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U.S. Army Aviation Epidemiology Data Register: Distribution of Sitting Heights Among Army Aviation Training Applicants, 1986 to 1995

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The Aviation Training Brigade, U.S. Army Aviation Center, Fort Rucker, Alabama, and the U.S. Army Aeromedical Center, Fort Rucker, Alabama, requested an analysis of the distribution of sitting heights among male and female applicants for entry into the Army Aviation Branch. They may revise the current sitting height entry standard of "less than or equal to 102 centimeters" to a new qualification standard as low as "less than or equal to 97 centimeters."

The analysis was conducted with a query of the U.S. Army Aviation Epidemiology Data Register. Flying duty medical examination data on applicant status, class of officer commissioning, gender, and sitting height were extracted for all Army aviator training applicants for the period 1 January 1986 to 31 December 1995.

The analysis showed that adoption of the lower standard (97 centimeters) would reduce the aviator training applicant pool by as much as 9.57 percent. Warrant officer applicants

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have a slightly greater risk for aeromedical disqualifications due to sitting heights exceeding the proposed standard than commissioned officer applicants (Relative risk (Katz)=1.13, CI 0.95=1.06,1.23). Male applicants would carry almost the entire burden of the increased risk for aeromedical disqualification if the sitting standard was changed (Relative risk (Katz)=19.6, CI 0.95=9.83,39.3).

Distribution tables and figures of sitting heights, stratified by class of officer, commissioned versus warrant, and by gender are included.

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Military relevance

The Aviation Training Brigade (ATB), U.S. Army Aviation Center, Fort Rucker, Alabama, and the U.S. Army Aeromedical Center, Fort Rucker, Alabama, requested an analysis of the distribution of sitting heights among male and female applicants for entry into the Army Aviation Branch. They may revise the current sitting height entry standard of "less than or equal to 102 centimeters" (U.S. Army Aeromedical Center, 1996) to a new qualification standard as low as "less than or equal to 97 centimeters."

In 1984, the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama, completed an anthropometric assessment in various Army aircraft with aircrew members wearing several aircrew clothing ensembles. For assessment of sitting heights, researchers looked for the top of the aircrew member helmet touching the cockpit ceiling. This occurred in the OH-58C for aircrew members with sitting heights above 97 centimeters wearing training, warm weather ensemble, and 95 centimeters for aircrew members wearing the cold weather, armored vest, and chemical defense ensembles (Schopper and Cote, 1984; Cote and Schopper, 1984).

In 1989, a working group of Fort Rucker aviation, aviation safety, and aeromedical clinical and research authorities made a recommendation to establish a sitting height qualification standard of less than or equal to 95 centimeters for aviators and aeroscout observers transitioning into the OH-58 aircraft, while maintaining the qualification standard of less than or equal to 102 centimeters for all other aircraft. The basis of the recommendation was:

a. The functional restrictions in the OH-58 related to sitting height noted in USAARL anthropometry reports (Schopper and Cote, 1984; Cote and Schopper, 1984).

b. USAARL and the U.S. Army Aeromedical Activity (USAAMA), Fort Rucker, Alabama, reviewed a series of aeromedical board cases of OH-58 aviators with chronic back and lower neck pain. All of the symptomatic aviators had sitting heights greater than 95 centimeters. Cockpit evaluations showed that the aviators assumed a crouched posture while flying to avoid hitting their head on the OH-58 cockpit ceiling. With their eye level above the upper door frame, they had restricted lateral view outside the aircraft, and had to crouch further to obtain a lateral view.

c. USAARL and the U.S. Army Safety Center, Fort Rucker, Alabama, noted several case reports of severe, permanently disabling, head injuries among tall personnel caused by head collisions against the vertical, anterior door frame and door emergency ejection knob in otherwise survivable mishaps. Statistical analysis showed no increase risk for head injury in OH-58 mishaps compared to UH-1 mishaps, however, the analysis was based on a small number of OH-58 mishaps (32 from FY1984 to FY1988).

d. USAARL biomedical engineers were concerned that the crouched posture, noted in (b) above, might increase spinal loading in mishaps resulting in an increased risk for spinal fractures.

