

Appendix B

Anthropometric Data of Federal Aviation Administration Technical Operations Personnel

B.1 Introduction

Anthropometric data are most appropriate when they are derived from a survey of the target population. Therefore, the Federal Aviation Administration (FAA) conducted an anthropometric survey of the Technical Operations workforce. A team of researchers collected clothed measurements of 1,244 Technical Operations individuals from 25 FAA sites around the United States. The data from this survey (presented in this Appendix) can be used in the design and sizing of FAA Technical Operations systems, equipment, and facilities.

B.2 Applicable documents

More detailed information on the anthropometric survey can be found in the following report:

Bradtmiller, B., Hodge, B., Kristensen, S., & Mucher, M. (2008). *Anthropometric Survey of Federal Aviation Administration Technical Operations Personnel - 2006-2008*. Yellow Springs, OH: Anthrotech.

In this report (Bradtmiller et al, 2008), the authors describe the calculation of the sample size, participant processing, computer procedures, the anthropometric instrumentation, data editing, and distribution of participants measured. The working data in this report includes a discussion of statistical weighting, summary statistics (including means, standard deviations, and percentile values for male and female participants), and descriptions of the clothed anthropometric dimensions. Each measurement is described and illustrated. Summary statistics are reported separately for men and women. A visual index precedes the statistical material to help readers identify and locate dimensions by their location on the body, even if the exact anthropometric term is unfamiliar.

B.3 Definitions

- **Anatomical Directions.**
 - a. **Distal.** Away from the trunk (torso).
 - b. **Lateral.** Away from the midline of the body.
 - c. **Proximal.** Closer to the trunk (torso).
 - d. **Ventral.** Toward the front of the body.

- **Bideltoid breadth.** The maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles.
- **Ectocanthus.** The outside corner of the right eye formed by the meeting of the upper and lower eyelids.
- **Frankfort plane.** A standard horizontal plane or orientation of the head. It is established by a line passing through the right tragion (approximately the earhole) and the lowest point of the eye socket.
- **Metacarpal.** The bones of the part of the hand between the carpus and the phalanges that typically contains five (more or less) elongated, cylindrical bones when all the digits are present.
- **Metacarpal – Phalangeal joints.** The joints between the metacarpals and the phalanges.
- **Metacarpus.** The intermediate part of the hand skeleton that is located between the fingers and the carpus which forms the connection to the forearm.
- **Olecranon (below and rear).** The lowest and rearmost points of the right elbow with the elbow flexed 90 degrees.
- **Phalanges.** The name commonly given to the bones that form the fingers and toes.
- **Proximal interphalangeal joint.** The joints between the first and second phalanges.
- **Stylian.** The most distal point on the styloid process of the radius.
- **Trochanter.** One of the bony prominences on the upper end of the femur (the thigh bone). The greater trochanter (used in these measurements) is the broad, flat protrusion on the femur, which is located at the upper end of its lateral surface.

B.4 The anthropometric survey

B.4.1 Survey dimensions.

Table 1 identifies the 25 dimensions that were measured. As Technical Operations personnel carry out their work in a variety of postures, the list generally comprises both standing and seated measurements. The measurements were obtained using traditional measuring instruments and methods. By convention, bilateral measurements were taken on the right side except in rare cases where an injury or anatomical abnormality made it necessary to measure on the left side. If additional dimensions of Technical Operations personnel be needed, users should consult the data contained in Chapter 14, Exhibit 14.3.2.1.

Table 1. The 25 measured dimensions

Dimension names	
1. Functional (Index-Finger) Reach	14. Hand Breadth
2. Functional (Index-Finger) Reach, Extended	15. Hand Length
3. Vertical Arm Reach	16. Sitting Height, Relaxed
4. Functional Leg Length	17. Sitting Height, Erect
5. Stature	18. Eye Height, Sitting
6. Eye Height, Standing	19. Elbow Rest Height
7. Chest Depth	20. Buttock-Knee Length
8. Abdominal Depth, Standing	21. Thigh Clearance
9. Elbow-Fingertip Length	22. Knee Height, Sitting
10. Elbow-Grip Length	23. Abdominal Depth, Sitting
11. Palm Length	24. Shoulder Breadth
12. Index Finger Length	25. Forearm-Forearm Breadth
13. Index Finger Width	

B.4.2 The sample.

