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Aircrew Sizing Survey 2011

HyegJoo Choi
Oak Ridge Institute for Science and Education

Andrew Coate, Michael Selby, Jeffrey Hudson, Casserly Whitehead
InfoSciTex, Dayton, Ohio

Gregory Zehner, Scott Fleming
711th Human Performance Wing

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AIR FORCE RESEARCH LABORATORY
711TH HUMAN PERFORMANCE WING
HUMAN SYSTEMS INTEGRATION DIRECTORATE
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7320
AIR FORCE MATERIEL COMMAND

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TIMOTHY W. BUSH, DR-IV, DAF	JON M. COLEMAN, DO-III, DAF
Technical Director	Chief, Human Systems Implementation Division
Human Systems Integration Directorate	Human Systems Integration Directorate
711th Human Performance Wing	711th Human Performance Wing
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14. ABSTRACT
The 711th Human Performance Wing recently undertook the Aircrew Sizing Survey of 2011 (ACSS). This survey is intended to replace the 1967 USAF Aircrew Anthropometric Survey, which has been the only actual USAF anthropometric dataset for aircrew product design. The 1967 data are more than 45 years old and represented male aircrew, consequently statistically created samples from more recent non-USAF military datasets have been used by the USAF for the design of protective equipment, and cockpits. The results of comparisons show that the aircrew population is growing heavier and exhibiting some increased measurements related to increased mass.

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ACRONYM LIST

ACSS	Aircrew Sizing Survey
AFB	Air Force Base
ANSUR	Army Anthropometric Survey
CAESAR	Civilian American & European Surface Anthropometry Resource
JSF	Joint Strike Fighter
JPATS	Joint Primary Aircraft Training System
USMC	United States Marine Corps
USAF	United States Air Force

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1.0 EXECUTIVE SUMMARY

The 711th Human Performance Wing recently undertook the Aircrew Sizing Survey of 2011 (ACSS). This survey is intended to replace the 1967 USAF Aircrew Anthropometric Survey, which has been the only actual USAF anthropometric dataset for aircrew product design. The 1967 data are more than 45 years old and represented only male aircrew. Consequently, statistically created samples from more recent non-USAF military datasets have been used by the USAF for the design of protective equipment, and cockpits. In the early 1990's the Joint Primary Aircraft Training System (JPATS) dataset was created from a subset of the 1988 Army Anthropometric Survey (ANSUR). In 2003 a subset of the Civilian American and European Surface Anthropometry Resource (CAESAR) was developed for the Joint Strike Fighter (JSF) program. The ACSS was intended to replace the JSF-CAESAR and JPATS datasets through a continuation of a small-scale USAF survey that began in 2008 and expanded into the first 3-D whole body anthropometric survey of USAF aircrew.

The aim of ACSS was to construct an anthropometric database that represented the gender, age, and racial variability of the USAF aircrew population. A total of 60 traditional body dimensions were measured, along with 3-D body shape scans. Survey volunteers at six Air Force bases totaled 640 male and 60 female aircrew. In order to assess secular changes in body proportions, the ACSS dataset was compared to the 1967 USAF and the JSF CAESAR datasets for torso and limb lengths and mass-related measurements (circumferences and weight). Multivariate analyses were also performed on the three datasets (JSF CAESAR, JPATS, and ACSS) to examine whether the multivariate cases previously developed for the JSF-CAESAR and JPATS USAF programs were still representative of the size and proportional variability in the aircrew population.

The results of these comparisons show that the aircrew population is growing heavier and exhibiting some increased measurements related to increased mass. Identification of these changes are important for the design of clothing, cockpits, and protective equipment. Although the ACSS showed slightly larger univariate percentile dimensions than previous surveys, the multivariate cases developed for JSF were representative of the ACSS distribution.

1.1 LIMITATIONS

Due to funding limitations this is a small sample for an anthropometric survey which utilized a "volunteer sampling strategy". As a result, there were too few females and non-Caucasian males in the ACSS to adequately describe size and proportional variability for that demographic. Hence, the JSF CAESAR database should continue to be used to supplement the ACSS sample. A future study will expand the ACSS sample with additional female and non-Caucasian male datasets.

2.0 INTRODUCTION

The U.S. Military has been collecting anthropometric data since the 1940's to provide databases and design tools to assure human size and shape variability considered for equipment designs. These surveys were done at least once every decade from 1942 until 1990 (Table 1). The U.S. Marine Corps and U.S. Army recently completed two large anthropometric surveys.

Table 1: Selected Anthropometric Surveys in U.S.A. (non-civilian)

Year	Gender	Population
1942	Female	Army Pilots Air Force Nurses
1950	Male	Air Force Flying Personnel
1959	Male	Army Aviators
1960	Male	Air Traffic Controllers
1964	Male	Navy Aviators
1965	Male	Air Force Male Personnel
1966	Male	Army Personnel
1967	Male	Air Force Aviators
1968	Female	Air Force
1970	Male	Army Aviators
1973	Male	Law Enforcement Officer
1988	Male	Army Personnel
1988	Female	Army Personnel
2010	Male	USMC Personnel
2010	Female	USMC Personnel
2012	Male	Army Personnel
2012	Female	Army Personnel

Among these surveys, the most recent of US Air Force flying personnel was performed in 1967. Until recently, this survey was considered the only military anthropometric reference for product design for USAF aircrew. However, the anthropometric data required for designing workstations or any products for Air Force personnel constantly changes and should consider secular growth changes from generation to generation. Since the baseline USAF data are more than 45years old, there have been efforts to create substitute datasets that would represent the target Air Force population. These attempts to replace the outdated Air Force anthropometric database were based on the 1988 US Army or US civilian datasets. Zehner (1996) statistically created the Joint Primary Aircraft Training System (JPATS) data set from the 1988 Army Anthropometric Survey (ANSUR) of 1774 Males and 2208 Females (Gordon et al., 1989). To produce the JPATS sample, 1301 males and 851 females were extracted from U.S. Army ANSUR to match USAF aircrew demographics and aircrew body-size restrictions from Air Force Instruction 48-123 (Medical Examinations and Standards), and were intended to be a substitute for contemporary USAF Aircrew in the mid 1990's.

A similar attempt to create an aircrew sample was made in 2003 by Hudson et al. They extracted a subset, named JSF CAESAR (Joint Strike Fighter), from the Civilian American and European Surface Anthropometry Resource (Robinette et al., 2002). The original CAESAR survey collected a total of 2332 female and 2094 male civilians in three geographic regions including: North America (1255 females and 1120 males), Italy (386 females and 410 males),

and the Netherlands (691 females and 564 males). The JSF CAESAR data subset included a total of 646 males and 695 females extracted from North American CAESAR and were intended to represent an updated replacement for the JPATS sample.

The resulting samples had to be used cautiously because they were not measured from the actual Air Force population - but statistically created. Thus, there has long been a need for an Air Force Anthropometric survey database to serve as a representative design reference for the current aircrew population. In addition, the new database includes not just the traditional anthropometric measurements with demographic information, but also 3-D surface scan data for body-shape analyses.

Since the 1980's, 3-D scanning technology has emerged as a tool to measure the size and shape of the human body as well as the linear dimensions that traditional anthropometry provides. The technology has improved digital human modeling and CAD applications required for equipment and workstation design. 3-D scanning technology gives users the ability to extract new measurement information after the data has been gathered from the subjects, as well as the advantage of using 3-D computer models for concept visualization or for rapid prototyping. However, the 1-D dimensions taken with traditional tools differ from those extracted from scans. This is particularly true for circumferences and measurements where soft tissue, posture, or breathing have an effect.

Due to the age of existing data on USAF Pilots, and the potential for inaccurate predictions from derived datasets, in 2008 the USAF began a small-scale effort to gather anthropometric data called the Aircrew Sizing Survey (ACSS). This is the first 3-D whole-body anthropometric survey of USAF aircrew. For the initial portion of the study, data were collected at two sites - Wright-Patterson AFB, Ohio, and Randolph AFB, Texas. The sample size was 234 subjects. Upon receiving additional funds in 2010/2011, data collection resumed and expanded the total sample size to 700 (640 male and 60 female). Comparisons were made between the 2008 and 2011 samples. Since no practical or statistically significant differences were found, the samples were combined.

Body size, shape, and proportions are greatly influenced by gender, age, and race (Zehner, 2001). Therefore, it is important to caution against combining male and female anthropometric data. Combining male and female samples can result in statistics that do not adequately represent either gender. The effect of race on size and shape is also quite important in some equipment designs. Caution must be exercised in some applications, and data may need to be analyzed separately to achieve a design that accommodates/fits the target population.

2.1 Demographic Aims

In the ACSS, attempts were made to recruit adequate gender, age, and racial variability. However, this was a volunteer sample over which we had limited control. In our recruiting, we attempted to over-sample groups other than white-male aircrew due to their limited numbers. However, this approach met with limited success. The ACSS sample was 91.4 percent male and 8.6 percent female. Table 2 shows the gender breakdown by group for the USAF 2011 aircrew population. The information is from the Personnel Center at Randolph AFB.

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Table 2: Gender Breakdown for 2011 USAF Aircrew Personnel

OFFICER /PILOT 2011	%
Female	4.8
Male	95.2
TOTAL	100
OFFICER/NAVIGATOR 2011	**%**
Female	7
Male	93
TOTAL	100
ENLISTED/AIRCREW 2011	**%**
Female	11
Male	89
TOTAL	100

An additional source of comparative data for Height, weight, and age are accessible from fitness tests of Aircrew. While there is no assurance that the included height measurements were taken in the exact same manner as in the ACSS, this comparison was deemed to be of value for estimating the fidelity of the sampling strategy for this sample. The Fitness dataset includes over 14,000 male aircrew. Prior to beginning the ACSS, comparisons of the ~11,000 Pilots, ~ 3000 Navigators, and other rated aircrew were made. No meaningful differences were found between these groups. For that reason, and the fact that they wear similar equipment, the ACSS measured all aircrew.