Following further deliberations of the working group and the Aeromedical Consultant Advisory Panel, the recommendation became aeromedical policy in 1990 (U.S. Army Aeromedical Center, 1990). However, the policy was problematic from its inception. The U.S. Army procured the OH-58D series for scout and light attack missions and the TH-67 series for training. These aircraft are similar in cockpit design, but not identical to the OH-58C, upon which the 95 centimeter sitting height policy was based. The anthropometric limitations of the OH-58D and TH-67 are unknown. Anthropometric assessments of the TH-67 were initiated in the summer of 1995, but are incomplete at this time. Currently, the Army proposes that all initial training students receive basic skills training in the TH-67 and combat skills training in the OH-58. During the same time, the U.S. Army Aeromedical Activity evaluated a series of male aviators who did not complete transition training in the AH-64 Apache because their sitting height, or a combination of sitting height and leg length, was too short. The dilemma is that restricting students to a 95 centimeter sitting height for IERW training in the OH-58, and possibly the TH-67, might reduce the pool of available students for later transition into the AH-64 where a taller sitting height is desirable.

To provide additional information to the anthropometry policy makers, USAARL queried the U.S. Army Aviation Epidemiology Data Register (AEDR) to determine the distribution of sitting height among applicants to Army aviator training. The AEDR is a family of databases storing information on the health of Army aviators, flight surgeons, aeroscout observers, air traffic controllers, and applicants to these occupations. One element of the AEDR stores flight physical information, which includes anthropometry measures for aviator training applicants.

Methods

The AEDR was queried for flying duty medical examinations (FDME) submitted on Army aviator training applicants with purpose of examination codes 1A (officer) and 1W (warrant officer). The query was limited to 1 January 1986 through 31 December 1995. In the case of multiple FDMEs on an individual, the applicant's last FDME containing sitting height data was kept for analysis. U.S. military flight surgeon office staff members made the measurements during FDMEs.

The query identified records on 39,349 individual applicants. Among these records, 275 had sitting heights that were outside the biologic range of 1st percentile through the 99th percentile general Army population individuals (Gordon et al., 1989). Most appeared as recording errors in inches rather than centimeters, such as 31.5 (inches) instead of 80.0 (centimeters), or cases of simple transposition of ASCII text alphanumerics, such as "012" instead of "102". These 275 records were discarded. Among the remaining 39,074 records, 93 had missing gender data, resulting in a final analysis cohort of 38,981 individual applicants. For each individual, the class of officer appointment, gender, and sitting height were retained for analysis.

Frequency distributions were compared by Goodness of Fit testing using the Kolmogorov-Smirnov method (Daniel, 1983). Relative risks with 95 percent confidence intervals were computed by the method of Katz (Kahn and Sempos, 1989).

Results

Table 1 shows the overall cumulative frequency distribution for applicant sitting heights. Table 1 is by descending sitting height since policy makers might revise the sitting height policy downward from 102 centimeters. Table 1 shows that 0.11% of applicants exceed the current qualification standard of less than or equal to 102 centimeters. Normally, individuals are aeromedically disqualified for sitting heights in excess of the standard, unless granted an exception to policy to enter aviator training despite the disqualification.

Table 1 can be used to predict the impact of sitting height entry standards modification on the applicant pool. For example, establishing a qualification sitting height standard of less than or equal to 97 centimeters (worse case proposed by ATB) would aeromedically disqualify 9.46% additional applicants (9.57% disqualified by the proposed standard minus 0.11% disqualified by both the current and the proposed standards). Adopting a qualification standard of less than or equal to 95 centimeters (current policy for the OH-58) would disqualify 22.56% additional applicants (22.67% disqualified by the proposed standard minus 0.11% disqualified by both the current and the proposed standards).

Table 1.
Summary cumulative frequency for all aviator training applicants
with sitting heights ranging from 110 to 95 centimeters.