The sampling plan created for this anthropometric survey was designed to reflect the major demographic groups with regard to age, sex, and racial/ethnic background of today's Technical Operations workforce. A proportionally stratified sample based on available demographic information on the Technical Operations workforce was used. The racial/ethnic categories were those found in the FAA personnel database.

B.4.3 Measurement sites.

Measurements were made at the National Operations Control Center, the three operations control centers, all 21 air route traffic control centers, the William J. Hughes

Technical Center, the Mike Monroney Aeronautical Center, all large and consolidated terminal radar approach control facilities, as well as many local terminal radar approach control centers, service operations centers, system support centers, and airport traffic control towers.

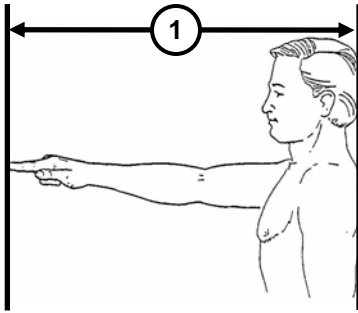
B.4.4 Clothed anthropometry.

Measurements presented in this appendix were taken of clothed participants. The clothing varied considerably in thickness and in style. Furthermore, because the data were collected throughout the year, clothing for all seasons is represented. Data from clothed participants have a distinct advantage for the user of the data – workspace designs should obviously take into account users' clothing, so nothing needs to be added in this case. The variety of clothing types and seasonal differences adds to the variation contained in the measurements. This is reflected in standard deviations that may be slightly larger than those found in nude anthropometry surveys. However, the human variability is so much larger than the variability in clothing thickness that the small amount of variability added by clothing essentially amounts to nothing more than noise in the system. Further, there is no reason to assume that clothing thickness is correlated in any way with anthropometric values. In other words, some small people will wear thicker clothing and some will wear thinner clothing, therefore, the variation added by clothing can be assumed to have been added equally throughout the anthropometric size distribution. Of course, when comparing these data to other surveys conducted nude, or with only minimal clothing, the user should take into account the effects of clothing on the measured dimension. From a design perspective, the values found in Section B.5 may be used exactly as they are presented.

B.5 Anthropometric data

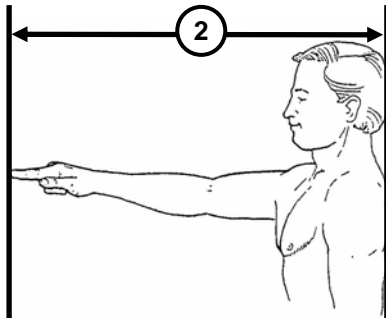
The following tables present static human anthropometric values, which should be used, as applicable, in the design of equipment to be used by Technical Operations personnel. **Note:** The statistics represent clothed individuals, so the typical clothing allowances for indoor workspaces do not need to be added. An allowance for heavy clothing should still be used for the design of outdoor workspaces.

Table 2. Anthropometric data



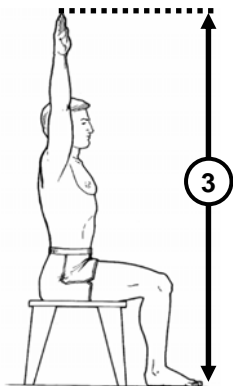
1 Functional (Index Finger) Reach. The horizontal distance from the wall and the tip of index finger, measured with the subject's shoulders against the wall and right arm and index finger extended.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	77.8	81.1	88.0	96.0	100.7
		(in)	(30.6)	(31.9)	(34.6)	(37.8)	(39.6)
B	Women	cm	70.0	73.6	79.8	86.9	92.9
		(in)	(27.5)	(29.0)	(31.4)	(34.2)	(36.6)



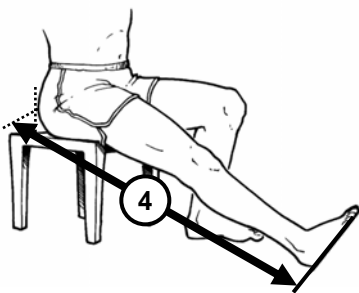
2 Functional (Index Finger) Reach, Extended. Similar to Functional (Index Finger) Reach, except that the right shoulder is extended forward, as far as possible, while the left shoulder is pressed firmly against the wall.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	83.2	87.0	94.8	104.3	108.0
		(in)	(32.7)	(34.3)	(37.3)	(41.1)	(42.5)
B	Women	cm	75.7	78.0	86.6	94.2	100.0
		(in)	(29.8)	(30.7)	(34.1)	(37.1)	(39.4)