Listed in Table 3 are the limited summary statistics comparing the Fitness data to the ACSS. The mean values are very close for both weight and stature. Age was slightly less in the 2011 data than was true in the 2010 Fitness tests. The differences in the minimum and maximum values for stature and weight are not unexpected due to the large differences in sample size. In any case, it appears that the small ACSS sample is similar to the Fitness test data for these measures.

Table 3: Comparison of ACSS and 2010 Fitness Age, Weight and Stature

Male Aircrew Sizing Survey 2011							
	Valid N	Mean	Min	Max	5%	95%	Std.Dev.
Age	640	30.4	18.0	58.0	23.0	43.0	6.0
Weight (lbs.)	640	185.4	129.0	285.4	147.2	231.4	24.9
Stature (cm)	640	178.5	161.1	198.0	168.2	189.6	6.5
Male Aircrew from Fitness Tests 2010							
	Valid N	Mean	Min	Max	5%	95%	Std.Dev.
Age	14535	33.1	22	58	25	44	6.0
Weight (lbs.)	14535	184	109	277.7	148	225.0	23.5
Stature (cm)	14535	179.6	157.5	201.9	168.9	190.5	6.4

The final demographic comparison again uses demographic data from the Personnel System database at Randolph AFB. Figure 1 and Figure 2 are comparisons of race distributions. The "other" category in the Randolph database includes a "no response" category that was not in the ACSS demographic questionnaire. That may explain the slightly higher percentage in the "other"

category in Figure 2. It appears that while we attempted to oversample non-white males, we were unsuccessful. The racial distributions are nearly identical.

Since small sample statistics can be misleading, most statistical comparisons in this report will be limited to male aircrew only. A separate study is underway to build adequate design databases for female and non-Caucasian male aircrew.

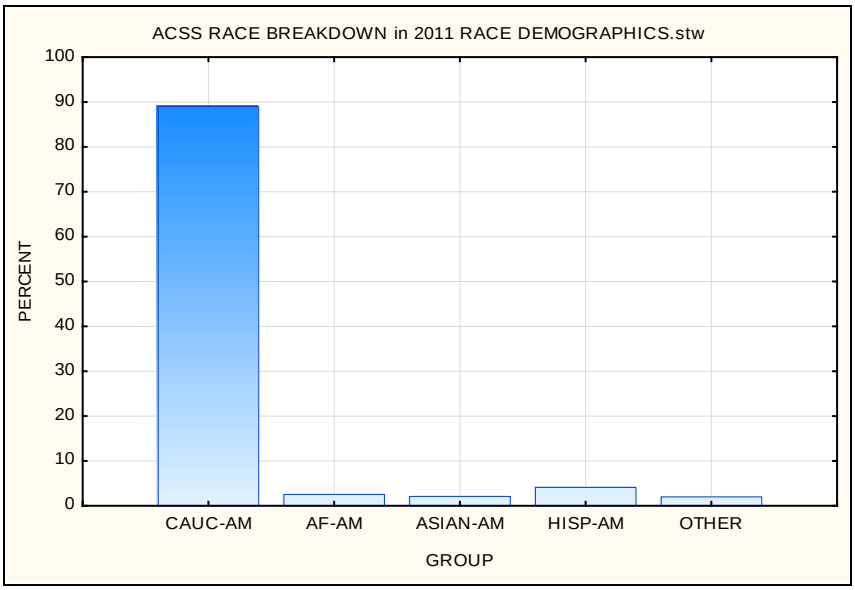

Figure 1: ACSS Race Breakdown

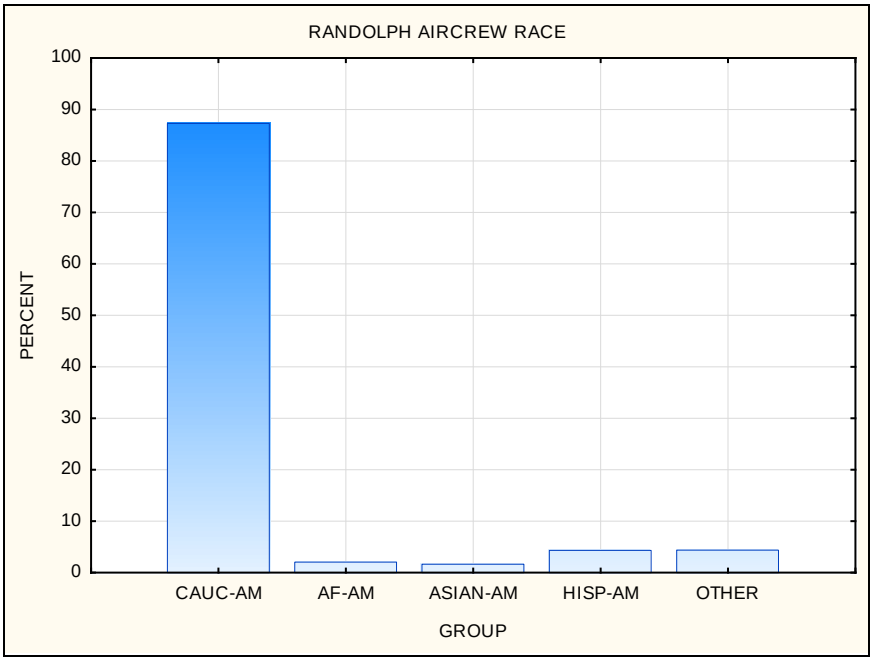

Figure 2: Randolph Aircrew Race Breakdown

2.2 Products

This survey includes:

- 60 Traditional style (1-D) measurements of three types with summary statistics
- Demographic data for each subject
- 3-D scansin4 postures (Pose A, B, C, and D) for each subject
- 3-D Landmarks (X, Y, Z coordinates) for two postures (Pose A and C)
- Appendices describing: Data Collection Form, 3-D Landmark Definitions, Measurement Descriptions, Measurers Training, and Traditional Landmark Descriptions.

3.0 DATA COLLECTIONPROCEDURE

Data collected include demographic and anthropometric information on each subject. There are 60 traditionally measured anthropometric dimensions that include 13 seated measurements. The demographic and the traditionally measured anthropometric dimensions are shown on the data collection forms (Appendix A). Appendix B provides 3-D landmark descriptions, and Appendix C provides measurement descriptions as well as measurer instructions.

The data collection process described below was duplicated at each base. Data were collected at three stations. At the first station, subjects were briefed on the reasons for collecting anthropometric data on aircrew, the process they would go through, and the safety of the laser used in the Cyberware scanner. Subjects were then asked to read and sign a consent form and fill out a brief questionnaire on demographic information (Appendix A).

Male subjects were measured in shorts, while female subjects were measured in shorts and a sports bra (Figure 3: Scanning garments) with all jewelry/watches removed. A lab coat was used for modesty when moving from station to station.

Figure 3: Scanning garments

At the second station, various anatomical landmarks of the face and body used as references for traditional anthropometric measurements were located by palpation or visual inspection and marked on the subjects with an eyeliner pencil (Appendix D). Traditional anthropometric data were collected using tools such as anthropometers, calipers and tapes. This station was staffed by a measurer and a recorder. During the 2008 portion, the recorder filled out the measurement sheet as the values were called out by the measurer. For the 2011 portion, a laptop, projector and wireless keypad were added. The recorder also assisted in measuring and positioning the subjects. The datasheet is shown in Appendix A.

The third station consisted of the whole body scanner. A Cyberware WB4 was used for the 2008 study. For the 2011 portion, a 3-dMD photogrammetric system replaced the WB4 for two reasons; the short data capture time (1.5 ms per scan) eliminated movement artifacts, and it was much easier to transport and set-up. The data formats were the same. A total of 75 one-centimeter white dots were placed on the subject's face and body to highlight additional body landmarks (see Figure 3, Appendix B). Since hair absorbs much of the laser light, a skull cap which reflects light was used to ensure that the image produced, and hence the data points, were more representative of the subject's skull than his or her hair. Hair under the cap still presents a shape problem for some subjects.

The subject was then carefully positioned for each scan. The two standing scans were captured and labeled as Pose A and Pose B as shown in Figure 4 and Figure 5. The subject was then seated for the next series of scans. A total of 9 green dots were added to indicate the correct location of landmarks that were affected by the postural change. These corrected landmarks include the left and right trochanters (2), medial and lateral femoral epicondyles (4), posterior superior iliac spine (PSIS) (2), and preferred waist posterior (1). Two seated scans were then captured and labeled as Pose C and Pose D as shown in Figure 6 and Figure 7.

Each volunteer was then assisted while removing the landmarks, and after changing back into uniform, were thanked and released.

3.1 Traditional Anthropometric Measurements

Traditional measurements taken in this survey were a blend of measurements from the CAESAR Survey and the US Army ANSUR. The measurements selected (Appendix C) were either specific for workstation accommodation applications (such as arm span, sitting height, and popliteal height) or necessary for clothing applications (such as chest circumference, waist circumference at natural indent, and crotch length). The measurement methods used have long been established for military anthropometric surveys and were reviewed prior to the start of this survey. They represent a continuation of the methods used by John McConville, Charley Clauser, Ken Kennedy, Bob White (Reid 1976), and many others from the US Army and Air Force that contributed to this field of endeavor from the 1950's though the 1980's.

3.2 3-D Scan Data

There were total of four scan poses: two standing (Pose A and Pose B) and two seated (Pose C and Pose D).Landmark coordinates were manually extracted from Pose A and Pose C.

3.2.1 Pose A (Standing)

The subjects placed their feet on foot outlines positioned 10.7 cm apart at the inside of the heel so that the thighs were apart, and the long axes of the feet were rotated outwards 33°. The subject stood on a platform 10 cm high, to improve coverage, and was instructed to stand up straight and look directly ahead. Instructions were given to align the head posture to achieve a

horizontal Frankfurt plane (i.e. a plane passing through the inferior margin of the eye orbit (orbitale) and the upper margin of the ear canal or external auditory meatus (porion or tragion)). Subjects were instructed to keep their elbows, wrists, and hands straight, with their fingers together and thumb apart. The arm was positioned away from the body by placing a 20 cm dowel between the trochanterion landmark and the wrist with the palms facing the body (Figure 4).