Sitting height (cm)	N	Frequency (%)	Cumulative frequency (%)
110	2	0.01	0.01
109	1	0.00	0.01
108	0	0.00	0.01
107	2	0.01	0.01
106	0	0.00	0.01
105	6	0.02	0.03
104	15	0.04	0.07
103	17	0.04	0.11
102	165	0.42	0.53
101	232	0.60	1.13
100	655	1.68	2.81
99	885	2.27	5.08
98	1,751	4.49	9.57
97	1,829	4.69	14.26
96	3,276	8.40	22.67
95	2,975	7.63	30.30
N	38,981		

Figure 1 and Table 2 show a comparison of the cumulative frequency distribution of sitting heights for commissioned officer applicants versus warrant officer applicants. The two curves are significantly different by Goodness of Fit testing (Kolmogorov-Smirnov, $p<0.01$). This finding is due to the large sample size (N=38,981), resulting in very narrow confidence intervals, and thus statistically different curves. Table 2 shows the number, frequency, and cumulative frequency for the comparison.

To quantify the operational impact of the differences between sitting heights of commissioned and warrant officer applicants, we can determine the relative risk of aeromedical disqualification if the Army adopted a new sitting height standard. Continuing with the example from above, the Army proposes a new sitting height qualification standard of less than or equal to 97 centimeters. In this case, warrant officers are at a significantly increased risk for aeromedical disqualification compared to commissioned officers (Relative $\text{risk}_{(\text{Katz})}=1.13$, $\text{CI}_{0.95}=1.06,1.23$), but this increased risk is very small, only 1.13 times (13%) more likely. Our opinion is that this degree of difference is not operationally significant in the applicant selection process.

