loss during spaceflight and the implementation of countermeasures to mitigate this loss, the subsequent risk of fracture among astronauts is not known. Multiple factors such as age, sex, fracture history, and others may combine to increase fracture risk. The purpose of this study was to describe fractures among the astronaut population and generate questions for future occupational surveillance studies.

Methods

In support of the 2016 Bone Research and Clinical Advisory Panel (RCAP), fracture data was compiled and analyzed on all 338 NASA astronauts through August 17, 2016. The Lifetime Surveillance of Astronaut Health (LSAH) database and the JSC Flight Medicine Clinic Electronic Medical Record (EMR) were the primary sources of data. We analyzed unadjusted differences across demographics, population-mission characteristics, and fracture history between crewmembers with and without fracture, using chi-squared tests and Fisher's exact test for categorical variables and Student's t-tests for continuous variables (Table 1).





Results

Table 1. Descriptive Statistics for Astronauts with and without *Post-Selection* Fracture¥

Measure	All n (%)	No Fracture n (%)	Fracture¥ n (%)	p value	Crude OR (95% CI)
All NASA Astronauts	338 (100)	223 (66.0)	112 (33.1)		
Sex					
Females (Ref)	52 (15.4)	40 (76.9)	12 (23.1)	0.09	1.82 (0.91, 3.63)
Males	286 (84.6)	183 (64.0)	100 (35.0)		
History of Pre-Selection Fracture¥					
Yes	185 (54.7)	119 (64.3)	66 (35.7)	0.33	1.25 (0.79, 1.98)
No (Ref)	150 (44.4)	104 (69.3)	46 (30.7)		
Flight Status					
Never Flown (Ref)	32 (9.5)	28 (87.5)	4 (12.5)	0.01*	3.88 (1.32, 11.34)
Flown	306 (90.5)	195 (63.7)	108 (35.3)		
Flight Duration					
Short Duration (Ref)	259 (76.6)	162 (62.5)	94 (36.3)	0.36	0.73 (0.37, 1.44)
Long Duration	47 (13.9)	33 (70.2)	14 (29.8)		
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**p value**	
Selection Age	34.5 (3.7)	34.3 (3.6)	34.7 (3.8)	0.39	
Age at First Mission	40.6 (4.6)	40.1 (4.1)	41.4 (5.3)	0.03*	
Cumulative # of Days in Space	57.4 (80.8)	61.5 (82.9)	50.9 (77.7)	0.28	
Years 1st Mission to 1st Fracture	9.6 (8.1)	--	9.6 (8.1)	--	
Age at 1st Fracture	45.9 (9.1)	--	45.9 (9.1)	--	

¥3 crewmembers experienced a fracture with unknown date, therefore timing relative to selection could not be determined.

*p value is statistically significant at the 0.05 level.

Figure 1. Activity during fracture, among all post-selection fracture events (n=205).

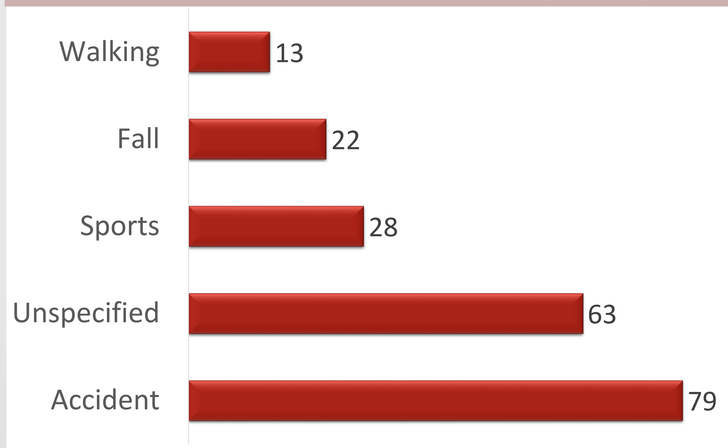
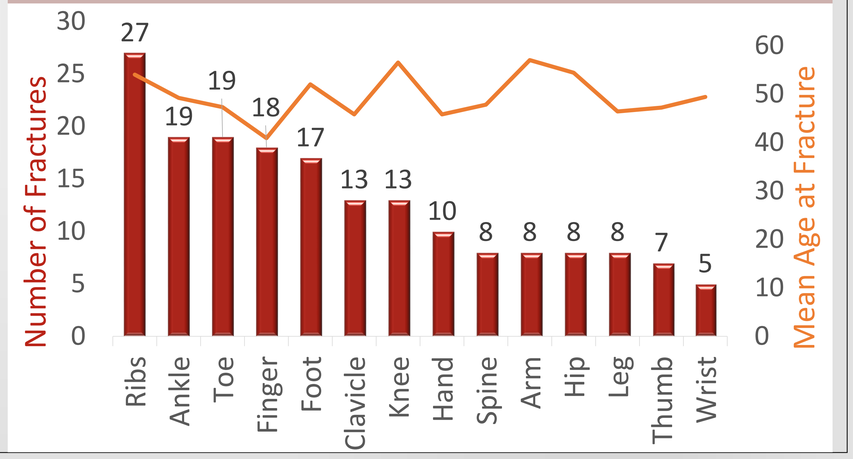


Figure 2. Number of Fractures and Mean Age at Fracture, for top 14 body sites of fracture (n=180)



Discussion

This study provides a preliminary examination of the potential relationships between having a post-selection fracture and the variables of interest. The ability to draw conclusions from descriptive statistics and unadjusted effect measures is limited. Additional analyses are needed to examine the combined impact of multiple variables on the outcome, as well as the addition of other relevant variables such as medication use, exercise practices, and mission characteristics. The number of fractures due to accidents and sports supports the idea that astronauts are a highly active population overall. The high proportion of "unspecified" fractures with no apparent trauma event may indicate an opportunity to encourage detailed EMR documentation, and may also represent the limitations of analyzing historical data. These unspecified fractures merit additional review and analysis. The significance of flight status on the odds of post-selection fracture is compelling, though not necessarily unexpected, given the known effects of microgravity on bone density and structure. Other factors may be underlying this effect, such as age. Although the average age at first mission is higher among those who had a fracture, the difference of one year on average may not have clinical relevance or operational application. Given the medication and exercise countermeasures already in place, characterizing the relationship between risk factors, exposures, and fracture outcomes may be especially challenging, and will require innovation in the design of meaningful studies to understand these relationships from a population perspective.