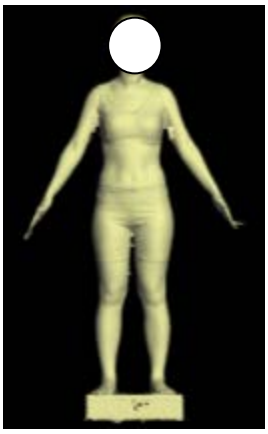

Figure 4: Scan pose A

3.2.2 Pose B (Standing)

The subject stood with feet parallel with the head was tipped back so there was a horizontal plane that included the upper margin of the ear canal or external auditory meatus and the base of the nose (subnasale). The arms were held away from the torso with forearms directed up, and palms facing forward. This posture provided a better view of the sides of the torso (Figure 5) than did Pose A.

Figure 5: Scan pose B

3.2.3 Pose C (Seated)

The subject sat on a stool 35.75 in. high with both feet on a foot block 16.75 in. high. In addition, blocks of varying heights (3 in., 4 in., and 5 in.) were used to adjust foot height so that knees were flexed to approximately 90°, with the trochanterion and lateral femoral epicondyle landmarks parallel to the floor. The lateral femoral epicondyle was positioned directly above the

lateral malleolus. Feet and knees were placed 20 cm apart using the dowel. Upper extremities were positioned such that the arms hung freely downwards with the forearms horizontal. The elbows were flexed to 90°, so that radiale and the ulnar styloid defined a parallel forearm to the seat pan (Figure 6). The subject sat erect with the head in Frankfurt plane.

Figure 6: Scan pose C

3.2.4 Pose D (Seated)

The subject sat with legs unsupported (i.e., dangling) on the stool. The head was tipped back so that there was a horizontal plane that included the upper margin of the ear canal or external auditory meatus and the base of the nose (subnasale). The arms were again held away from the torso, forearms vertical, and palms facing forward. The knees were further apart than in pose C in order to obtain a better view of the upper thighs (Figure 7). The subject sat erect.

Figure 7: Scan pose D

3.3 3-D Landmark Data

The 3-dMD Vultus program was used to generate a landmark file for Poses A and C for each subject. The software's "3-D analysis" feature permits (manual) 3-D landmark picking and coordinate export to an Excel or text file.

To "point pick" the landmarks in the scans, it was necessary to create a 'landmark template'. For ACSS, the landmark template began in an anterior view and listed the landmarks that could be clearly seen in this view. Next, landmarks were selected from the feet upwards to the head in the order in which they appeared, moving from the subject's right to left. When completed, the image was then rotated so that the right lateral view landmarks were visible, and then landmark points from the head, downwards to the feet, were selected. This process continued for the posterior view and the left lateral view (Figure 8). By following these procedures the chance for error was greatly reduced and required moving the image the least amount possible.

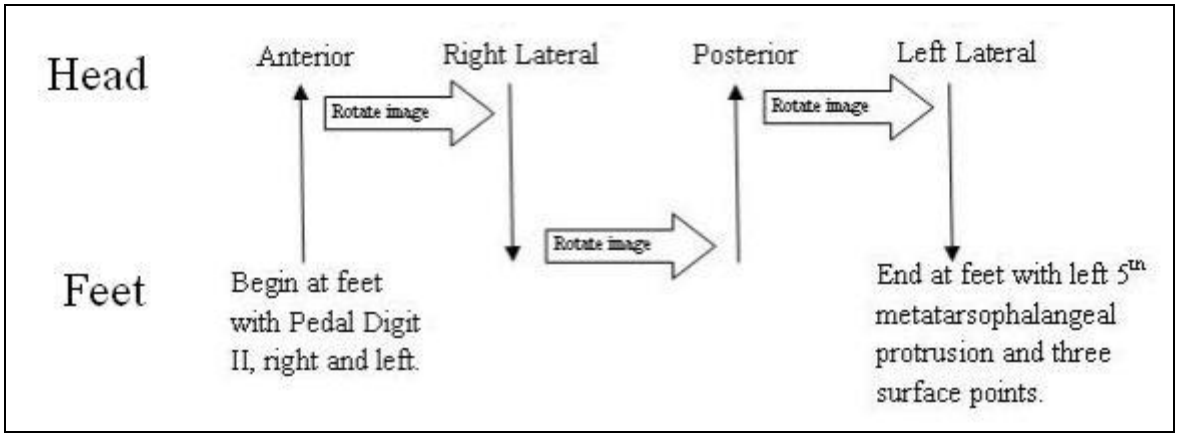

Figure 8: Landmark template arrangement scheme

Unfortunately, some landmarks could not be clearly seen in any particular view, especially medial landmarks (e.g. medial humeral and femoral epicondyles). In this situation, the landmarks were listed in the view in which they were easiest to locate and identify. For example, the right and left medial humeral epicondyles could not be seen clearly from any anterior perspective. But they were relatively easy to locate in the posterior view and so were included in the standing landmark template among the other posterior viewed landmarks. Likewise, the right and left medial femoral epicondyles were best observed from the anterior view and so were included in the standing landmark template amongst the other landmarks seen in this view.

Two landmark templates were necessary – one for the standing position (standing on platforms of varying heights; 3 in., 4in., or 5 in.) and another for the sitting position. Depending on the subject's body posture, the relative position of a landmark can move. Thus, it was necessary to use green stickers and re-assign particular landmarks to illustrate how much the landmark had moved. These corrected landmarks include the left and right trochanters (2), medial and lateral femoral epicondyles (4), posterior superior iliac spine (PSIS) (2), and preferred waist posterior (1). Some landmarks were removed from the sitting landmark template because in the seated posture these points were obscured or hidden (e.g. knee crease (2) and calcaneus (2)). Finally, stickers were placed on the box surfaces used for standing and seated scans so an exact box orientation could be defined for data post processing.

As a result, for the standing posture there were75 anatomical landmarks and an additional three standing box surface points; and for the seated posture there were 80 anatomical landmarks (71 traditional landmarks and 9 corrected landmarks) plus six box surface points (3 on the sitting box and 3 on the footbox).

When the landmarking was complete, the landmark file was exported to an Excel file and saved for each subject. Due to the length of time needed to manually extract each of the

landmarks on all 700 subjects, only the scan Poses A (standing, Figure 4) and C (seated, Figure 6) were completed. The other two poses (which have the arms raised to reveal the sides of the torso), will be analyzed and used when needed for a particular application.

4.0 SUMMARY STATISTICS FOR THE AIRCREW SIZING SURVEY

The next section of this report presents summary statistics and demographic information of the 700ACSS subjects and compares the data collected with the 1967 Air Force anthropometric database as well as the extracted dataset JSF CAESAR. The comparison results show chronological trends in body dimensions (1967 USAF vs. 2011 ACSS) and differences in potential design databases (JSF CAESAR vs. 2011 ACSS). These comparisons will help determine if the JSF CAESAR dataset is an adequate representation of current Air Force aircrew for design purposes.

4.1 ACSS Sample Demographics

Data were collected on 700subjects at five sites. Table 4 shows the measuring sites for ACSS, collection dates, and the number of each gender measured from each site. Table 5 and Table 6 represent the race and aircrew position breakdown by gender, respectively. The age distribution of all 700 subjects is shown in Figure 9 and Table 7.

Table 4: Measurement Sites

Locations	Collection Dates	Male	Female	Total
Randolph AFB, TX (Trainer)*	Jan. 2008 – Mar. 2008	210	24	234
Little Rock AFB, AR (C-130)	April 2011	75	12	87
Shaw AFB, SC (F-16)	May 2011	75	1	76
Seymour Johnson, NC(F-15)	June 2011	194	12	206
Charleston AFB, SC (C-17)	July 2011	86	11	97
Total		**640**	**60**	**700**

*Including eleven male subjects measured at Wright-Patterson AFB

Table 5: Race Breakdown

Race	Male Freq.	%	Female Freq.	%	Total Freq.	%
African American/Black	15	2.34	3	5.00	18	2.57
Asian/ Pacific Islander	15	2.34	0	0.99	15	2.14
Caucasian/White	573	89.53	51	85.00	624	89.14
Spanish/Hispanic	25	3.90	4	6.67	29	4.14
Other	12	1.86	2	3.33	14	2.00
Total	**640**	**100**	**60**	**100**	**700**	**100**

Table 6: Aircrew Position Breakdown

Aircrew Position	Male Freq.	%	Female Freq.	%	Total Freq.	%
Pilot	397	61.86	28	46.67	425	62.03
NAV, WSO	180	28.13	21	35.00	201	28.71
Loadmaster	32	5.00	4	6.67	36	5.14
Flight surgeon	22	3.43	2	3.33	24	3.43
Other	9	1.56	5	8.33	14	1.41
Total	**640**	**100**	**60**	**100**	**700**	**100**