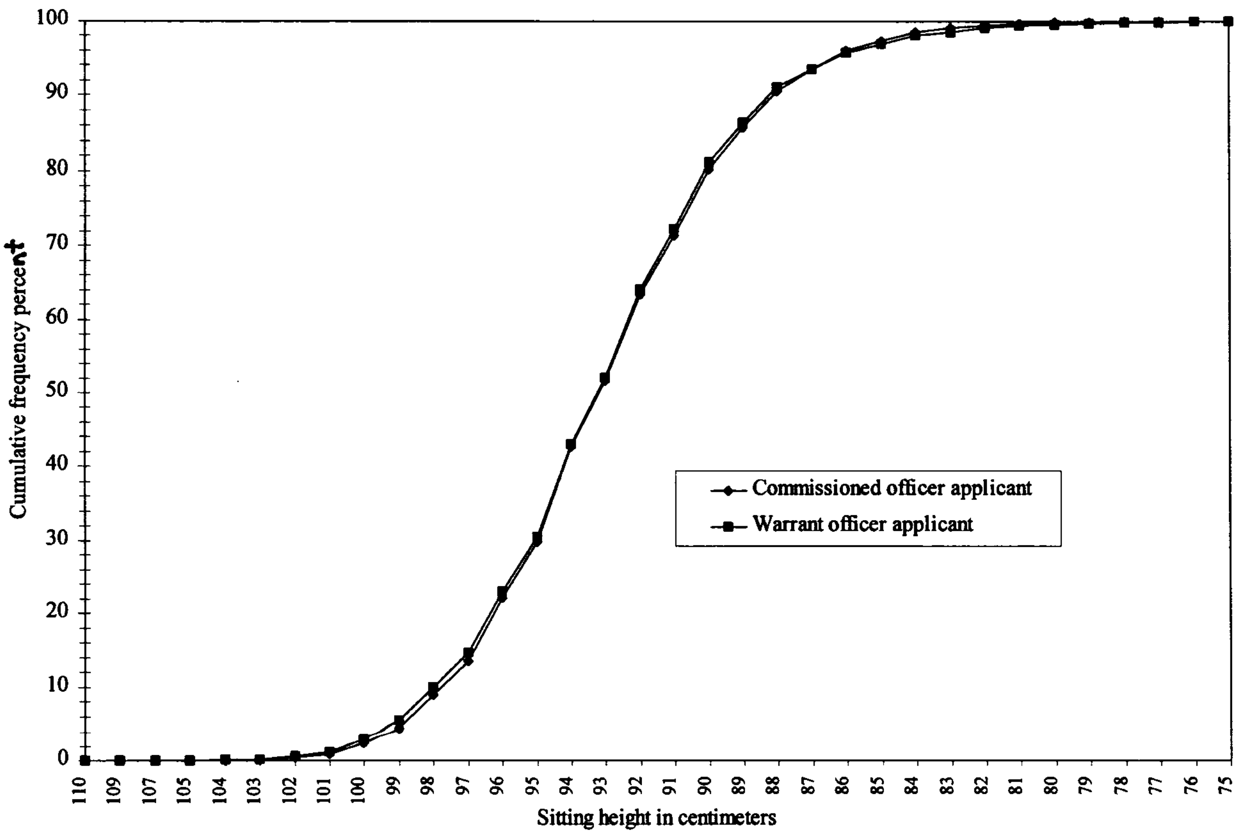

Figure 1. Cumulative frequency percent of sitting height in centimeters stratified by class of officer, commissioned versus warrant officer applicant.

Table 2.
Sitting height by class of officer, commissioned (CO) versus warrant officer (WO) applicant.

Sitting	Class of officer		Frequency (%)		Cumulative frequency (%)	
height (cm)	CO	WO	CO	WO	CO	WO
110	1	1	0.01	0.00	0.01	0.00
109	1	0	0.01	0.00	0.01	0.00
107	0	2	0.00	0.01	0.01	0.01
105	0	6	0.00	0.02	0.01	0.04
104	4	11	0.03	0.04	0.04	0.08
103	6	11	0.04	0.04	0.09	0.12
102	43	122	0.31	0.49	0.39	0.61
101	78	154	0.56	0.62	0.95	1.23
100	202	453	1.45	1.81	2.40	3.04
99	289	596	2.07	2.38	4.47	5.42
98	609	1,142	4.36	4.57	8.83	9.99
97	656	1,173	4.70	4.69	13.53	14.68
96	1,198	2,078	8.58	8.31	22.10	22.98
95	1,084	1,891	7.76	7.56	29.87	30.54
94	1,801	3,112	12.90	12.44	42.76	42.98
93	1,247	2,284	8.93	9.13	51.69	52.11
92	1,621	3,011	11.61	12.04	63.30	64.15
91	1,126	2,010	8.06	8.04	71.36	72.18
90	1,253	2,227	8.97	8.90	80.33	81.09
89	767	1,335	5.49	5.34	85.82	86.42
88	658	1,162	4.71	4.65	90.53	91.07
87	406	591	2.91	2.36	93.44	93.43
86	363	574	2.60	2.29	96.04	95.73
85	179	301	1.28	1.20	97.32	96.93
84	169	287	1.21	1.15	98.53	98.08
83	73	128	0.52	0.51	99.05	98.59
82	59	128	0.42	0.51	99.48	99.10
81	31	67	0.22	0.27	99.70	99.37
80	22	65	0.16	0.26	99.86	99.63
79	5	26	0.04	0.10	99.89	99.73
78	6	25	0.04	0.10	99.94	99.83
77	3	15	0.02	0.06	99.96	99.89
76	4	19	0.03	0.08	99.99	99.97
75	2	8	0.01	0.03	100.00	100.00
N	13,966	25,015				

Figure 2 shows a comparison of the cumulative frequency distribution of sitting heights for male versus female applicants. The two distributions are significantly different by Goodness of Fit testing (Kolmogorov-Smirnov, $p<0.01$). Table 3 shows the number, frequency, and cumulative frequency for the comparison.

To quantify the operational impact of the differences between sitting heights of male and female applicants, we can determine the relative risk of aeromedical disqualification if the Army adopted a new sitting height standard. Continuing with the example from above, the Army proposes a new sitting height qualification standard of less than or equal to 97 centimeters. In this case, male applicants are at a significantly increased risk for aeromedical disqualification compared to females (Relative $risk_{(Katz)}$=19.6, $CI_{0.95}$=9.83,39.3), nearly 20 times (1,860%) more likely.