3 Vertical Arm Reach (Overhead Fingertip Reach, Sitting). The vertical distance between the floor and tip of right middle finger, measured with the subject sitting and right arm, hand, and fingers extended vertically.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	167.0	171.0	181.7	192.4	196.5
		(in)	(65.7)	(67.3)	(71.6)	(75.7)	(77.3)
B	Women	cm	157.7	159.8	170.6	181.7	185.5
		(in)	(62.1)	(62.9)	(67.2)	(71.5)	(73.0)



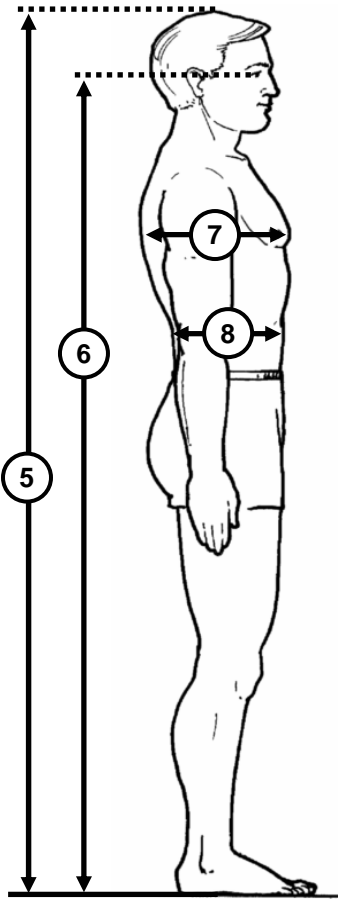
4 Functional Leg Length. The straight-line distance from the base of the foot to the back surface of the body in line with trochanter, measured with the subject sitting and right leg extended.

		Percentiles					
Sample			1st	5th	50th	95th	99th
Men	cm	99.0	102.5	112.4	122.5	126.5	
		(in)	(39.0)	(40.4)	(44.3)	(48.2)	(49.8)
Women	cm	89.6	93.4	103.8	112.9	118.2	
		(in)	(35.3)	(36.8)	(40.9)	(44.5)	(46.5)

Table 2. Anthropometric data (continued)

5 Stature. The vertical distance from the floor to the top of the head.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	159.2	164.7	176.7	187.6	192.7
		(in)	(62.7)	(64.8)	(69.6)	(73.9)	(75.9)
B	Women	cm	146.1	151.6	162.6	173.1	181.7
		(in)	(57.5)	(59.7)	(64.0)	(68.1)	(71.5)



6 Eye Height. The vertical distance from the floor to the outer corner of the eye (ectocanthus), measured with the subject standing.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	148.0	153.5	165.2	175.6	181.2
		(in)	(58.3)	(60.4)	(65.0)	(69.1)	(71.3)
B	Women	cm	135.5	141.2	151.8	162.1	170.1
		(in)	(53.4)	(55.6)	(59.8)	(63.8)	(67.0)

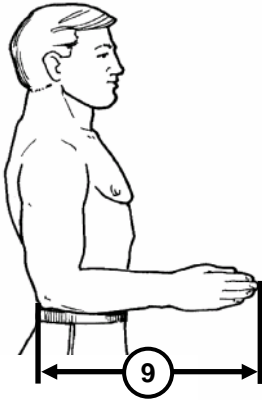
7 Chest Depth. The horizontal distance between the chest at its maximum fullness on the right side and the back at the same level, measured with the subject standing.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	21.6	23.4	27.8	33.5	36.0
		(in)	(8.5)	(9.2)	(10.9)	(13.2)	(14.2)
B	Women	cm	21.4	23.3	27.8	35.3	38.9
		(in)	(8.4)	(9.2)	(10.9)	(13.9)	(15.3)

8 Abdominal Depth Standing (Abdominal Ext. Depth, Standing). The horizontal distance between the most anterior point of the abdomen (abdominal point, anterior, standing) and the back at the same level, measured with the subject standing.