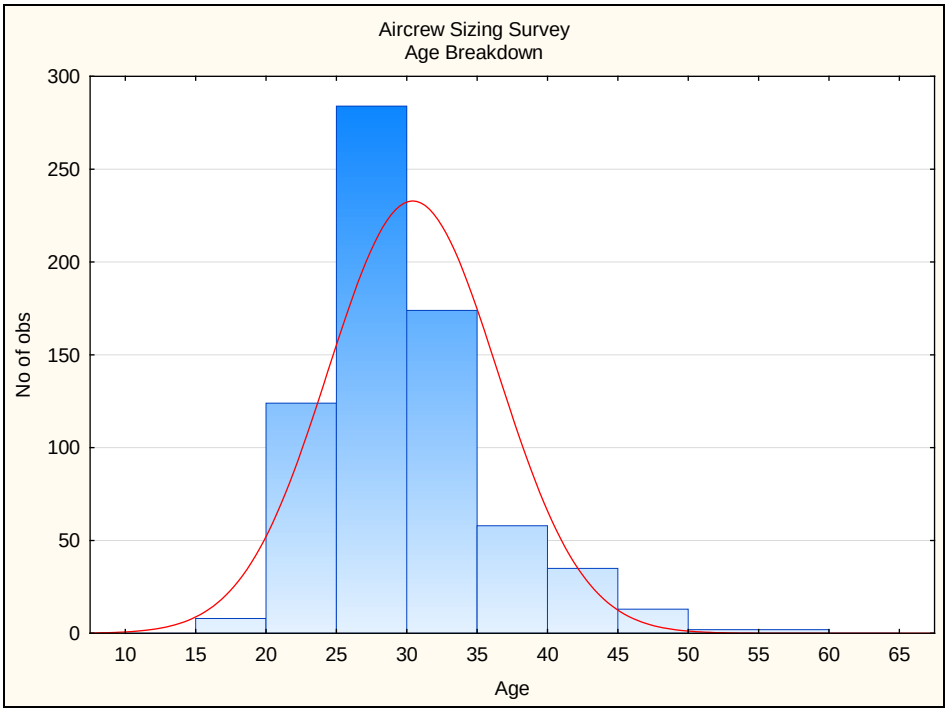

Figure 9: ACSS Age Breakdown

Table 7: ACSS Frequency Distribution Age Breakdown

Age	Count	Cumulative Count	Percent	Cumulative Percent
17.0 ≤ x < 20.0	7	7	1.00	1.00
20.0 ≤ x <25.0	72	79	10.29	11.29
25.0 ≤ x <30.0	291	370	41.57	52.86
30.0 ≤ x < 35.0	204	574	29.14	82.00
35.0 ≤ x <40.0	67	641	9.57	91.57
40.0 ≤ x <45.0	37	678	5.29	96.86
45.0 ≤ x <50.0	16	694	2.29	99.15
50.0 ≤ x < 55.0	4	698	0.57	99.72
55.0 ≤ x <60.0	2	700	0.29	100.00
60.0 ≤ x < 65.0	0	700	0.00	100.00
Missing	0	700	0.00	100.00

4.2 ACSS Sample Summary Statistics

A total of sixty dimensions were measured using traditional measuring instruments and methods in this survey. All unilateral measurements were taken on the right side unless otherwise specified (i.e. in the case of an injury on participant's right side or anatomical abnormality). All measurements were read to the nearest millimeter. Weight was recorded to the nearest 0.1 pound. Detailed illustrated instructions for making these measurements and the percentile distributions by variable are shown in Appendix C.

There were changes in the list of dimensions measured between 2008 and 2011. Three dimensions – Neck Base Circumference, Spine to Scye, and Spine to Wrist II – measured on 210 subjects in 2008 were excluded in 2011. Three additional dimensions – Forearm-to-Forearm Breadth, Knee Circumference (Lower Thigh), and Wrist circumference – were measured on 430 male subjects in 2011. Thus, the valid N on those dimensions in the Table 8 through Table 10 are different than 640, the total number of male subjects.

Table 8: ACSS Male Summary Statistics (Face, Head and Neck measurements, Unit: cm)

Measure	N	Mean	Min.	Max.	5%	95%	S.D.	S.E.
Bizygomatic Breadth	640	14.2	12.4	15.7	13.3	15.2	0.6	0.02
Face Length	640	12.1	10.1	14.2	11	13.2	0.6	0.03
Head Breadth	640	15.5	14.2	17.2	14.6	16.4	0.5	0.02
Head Circumference	640	57.5	53.5	61.7	55.3	60	1.4	0.06
Head Length	640	20.2	18.2	21.8	19.1	21.3	0.6	0.03
Neck Base Circumference	210	47.1	41	55	43.3	52.1	2.6	0.18
Neck Circumference	640	38.9	33.4	45.5	35.7	42.2	2	0.08

Table 9: ACSS Male Summary Statistics (Seated measurements, Unit: cm)

Measure	N	Mean	Min.	Max.	5%	95%	S.D.	S.E.
Abdomen Depth	640	24.8	18.4	37.3	20.6	29.5	2.8	0.11
Acromial Height, Sitting	640	61.4	53.3	70.1	57	66.2	2.9	0.11
Buttock Knee Length	640	61.7	53.6	70	57.5	66.4	2.7	0.11
Buttock-Popliteal Length	640	50.3	42.6	59.4	46.3	54.5	2.5	0.1
Chest Depth	640	25.2	19	33.2	21.5	29.1	2.2	0.09
Elbow Height, Sitting	640	25	17.2	33.6	20.8	29.6	2.6	0.1
Eye Height, Sitting	640	82.3	73.6	91.4	77.3	87.5	3.1	0.12
Forearm-to-Forearm Breadth	430	56.1	42.8	69.1	48.9	63.4	4.4	0.21
Hip Breadth, Sitting	640	38.2	31.7	47.9	34.5	42.5	2.5	0.1
Knee Height, Sitting	640	55.8	48.4	63	51.8	60	2.5	0.1
Popliteal Height	640	43.7	36.8	49.3	39.7	47.5	2.3	0.09
Sitting Height	640	93.7	84.4	104	88.1	99.3	3.3	0.13
Thigh Clearance	640	17.2	13.2	22.1	15.1	19.3	1.3	0.05

Table 10: ACSS Male Summary Statistics (Standing measurements, Unit: cm, lbs.)

Measure	N	Mean	Min.	Max.	5%	95%	S.D.	S.E.
Ankle Circumference	640	26.9	22.8	30.6	25	29	1.2	0.05
Arm Length (Spine-Elbow)	640	56.5	50	63.5	52.5	60	2.3	0.09
Arm Length (Spine-Shoulder)	640	21.7	18.6	26.2	19.9	23.7	1.2	0.05
Arm Length (Spine-Wrist)	640	86.3	77.3	96.2	81	91.8	3.3	0.13
Armscye Circumference	640	45.7	38.2	57.1	41	50.8	2.9	0.12
Axilla Height	640	133	117.7	147.9	123.7	142.1	5.6	0.22
Bicep Circumference, Flexed	640	35.6	27.2	45.5	30.9	40.9	2.9	0.11
Bust/Chest Circumference	640	102.9	86.7	130	91.5	115.8	7.2	0.29
Buttock Circumference	640	102.8	87	129.9	93	113.2	6.1	0.24
Buttock Circumference Height	639	91.6	79	103.1	84.4	99	4.3	0.17
Calf Circumference	640	38.6	31.7	46.8	34.7	42.7	2.4	0.1
Cervicale Height	640	152.8	134.5	171	143.1	162.9	6.1	0.24
Chest Girth (Chest at Scye)	640	107.1	89.4	130.5	95.8	119.6	7	0.28
Crotch Height	640	80.2	69.2	92	73.2	87.9	4.3	0.17
Foot Length	640	26.9	23.4	30.5	24.9	29	1.3	0.05
Forearm Circumference, Flexed	640	30.6	22.3	36	27.6	33.8	1.9	0.07
Hand Circumference	640	21.3	18.2	24.9	19.8	22.9	1	0.04
Hand Length	640	20.2	17.5	23.9	18.6	21.8	0.9	0.04
Hip Circumference Max	640	104.2	87.8	131.1	94.4	114.7	6.1	0.24
Hip Circumference Max Height	640	88.5	76.9	102.4	81.5	95.7	4.3	0.17
Knee Circ. (Lower Thigh)	430	40.4	34.2	48.1	36.6	44.2	2.3	0.11
Shoulder (Bideltoid) Breadth	640	49.4	42	58.2	45.4	53.9	2.6	0.1
Span	640	182.2	160	203.9	169.7	194	7.2	0.29
Spine to Scye	210	21.3	17.1	28.2	18.3	24.3	1.7	0.12
Spine to Wrist 2	210	89	81.1	98	83.9	94.3	3.3	0.23
Stature	640	178.5	161.1	198	168.1	189.6	6.5	0.26
Thigh Circumference Max	640	62	50.8	76.8	54.8	69.2	4.4	0.17
Thumb-Tip Reach	640	81.5	71	92.9	75.1	87.4	3.7	0.15
Total Crotch Length	640	64	51	81.5	57	70.8	4.2	0.17
Vertical Trunk Circumference	640	170.9	149.5	196	158.6	183.6	7.7	0.31
Waist Back Length	640	50.2	40	60.6	45.2	55.1	3.1	0.12
Waist Circ. at Natural Indent	640	87.9	68.3	117	76.4	102	7.7	0.31
Waist Circ. at Omphalion	640	91.7	72.6	121.6	78.5	106.3	8.4	0.33
Waist Circ. at Preferred Waist	640	89.9	71.6	119.4	79	102.2	7.1	0.28
Waist Front Length	640	46.4	37.6	56.7	41.4	52.2	3.3	0.13
Waist Height at Natural Indent	640	114.5	97.5	128.6	106.5	122.6	4.9	0.19
Waist Height at Omphalion	640	107.9	93.3	121.8	99.9	115.8	4.8	0.19
Waist Height at Preferred Waist	640	103.3	89.4	118.6	95.5	111.3	4.8	0.19
Weight (lbs.)	640	185.4	129	285.4	147.2	231.3	24.9	0.98
Wrist Circumference	430	17.5	15.2	19.8	16.1	18.8	0.8	0.04

4.3 Comparisons to other USAF Anthropometric Databases

For all comparisons that follow, only data for male Caucasian subjects from the Aircrew Sizing Survey were used. In the past, female design parameters were based on the 1968 Air Force Anthropometric Survey data. However, since the subjects recruited in the 1968 survey were not aircrew, it would not be valid to compare these data with the ACSS female aircrew subjects. Also, the female data in the JSF CAESAR sample are unique since that sample expanded the size limits far beyond those set for aircrew in the Air Force Instruction 48-123 (Medical Examinations and Standards). In the JSF dataset, an attempt was made to create an "expanded" sample which more fairly represented "potential" female pilots (Zehner 1996). Comparisons with the 60 females measured in the ACSS would be misleading. For that reason, only male data will be compared in the following analyses.

In order to make comparisons between different databases, it was necessary to review measurements lists, descriptions, and protocols. This process was essential to assure that the selected body dimensions were measured with identical procedures. The 1967 Air Force Aviators Anthropometric survey (Kennedy 1986) and the JSF CAESAR dataset (Hudson et al., 2003) were selected to compare dimensions and for extracting multivariate cases.