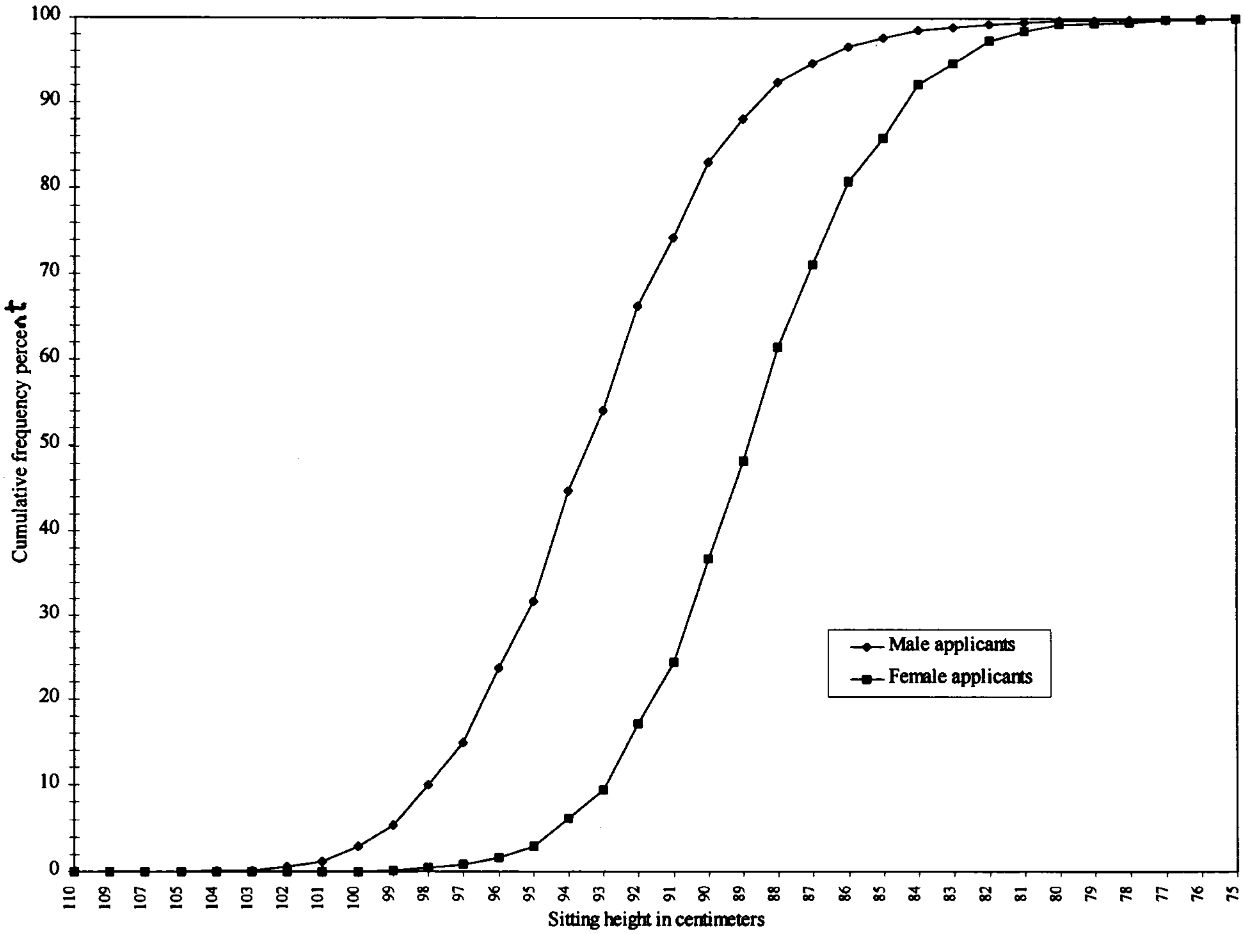

Figure 2. Cumulative frequency percent of sitting height in centimeters stratified by gender, male versus female applicant.

Table 3.
Sitting height by gender, male versus female applicant.