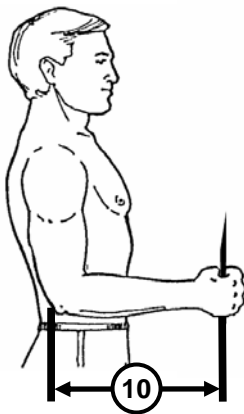
		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	19.6	21.5	28.1	37.1	41.1
		(in)	(7.7)	(8.5)	(11.1)	(14.6)	(16.2)
B	Women	cm	17.0	18.9	25.5	34.3	43.6
		(in)	(6.7)	(7.5)	(10.0)	(13.5)	(17.2)

Table 2. Anthropometric data (continued)



9 Elbow-Fingertip (Forearm-Hand) Length. The horizontal distance from the back of the elbow (olecranon, rear) to the tip of the middle finger, with the hand extended.

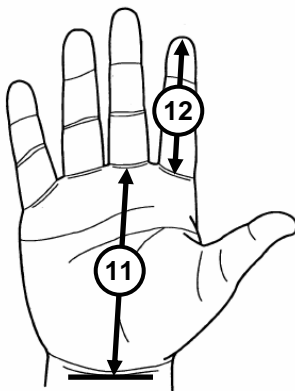
			Percentiles				
Sample			1st	5th	50th	95th	99th
A	Men	cm	43.0	44.5	48.0	52.1	54.3
		(in)	(16.9)	(17.5)	(18.9)	(20.5)	(21.4)
B	Women	cm	38.4	39.9	43.4	47.5	49.6
		(in)	(15.1)	(15.7)	(17.1)	(18.7)	(19.5)



10 Elbow-Grip (Elbow-Center of Grip) Length. The horizontal distance from the back of the elbow (olecranon, rear) to the thumb crook of a clenched fist.

			Percentiles				
Sample			1st	5th	50th	95th	99th
A	Men	cm	31.3	32.1	34.9	38.0	39.3
		(in)	(12.3)	(12.6)	(13.7)	(15.0)	(15.5)
B	Women	cm	27.5	28.7	31.4	34.5	35.9
		(in)	(10.8)	(11.3)	(12.4)	(13.6)	(14.2)

11 Palm Length. The perpendicular distance between the center of the crease at the base of the middle finger and the extension of the stylium landmark (stylium, on ventral wrist).



			Percentiles				
Sample			1st	5th	50th	95th	99th
A	Men	cm	10.3	10.7	11.7	12.7	13.2
		(in)	(4.1)	(4.2)	(4.6)	(5.0)	(5.2)
B	Women	cm	9.2	9.7	10.6	11.7	12.2
		(in)	(3.6)	(3.8)	(4.2)	(4.6)	(4.8)

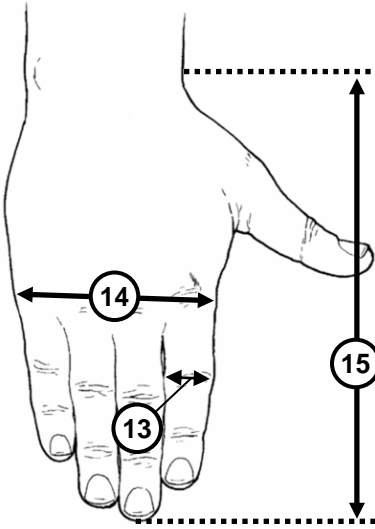
12 Index Finger Length. The distance between the tip of the index finger and the center of the crease at the base of the index finger.

			Percentiles				
Sample			1st	5th	50th	95th	99th
A	Men	cm	6.4	6.7	7.4	8.2	8.6
		(in)	(2.5)	(2.6)	(2.9)	(3.2)	(3.4)
B	Women	cm	5.9	6.2	6.9	7.6	8.1
		(in)	(2.3)	(2.4)	(2.7)	(3.0)	(3.2)

Table 2. Anthropometric data (continued)