In all comparisons, the ranges for stature and sitting height were limited based on AFI 48-123 body size requirement for pilots. Individuals that had statures between 64-77 inches and sitting heights between 34-40 inches were selected for the data comparison. Since there were not enough subjects from other ethnic groups, and their contributions to anthropometric differences in groups can be substantial, most comparisons were made only between Caucasian subjects.

4.3.1 1967 USAF Survey vs. ACSS

MIL STD 1472 and many other documents that list data for USAF Aircrew typically use the USAF 1967 data. Body-size requirements for flight training at that time were different than they are now. As can be seen in the 95% probability ellipse below (Figure 10), current pilots are taller and much heavier than in 1967. Figures 11 through 13 document the percentage increases in the mean values. The 1967 dataset was represented as 100%, while the ACSS data was shown as a percent increase/decrease relative to 1967 data.

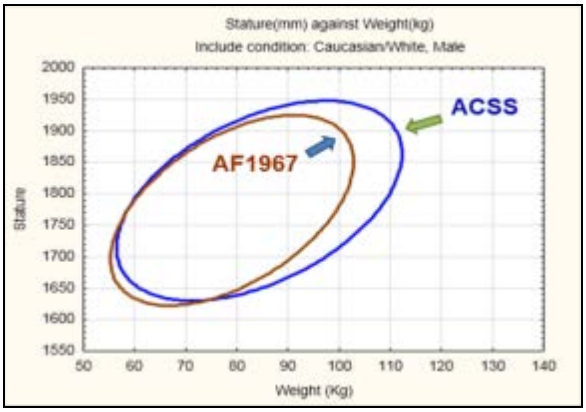

Figure 10: 95% Probability Ellipses for 1967 USAF and ACSS

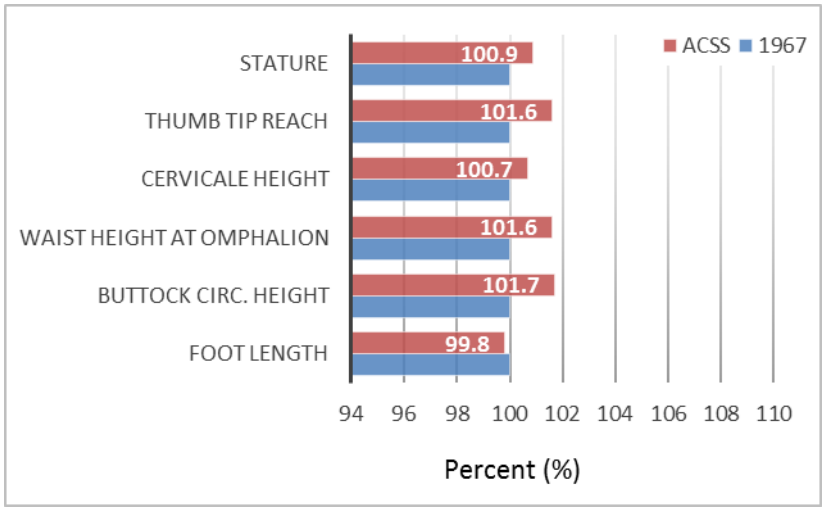

Figure 11: 1967 USAF vs. ACSS: Heights and Lengths-White males only

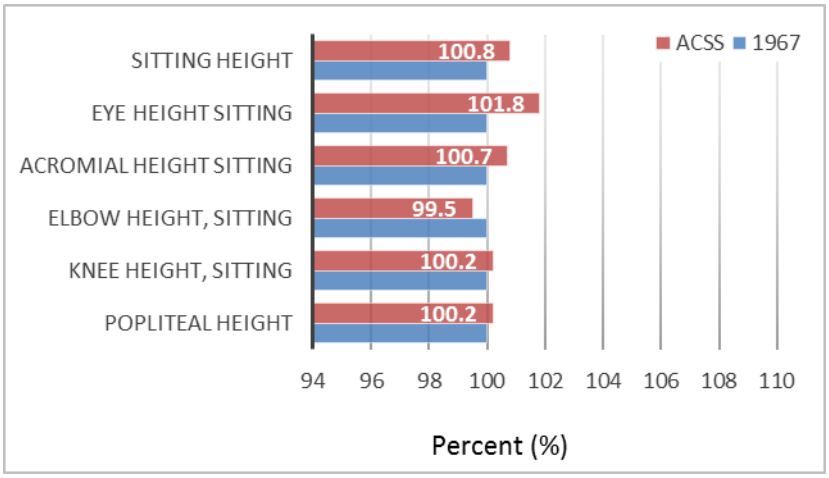

Figure 12: 1967 USAF vs. ACSS: Seated Heights-White males only

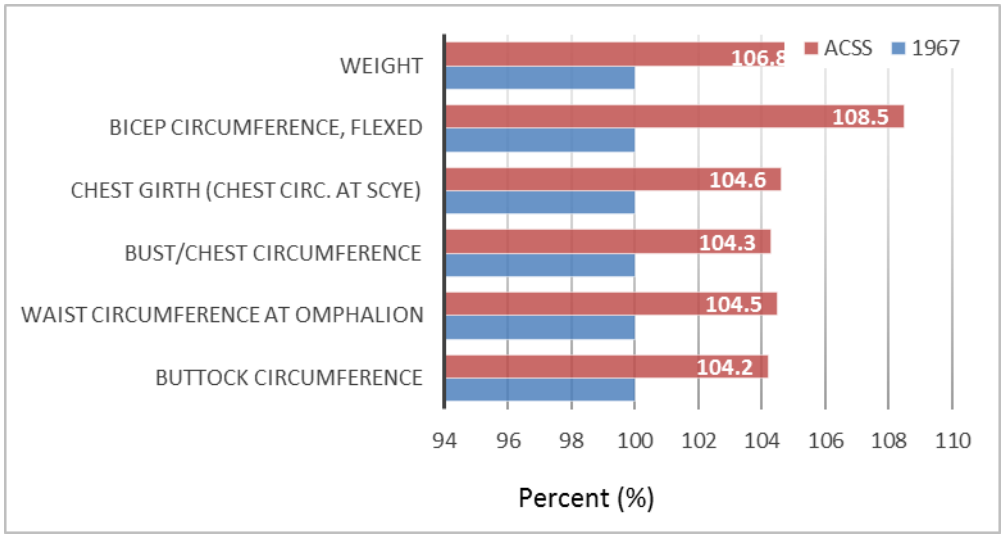

Figure 13: 1967 USAF vs. ACSS: Mass-related measurements-Circumferences and Weight

Figures 10-13 show that for white males on average, there has been less than a 2% change in linear dimensions over the years but an up to 8.5% increase in mass related dimensions. In the past, univariate design values have been reported as the 5th and 95th percentile values for lists of dimensions. While this can lead to gross errors in a design where more than one measurement is important (Moroney, 1972), they still can be enlightening for describing the distribution of single measurements. An example of the change in these values from 1967 to 2011 is shown in Table 11. In general terms, the torso and limb lengths and stature are within a couple of centimeters of each other. This is relatively good news in terms of workstation designs.

However, circumferences have grown more than 6 centimeters on the 95th percentile end of the scale. Clothing and Protective Equipment acquisition programs must consider this in new designs. Finally, the 95th percentile weight is more than 20 pounds heavier, which should be considered for ejection seat safety. This comparison suggests that all Standards and Design Guides that use the 1967 data need to be updated. Below are comparisons between the 640 ACSS male subjects and the 2420 male subjects from the 1967 survey on selected measurements.

Table 11: 1967 USAF vs. ACSS: percentile values for selected dimensions

	ACSS				1967			
	Valid N	Mean	5%	95%	Valid N	Mean	5%	95%
Bideltoid Breadth	640	49.4	45.4	53.9	2420	48.2	44.1	52.6
Buttock Knee Length	640	61.7	57.5	66.4	2420	60.4	56.1	65.0
Bust/Chest Circumference	640	102.9	91.5	115.8	2420	98.6	88.6	109.4
Stature	640	178.5	168.1	189.6	2420	177.3	167.2	187.7
Sitting Height	640	93.7	88.1	99.3	2420	93.2	88.1	98.6
Waist Circumference at Omphalion	640	91.7	78.5	106.3	2420	87.6	75.7	100.1
Weight lbs.	640	185.4	147.2	231.3	2420	173.5	140.2	210.7

4.3.2 JSF CAESAR Sample vs. ACSS

The results described above were not unexpected given the 45 years between surveys and the publicity given the increasing weight of the civilian population. If anything, it was surprising that the linear dimensions had not changed more dramatically. Anticipation of those differences led Hudson et al. (2003) to develop an interim design solution for the Joint Strike Fighter program (F-35). The Civilian American and European Surface Anthropometry Resource (CAESAR, Robinette, 2002) is an international database of 3-D whole body scans as well as traditional measurements. CAESAR includes many individuals that are beyond the entrance criteria for body-size and age for acceptance into the U.S. military. To correct this, the North American portion of the CAESAR Survey was sub-sampled at the request of the JSF Life Support Working Group, who wanted to represent the future flying population of the JSF as realistically as possible (Figure 14). This sub-sample resulted in more realistic allowances for weight and age (with older/heavier reservists in mind) as well as a projection of the demographics of JSF flyers in the US Joint Services to the year 2010. After a subsequent multivariate analysis, and overlay of the required JSF Multivariate Cases, the CAESAR Sample

was reduced to 646 men and 708 women who were identified as falling *within* the reconstructed ellipses of accommodation defined by the original JSF Cases 1-8.