Sitting height (cm)	Gender Male	Gender Female	Frequency (%) Male	Frequency (%) Female	Cumulative frequency (%) Male	Cumulative frequency (%) Female
110	2	0	0.01	0.00	0.01	0.00
109	1	0	0.00	0.00	0.01	0.00
107	2	0	0.01	0.00	0.01	0.00
105	6	0	0.02	0.00	0.03	0.00
104	15	0	0.04	0.00	0.07	0.00
103	17	0	0.05	0.00	0.12	0.00
102	165	0	0.44	0.00	0.56	0.00
101	232	0	0.63	0.00	1.19	0.00
100	654	1	1.76	0.05	2.95	0.05
99	884	1	2.38	0.05	5.33	0.11
98	1,745	6	4.71	0.32	10.04	0.42
97	1,821	8	4.91	0.42	14.95	0.84
96	3,261	15	8.79	0.79	23.74	1.63
95	2,951	24	7.96	1.26	31.70	2.90
94	4,851	62	13.08	3.27	44.78	6.16
93	3,468	63	9.35	3.32	54.14	9.48
92	4,487	145	12.10	7.64	66.24	17.12
91	2,998	138	8.08	7.27	74.32	24.39
90	3,244	236	8.75	12.43	83.07	36.83
89	1,884	218	5.08	11.49	88.15	48.31
88	1,570	250	4.23	13.17	92.38	61.49
87	814	183	2.20	9.64	94.58	71.13
86	753	184	2.03	9.69	96.61	80.82
85	385	95	1.04	5.01	97.65	85.83
84	336	120	0.91	6.32	98.55	92.15
83	153	48	0.41	2.53	98.96	94.68
82	137	50	0.37	2.63	99.33	97.31
81	75	23	0.20	1.21	99.54	98.52
80	73	14	0.20	0.74	99.73	99.26
79	28	3	0.08	0.16	99.81	99.42
78	28	3	0.08	0.16	99.88	99.58
77	13	5	0.04	0.26	99.92	99.84
76	22	1	0.06	0.05	99.98	99.89
75	8	2	0.02	0.11	100.00	100.00
N	37,083	1,898				

Discussion

There are several sources of measurement error in this study. First, the measurements on Army personnel are conducted in over 700 flight surgeon offices across the Department of Defense and host Allied nations, instead of a centralized examination station staffed with anthropometrists. The quality assurance across these examination sites is known to be variable. For example, the first author visited a facility where a torn paper measuring tape was retaped to the wall many times. Calibration showed the sitting heights were in error by 3 centimeters. Another clinic measured applicants fully clothed with shoes or boots, rather than in the prescribed measurement ensemble of socks and physical training uniform. Another clinic had a fixed sitting block with a permanently mounted and calibrated metal tape for measuring sitting height, and measurement policy on display. Which clinic provided the most accurate and reproducible sitting height measurements?

Second, there is a tendency to record measurements in a more favorable direction away from a standard to avoid disqualifying otherwise qualified applicants. Is a measurement of 102.9 centimeters recorded as 102 or 103? Recording 102 would qualify the individual, while 103 would disqualify the individual. What is the judgement of the flight surgeon who makes the final call on borderline measurements conducted in his or her office? The first author witnessed flight surgeon office staff coaching tall examinees to compress themselves downward in order to improve their chances of passing the sitting height standard. The compression reduces the actual sitting height by several centimeters. USAAMA encountered circumstances where sympathetic staff members admitted to recording qualifying measurements when they measured the applicant as disqualified.

Third, how many applicants are discouraged from applying by aviation mentors or flight surgeon office staff because the applicant is obviously too tall or too short? These applicants at the extremes of anthropometry miss having their findings recorded in the AEDR and bias our report.

Summary and conclusions

The U.S. Army Aviation Training Brigade and the U.S. Army Aeromedical Center requested an analysis of the effect of changing the sitting height entry standards for aviator training downwards from the current qualification standard of "less than or equal to 102 centimeters" down to as low as "less than or equal to 97 centimeters." The analysis shows that adoption of the lower standard could reduce the aviator training applicant pool by as much as 9.57%. Warrant officer applicants have a slightly greater risk for aeromedical disqualification due to sitting heights exceeding the proposed standard compared to commissioned officer applicants (Relative $risk_{(Katz)}$=1.13, $CI_{0.95}$=1.06,1.23). Male applicants would carry almost the entire burden of the increased risk for aeromedical disqualification if the sitting height standard were changed (Relative $risk_{(Katz)}$=19.6, $CI_{0.95}$=9.83,39.3).

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