13 Index Finger Width (Breadth). The breadth of the index finger, measured at the proximal interphalangeal joint.

		Percentiles					
Sample		1st	5th	50th	95th	99th	
A	Men	cm	1.8	1.9	2.1	2.3	2.4
		(in)	(0.7)	(0.7)	(0.8)	(0.9)	(0.9)
B	Women	cm	1.5	1.6	1.8	2.1	2.2
		(in)	(0.6)	(0.6)	(0.7)	(0.8)	(0.9)

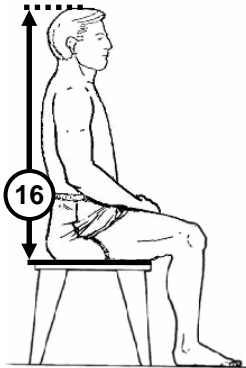


14 Hand Breadth. The breadth of the hand, measured at the ends of the metacarpal bones (metacarpal-phalangeal joints).

		Percentiles					
Sample		1st	5th	50th	95th	99th	
A	Men	cm	7.8	8.0	8.8	9.6	9.9
		(in)	(3.1)	(3.1)	(3.5)	(3.8)	(3.9)
B	Women	cm	6.8	7.1	7.7	8.4	8.6
		(in)	(2.7)	(2.8)	(3.0)	(3.3)	(3.4)

15 Hand Length. The distance between the stylium landmark on the wrist and the tip of the middle finger, measured parallel to the long axis of the arm.

		Percentiles					
Sample		1st	5th	50th	95th	99th	
A	Men	cm	17.5	18.0	19.6	21.2	22.2
		(in)	(6.9)	(7.1)	(7.7)	(8.3)	(8.7)
B	Women	cm	15.5	16.3	17.8	19.3	20.3
		(in)	(6.1)	(6.4)	(7.0)	(7.6)	(8.0)



16 Sitting Height, Relaxed. The vertical distance from the sitting surface to the top of the head, measured with the subject sitting in a relaxed position.

		Percentiles					
Sample		1st	5th	50th	95th	99th	
A	Men	cm	81.5	84.5	90.5	96.9	99.1
		(in)	(32.1)	(33.3)	(35.6)	(38.1)	(39.0)
B	Women	cm	77.6	79.9	85.7	91.0	94.2
		(in)	(30.6)	(31.5)	(33.7)	(35.8)	(37.1)

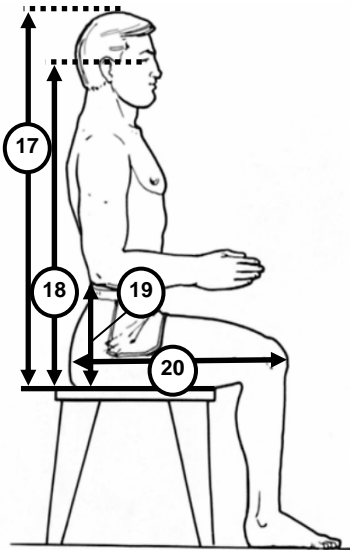
Table 2. Anthropometric data (continued)

17 Sitting Height, Erect. The vertical distance from the sitting surface to the top of the head, measured with the subject sitting erect and the head in the Frankfort plane.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	83.7	86.0	92.7	98.6	100.6
		(in)	(33.0)	(33.9)	(36.5)	(38.8)	(39.6)
B	Women	cm	79.0	81.3	86.5	92.1	94.8
		(in)	(31.1)	(32.0)	(34.1)	(36.3)	(37.3)

18 Eye Height, Sitting. The vertical distance from the sitting surface to the outer corner of the eye (ectocanthus), measured with the subject sitting erect and the head in the Frankfort plane.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	72.5	74.8	81.0	86.7	89.0
		(in)	(28.5)	(29.4)	(31.9)	(34.1)	(35.0)
B	Women	cm	67.6	69.7	75.4	81.4	83.7
		(in)	(26.6)	(27.4)	(29.7)	(32.0)	(33.0)



19 Elbow Rest Height. The vertical distance from the sitting surface to the bottom of the tip of the elbow (olecranon, below), measured with the subject sitting erect and the forearm held horizontally.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	18.0	20.2	25.3	30.3	32.4
		(in)	(7.1)	(8.0)	(10.0)	(11.9)	(12.8)
B	Women	cm	17.5	20.3	24.2	28.9	30.2
		(in)	(6.9)	(8.0)	(9.5)	(11.4)	(11.9)