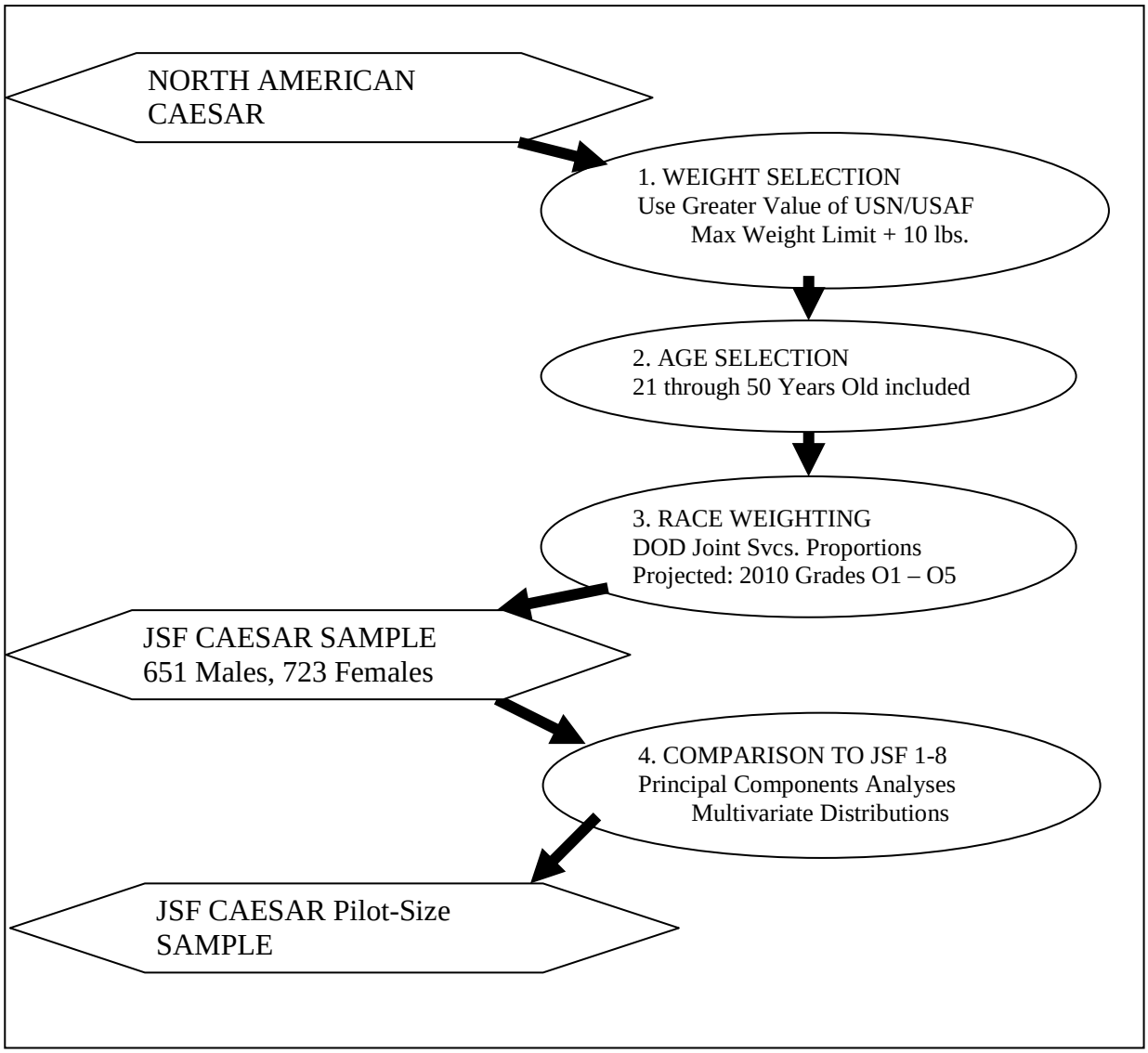

Figure 14: Sub-Sampling procedure for JSF CAESAR

As mentioned before, the body-size limits of this sample go beyond pilot entrance requirements listed in AFI 48-123 and are much more representative of the entire civilian population than the current pilot population. For that reason, the following comparisons were restricted to those in JSF CAESAR that fall within AFI 48-123 restrictions.

The comparison of 90% probability ellipses in Figure 15 shows that the ACSS sample is slightly shorter in stature than JSF CAESAR, but substantially heavier across most heights. Figure 16 documents the percentage increases and decreases in mean values. The JSF CAESAR database is represented as 100%, while the ACSS data are shown as a percent increase/decrease. This plot shows a similar (though not as pronounced) trend as that seen when comparing ACSS to the 1967 survey. The linear dimension means are within one percent of each other, while the

ACSS mass related variables are up to 4.5% greater. On average, the aircrew population is getting heavier and thicker.

Figure 15: JSF CAESAR vs. ACSS: Height and Weight

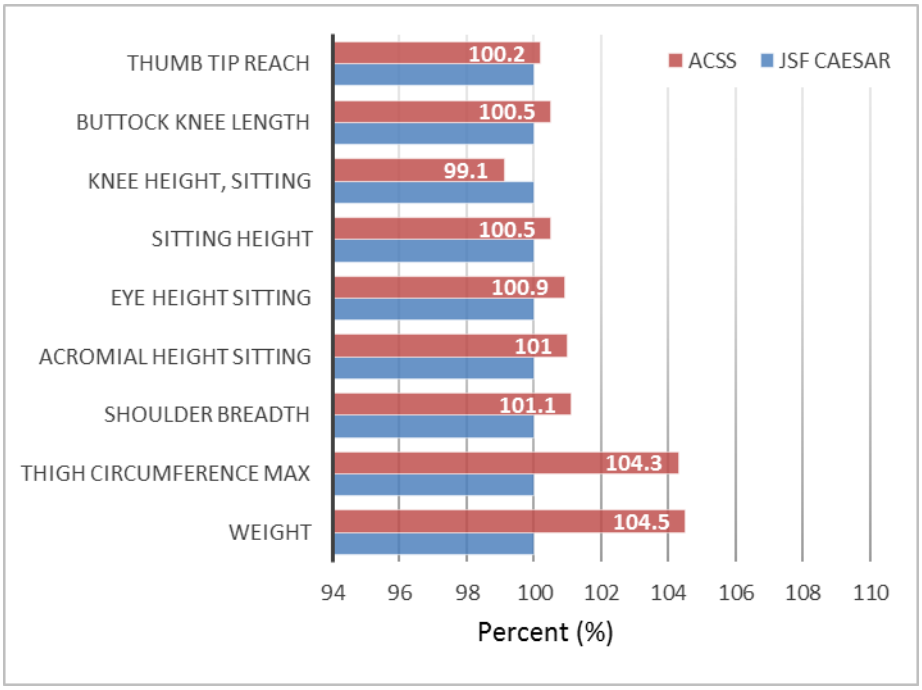

Figure 16: JSF CAESAR vs. ACSS: Dimension Means for Multivariate Cases

Table 12: JSF CAESAR vs. ACSS percentile comparisons for selected measures

	ACSS				JSF			
	Valid N	Mean	5%	95%	Valid N	Mean	5%	95%
Bideltoid Breadth	573	49.3	45.4	53.9	517	48.8	44.4	52.9
Buttock Knee Length	573	61.8	57.5	66.4	517	61.5	56.8	66.9
Bust/Chest Circumference	573	102.8	91.5	115.8	517	100.5	88.6	111.3
Stature	573	178.9	168.7	189.8	517	179.1	167.9	192.5
Sitting Height	573	94.0	88.7	99.5	517	93.5	87.6	99.9
Hip Circumference, Max	573	104.1	94.4	114.6	517	101.9	93.2	111.2
Weight lbs.	573	185.5	147.2	231.2	517	178.1	142.5	218.5

Finally, a comparison of the values at the 5th and 95th percentiles is enlightening when concerned with univariate design values (Table 12). Here the mass related variables were up to 4.5 centimeters longer and 13 pounds heavier at the 95th percentile end of the distribution. The effect of these differences was revealed in a recent fit-test of the flight coverall designed for the JSF (Choi et al., 2011). Fifteen percent of the pilot test-subjects were unable to get an acceptable fit. This was almost entirely due to the lack of large/wide sizes. An overlay of the size-roll of the prototype garment on the JSF sample showed that it covered the distribution quite well. However, when the size-roll was compared with the ACSS sample, the lack of wide sizes was clearly evident. Therefore, when designing protective equipment, the JSF sample must be used with caution. The ACSS sample gives a much better representation of male aircrew body sizes. For female aircrew, there is no current USAF sample that is adequate to replace or compare to that of the JSF. That issue is being addressed in a 2014/2015 research study.

5.0 MULTIVARIATE CASE COMPARISONS

For many years the USAF has been using Multivariate Cases (statistical boundary conditions) for designing cockpits and workstations (Meindl et al., 1993). The multivariate accommodation method is a more appropriate alternative to the use of percentiles when it is necessary to describe more than one measurement at a time. However, the method retains the concept of accommodating a specific percentage of the population in the design. Briefly, the multivariate accommodation method is based on principal component analysis, which reduces a list of variables to a small manageable number, and then enables designers to select the desired percentage level of a population to be accommodated on all measurements simultaneously. This percentage level is accommodated in a way which takes into account not only size variance but proportional variability as well. For example, this includes not only individuals who are uniformly large or small, but those whose measurements combine, for example, small torsos with long limbs, or vice versa (Figure 17). The method is based on a technique developed by Bittner et al., 1986.

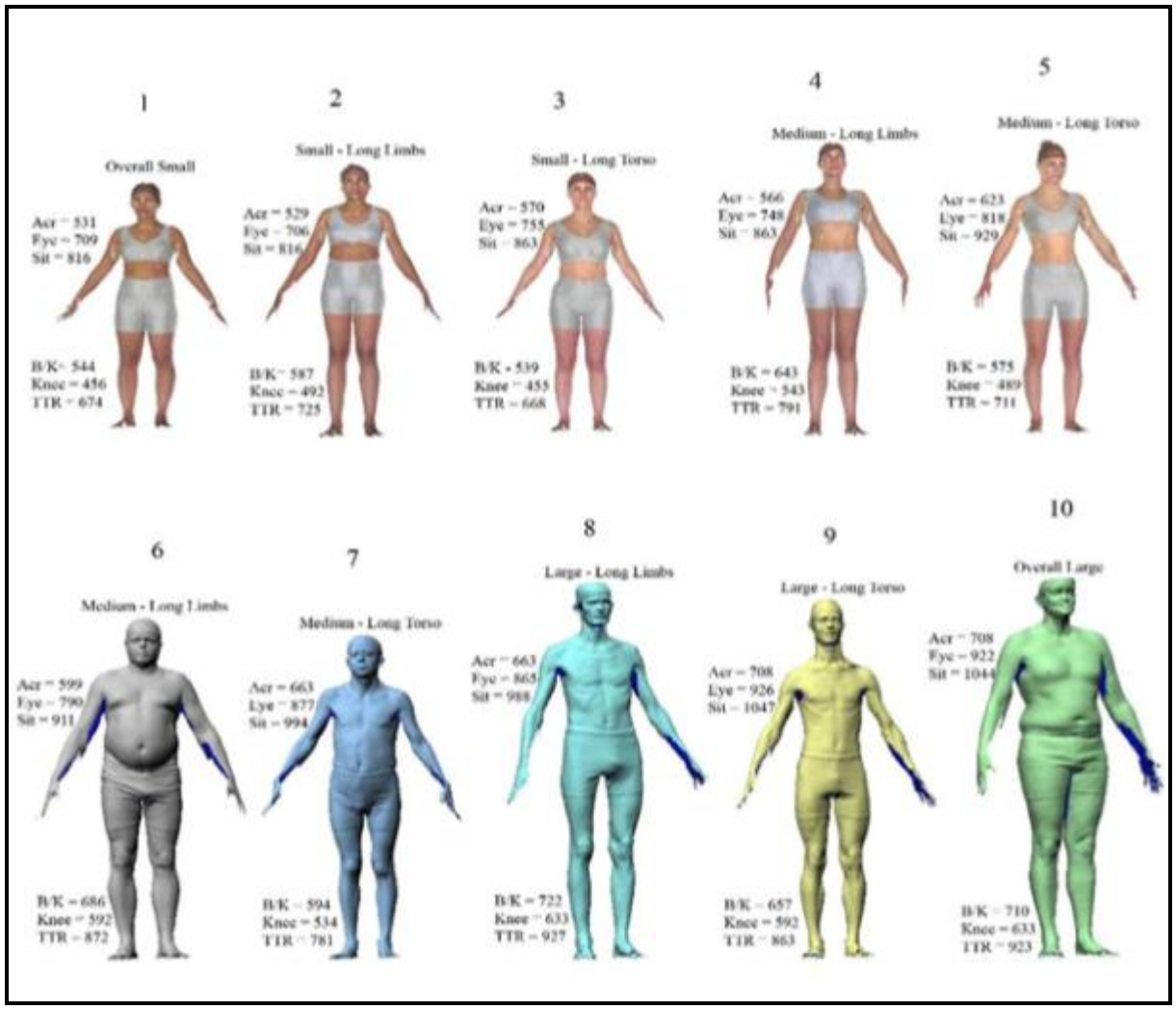

Figure 17: Example Cases with Differing Proportions

The final question when comparing ACSS to different Aircrew samples is to determine if the Multivariate Cases developed for past USAF programs are still representative of the size and proportional variability in the aircrew population. To examine this issue, the three datasets (JSF CAESAR, JPATS, and ACSS) were compared using the Multivariate Models Program (Meindl et al., 1993). Again, only white males were used in the comparison to avoid the effects of sampling differences.

The initial comparison was based on the six simple cockpit measurements which related to seat adjustability in aircraft, as shown in Table 13. Given the similar summary statistics for these variables in the three surveys, major differences were not expected. A second comparison was made using additional variables typically specified for an entire workstation where girths and depths are also important. Mass related measurement variables did show significant/meaningful differences between the samples.

5.1 Cockpit Variable Comparison

Three torso heights and three limb lengths have been used to determine adjustability adequacy in many recent aircraft. Those measurements are shown below in Table 13.

Table 13: Measurements Used to Determine Aircraft Adjustability Adequacy

Limb Length Measurements	Torso Height Measurements
Thumb tip reach (TTR)	Sitting height
Buttock-knee length	Eye height sitting
Knee-height sitting	Acromial height sitting

The comparisons were made using a 98% accommodation level (or ellipse).These six measurements result in a two component model when run through a Principal Component Analysis program. Figure 18 is an illustration of how the boundary locations, or Cases, are assigned. The Case locations are indicated by Orange, while the major Principal Component axes are pink. The ellipse contains 98% of the sample. Cases B, Y, and D are small people with varying limb to torso ratios, while Cases A, W, and C are large people with varying limb to torso ratios. Cases X and Z are average size but show extreme limb to torso ratios. Each position/Case located on the ellipse would adjust the seat and rudders to different locations within a vehicle.

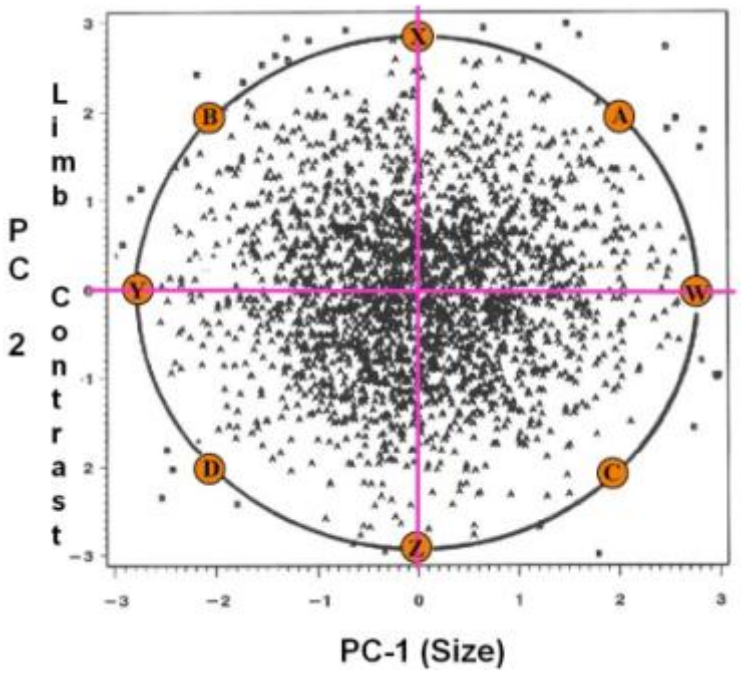

Figure 18: Plot of 6 measurements reduced to two components.

Listed below are a series of tables which compare the resulting cases from the three samples. The first table is descriptive of the body segment proportions in terms of percentile values for the individual measurements from the ACSS sample. These percentiles are used to interpret and name each model. For example, Case A is described as "Large/+Leg" in Table 14. This means

overall large size with emphasis on long limbs. Case C is overall large with emphasis on large torso measurements (Large/+Torso).

Table 14: Percentile Values for each Case by Measurement, ACSS Sample.

	A= Large/+Leg	B= Small/+Leg	C= Large/+Torso	D= Small/+Torso
Acromial Height Sitting	75	0	99	24
Buttock-Knee Length	99	29	70	0
Eye Height Sitting	78	0	99	21
Knee Height Sitting	99	23	76	0
Sitting Height	79	0	99	20
TTR	99	29	70	0
	W= Large	X= Med. Torso-/+Leg	Y= Small	Z= Med. Torso+/-Leg
Acromial Height Sitting	98	10	1	89
Buttock-Knee Length	98	91	1	8
Eye Height Sitting	99	10	0	89
Knee Height-Sitting	98	89	1	10
Sitting Height	99	10	0	89
TTR	98	91	1	8

Table 15 shows the actual values for each Case by measurement for all three surveys. The gray shading is only for visual separation of Cases. The majority of differences between the Cases for the different surveys are about one centimeter or less. A few measurements (highlighted) show a smaller value for the JPATS sample when compared to the other two. With the exception of the eye height sitting for Cases Y and B, the magnitude of the differences between ACSS and JSC are not meaningful in general cockpit design. However, the eye height sitting differences are somewhat surprising and may suggest measurement technique variation.

Table 15: Cockpit Accommodation 98% Multivariate Case Comparisons

Case	A Large/+Leg			B Small/+Leg		
Survey	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height Sitting	63.8	63.6	62.9	54.9	53.6	53.9
Buttock Knee Length	68.2	68.8	68.1	59.8	59.3	59.6
Eye Height Sitting	85.0	85.2	83.2	74.8	72.7	72.1
Knee Height Sitting	62.1	63.5	62.5	53.9	53.3	53.5
Sitting Height	96.9	97.1	95.7	85.8	84.3	84.2
TTR	90.8	90.9	89.1	79.7	78.3	77.5
Case	C Large/+Torso			D Small/+Torso		
Survey	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height Sitting	68.1	68.2	67.5	59.2	58.1	58.5
Buttock Knee Length	63.8	63.7	63.0	55.5	54.2	54.5
Eye Height Sitting	90.1	90.7	88.9	79.9	78.2	77.8

Knee Height Sitting	57.8	59.4	57.9	49.7	49.2	48.9
Sitting Height	102.1	102.7	101.1	91.0	89.8	89.7
TTR	83.4	84.4	82.3	72.3	71.9	70.7
Case	W Large			X Med. Torso-/+Leg		
Survey	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height Sitting	67.8	68.0	67.1	58.5	57.7	57.5
Buttock Knee Length	67.7	68.2	67.3	64.9	65.1	64.9
Eye Height Sitting	89.7	90.5	88.3	78.9	77.8	76.5
Knee Height Sitting	61.6	63.6	62.1	58.9	59.2	58.9
Sitting Height	101.8	102.6	100.7	90.3	89.6	88.8
TTR	89.4	90.2	88.0	86.8	85.9	84.7
Case	Y Small			Z Med. Torso+/-Leg		
Survey	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height Sitting	55.2	53.8	54.4	64.6	64.1	64.0
Buttock Knee Length	55.9	54.8	55.2	58.7	57.9	57.7
Eye Height Sitting	75.2	72.8	72.7	86.1	85.6	84.5
Knee Height Sitting	50.1	49.1	49.3	52.9	53.5	52.5
Sitting Height	86.1	84.4	84.6	97.7	97.4	96.5
TTR	73.7	72.5	71.7	76.3	76.8	75.1

Finally, Table 16 lists the smallest to largest values on each individual measurement across all Cases and their ranges. Notice that the JSF survey has the greatest range for all of these measurements. It appears that the smallest males in the ACSS are not as small as those in the JSF/JPATS samples and that the largest males in ACSS fall between JSF/JPATS.