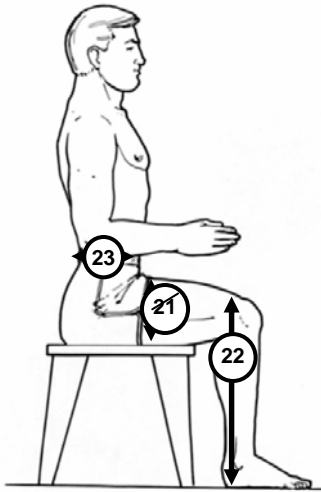
20 Buttock-Knee Length. The distance between the most posterior point of the right buttock and the anterior point of the right knee, measured with the subject sitting erect.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	54.5	57.1	62.3	68.1	70.6
		(in)	(21.5)	(22.5)	(24.5)	(26.8)	(27.8)
B	Women	cm	50.5	53.1	59.3	65.6	67.6
		(in)	(19.9)	(20.9)	(23.3)	(25.8)	(26.6)

Table 2. Anthropometric data (continued)

21 Thigh Clearance. The vertical distance from the sitting surface to the highest point of the thigh, measured with the subject sitting erect.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	13.7	15.0	17.8	21.0	22.5
		(in)	(5.4)	(5.9)	(7.0)	(8.3)	(8.9)
B	Women	cm	13.2	14.2	16.6	20.6	22.5
		(in)	(5.2)	(5.6)	(6.5)	(8.1)	(8.9)

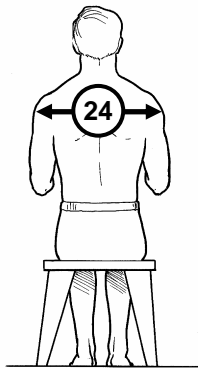


22 Knee Height, Sitting. The vertical distance from the footrest surface to the top of the knee at the center of the widest part of the calf, measured with the subject sitting.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	49.7	52.0	56.6	61.6	64.0
		(in)	(19.6)	(20.5)	(22.3)	(24.3)	(25.2)
B	Women	cm	44.9	46.8	51.6	56.1	58.6
		(in)	(17.7)	(18.4)	(20.3)	(22.1)	(23.1)

23 Abdominal Depth, Sitting (Abdominal Ext. Depth, Sitting). The horizontal distance between the most anterior point of the abdomen (abdominal point, anterior, sitting) and the back at the same level, measured with the subject sitting erect.

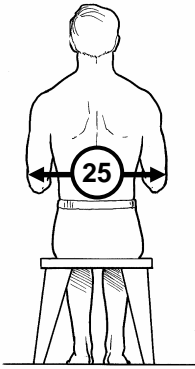
		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	20.8	22.8	29.9	40.3	45.5
		(in)	(8.2)	(9.0)	(11.8)	(15.9)	(17.9)
B	Women	cm	18.1	20.1	26.6	37.5	48.5
		(in)	(7.1)	(7.9)	(10.5)	(14.8)	(19.1)



24 Shoulder (Bideloid) Breadth. The maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles, measured with the subject sitting erect and forearms held horizontally.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	43.6	45.7	51.1	58.4	62.3
		(in)	(17.2)	(18.0)	(20.1)	(23.0)	(24.5)
B	Women	cm	38.2	40.0	45.4	54.2	58.0
		(in)	(15.0)	(15.7)	(17.9)	(21.4)	(22.8)

Table 2. Anthropometric data (continued)



25 Forearm-Forearm Breadth. The maximum horizontal distance across the upper body between the lateral margins of the forearms, measured with the subject sitting erect and forearms held horizontally.

		Percentiles					
Sample			1st	5th	50th	95th	99th
A	Men	cm	46.5	50.3	59.2	68.8	73.9
		(in)	(18.3)	(19.8)	(23.3)	(27.1)	(29.1)
B	Women	cm	40.9	42.6	51.8	62.8	67.9
		(in)	(16.1)	(16.8)	(20.4)	(24.7)	(26.7)

References

- Gordon, C., Churchill, T., Clauser, C., Bradtmiller, B., McConville, J., Tebbetts, I., & Walker, R. (1989). *1988 Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics* (TR-89-044). Natick, MA: U.S. Army Natick Research, Development and Engineering Center.
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