Table 16: Cockpit Accommodation 98% Multivariate Case Ranges

SURVEY	ACSS			JSF			JPATS		
	min	max	range	min	max	range	min	max	range
Acromial-Height-Sitting	54.9	68.1	13.2	53.6	68.2	14.6	53.9	67.5	13.6
Buttock-Knee-Length	55.5	68.2	12.7	54.2	68.8	14.6	54.5	68.1	13.6
Eye-Height-Sitting	74.8	90.1	15.3	72.7	90.7	18.0	72.1	88.9	16.8
Knee-Height-Sitting	49.7	62.1	12.4	49.2	63.6	14.4	48.9	62.5	13.6
Sitting-Height	85.8	102.1	16.3	84.3	102.7	18.4	84.2	101.1	16.9
TTR	72.3	90.8	18.5	71.9	90.9	19.0	70.7	89.1	18.4

Given this set of measurements, the use of the JSF sample multivariate cases continues to be acceptable. The JPATS sample multivariate Cases produce smaller values consistently and should not be used in future analyses.

5.2 Workspace Variable Comparison

Hudson et al., 2006 used a list of 14 body measurements to describe body size variability for workstation operators. For this comparison, the list was reduced to 10 measurements. Unlike the six cockpit seat adjust variables described above, body mass related measurements (torso circumferences, shoulder breadth and weight) were included in this analysis. The analysis

required three Principal Components to explain the variation in the groups of measurements. Again, overall size was the first component, followed by mass variables in various ratios to size, and finally differing limb/torso ratios. Three principal component analyses require more Cases (14) to describe the variation in the sample. Cases are selected at both ends of the three major axes and at eight mid-octant point on the ellipse. Once again, the values in the Tables 17 and 18 are percentile values for the individual measurements in the ACSS. The Case descriptors in the tables are based on them. For example, Case A is described as large overall with a large torso relative to limb length. While the mass measurements are somewhat large ranging from 54th to 80th percentile, for a person exhibiting other measurements ranging from 79th through 99th percentile, this is not extreme. These descriptors are relative and must be used carefully. Another example is Case D. This Case is 12th percentile or less for each of the torso and limb dimensions, but 20th to 41st percentile for the mass related measures. Case D is labeled as "Small/+Torso/-Mass. The mass measures are only + for someone that small on the other dimensions.

Table 17: Percentile Values for each Case by Measurement (A to H)

CASE	A	B	C	D
Interpretation	Large/+Torso/ +Mass	Small/+Limb/ -Mass	Medium/+Torso/ +Mass	Small/+Torso/ -Mass
Acromial Height, Sitting	99	5	94	12
Buttock-Knee Length	82	42	57	0
Shoulder (Bideltoid) Breadth	63	1	98	39
Bust/Chest Circ.	54	1	98	41
Eye Height, Sitting	99	10	89	8
Hip Circ., Max	74	0	99	34
Knee-Height-Sitting	87	63	36	0
Sitting-Height	99	10	89	7
TTR	79	66	33	0
Weight	80	0	99	20
CASE	E	F	G	H
Interpretation	Large/ -Mass	Small/+Torso/ -Mass	Medium/+Limbs/ -Mass	Small/+Limbs/ -Mass
Acromial Height, Sitting	87	43	56	0
Buttock-Knee Length	99	3	96	17
Shoulder (Bideltoid) Breadth	60	1	98	36
Bust/Chest Circ.	58	0	99	45
Eye Height, Sitting	91	62	37	0
Hip Circ., Max	65	1	98	25
Knee-Height-Sitting	99	9	90	12
Sitting-Height	92	59	40	0
TTR	99	6	93	20
Weight	79	1	98	19

Table 18: Percentile Values for each Case by Measurement (U to Z)

CASE	U	V	W
	Largest	Large/-Mass	Medium/+Limbs/-Torso
Acromial Height, Sitting	99	80	10
Buttock-Knee Length	99	74	91
Shoulder (Bideltoid)-Brea	98	4	47
Bust/Chest Circ.	98	2	54
Eye Height, Sitting	98	92	8
Hip Circ., Max	99	6	41
Knee Height, Sitting	98	90	92
Sitting Height	98	92	9
TTR	97	85	95
Weight	99	9	48
CASE	X	Y	Z
	Smallest	Small/-Limbs/+Mass	Medium/+Limbs/+Mass
Acromial Height, Sitting	0	19	89
Buttock-Knee Length	0	25	8
Shoulder (Bideltoid)Breadth	1	95	52
Bust/Chest Circ.	1	97	45
Eye Height, Sitting	1	7	91
Hip Circ., Max	0	93	58
Knee Height, Sitting	1	9	7
Sitting Height	1	7	90
TTR	2	14	4
Weight	0	90	51

The next series of tables (Table 19 to Table 24) show the actual measurement values for each of the Cases. Case values are listed together for the three surveys to allow comparison.

Table 19: 98% Multivariate Case Comparisons A+B

CASE	A Large/+Torso/ +Mass			B Small/+Limb/ -Mass		
	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height, Sitting	64.6	65.0	65.1	57.2	58.2	58.7
Buttock-Knee Length	68.4	67.4	67.0	61.3	60.0	59.5
Shoulder (Bideltoid) Breadth	50.0	48.6	48.4	43.3	42.4	43.4
Bust/Chest Circumference	104.5	99.8	97.2	86.2	83.9	85.1
Eye Height, Sitting	86.3	87.2	86.1	78.9	79.4	78.5
Hip Circumference, Max	106.5	103.7	99.0	89.6	89.4	86.1
Knee Height, Sitting	62.9	62.8	62.2	56.7	55.7	54.8
Sitting Height	98.2	99.0	98.5	90.1	90.8	90.5
TTR	91.7	89.8	88.5	83.1	80.4	79.0
Weight	205.4	193.0	182.8	127.6	125.2	125.4

Table 20: 98% Multivariate Case Comparisons C+D

CASE	C Medium/+Torso/ +Mass			D Small/+Torso/ -Mass		
	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height, Sitting	62.0	60.6	60.5	54.6	53.8	54.1
Buttock-Knee Length	66.4	67.3	67.4	59.3	59.8	59.9
Shoulder (Bideltoid) Breadth	55.1	53.0	52.1	48.5	46.9	47.0
Bust/Chest Circumference	120.5	113.9	108.4	102.1	98.0	96.2
Eye Height, Sitting	81.6	81.1	80.1	74.1	73.2	72.4
Hip Circumference, Max	117.1	111.5	105.0	100.2	97.2	92.2
Knee Height, Sitting	59.1	61.1	61.3	53.0	54.0	53.9
Sitting Height	93.3	93.0	92.5	85.2	84.8	84.6
TTR	87.1	88.3	87.6	78.6	78.9	78.1
Weight	241.9	223.4	204.2	164.2	155.6	146.7

Table 21: 98% Multivariate Case Comparisons E+F

CASE	E Large/ -Mass			F Small/+Torso/ -Mass		
	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height, Sitting	68.4	67.9	67.6	61.1	61.1	61.2
Buttock-Knee Length	64.3	63.1	62.8	57.2	55.7	55.3
Shoulder (Bideltoid) Breadth	50.2	50.7	50.5	43.5	44.6	45.4
Bust/Chest Circumference	103.6	103.1	100.8	85.3	87.2	88.7
Eye Height, Sitting	90.8	90.2	88.9	83.3	82.3	81.2
Hip Circumference, Max	108.1	106.6	102.3	91.2	92.4	89.4
Knee Height, Sitting	58.8	58.6	57.7	52.6	51.5	50.2
Sitting Height	102.7	102.2	101.0	94.6	94.0	93.1
TTR	84.6	83.8	81.9	76.0	74.4	72.4
Weight	206.8	200.4	190.4	129.0	132.6	133.0

Table 22: 98% Multivariate Case Comparisons G+H

CASE	G Medium/+Limbs/ -Mass			H Small/+Limbs/ -Mass		
	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height, Sitting	65.8	63.5	63.0	58.4	56.7	56.5
Buttock-Knee Length	62.3	63.0	63.2	55.2	55.5	55.7
Shoulder (Bideltoid) Breadth	55.3	55.2	54.1	48.7	49.0	49.0
Bust/Chest Circumference	119.6	117.2	112.0	101.2	101.3	99.8
Eye Height, Sitting	86.0	84.0	82.8	78.6	76.2	75.2
Hip Circumference, Max	118.7	114.4	108.3	101.8	100.1	95.5
Knee Height, Sitting	55.1	56.9	56.7	48.9	49.8	49.3
Sitting Height	97.8	96.2	95.1	89.7	88.0	87.2
TTR	80.0	82.3	80.9	71.5	72.9	71.4
Weight	243.3	230.8	211.8	165.5	163.0	154.4

Table 23: 98% Multivariate Case Comparisons U, V, W

CASE	U Largest			V Large/-Mass			W Medium/+Limbs/-Torso		
	ACSS	JSF	JPATS	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height, Sitting	67.9	66.7	66.4	63.8	64.7	64.8	58.2	58.4	58.7
Buttock-Knee Length	67.9	67.9	67.9	63.6	61.6	61.0	65.4	65.2	65.0
Shoulder (Bideltoid) Breadth	55.1	54.1	53.1	44.9	45.0	45.6	49.2	46.9	47.0
Bust/Chest Circumference	118.7	114.3	109.0	89.0	88.3	88.8	103.6	97.7	95.4
Eye Height, Sitting	88.9	88.5	87.3	86.6	87.0	85.9	78.6	79.1	78.3
Hip Circumference, Max	118.8	114.3	108.4	94.9	95.2	92.0	102.8	99.4	94.4
Knee Height, Sitting	61.2	62.4	62.2	59.1	57.8	56.6	59.4	59.9	59.7
Sitting Height	101.0	100.6	99.7	98.3	98.7	98.0	90.0	90.7	90.6
TTR	89.0	89.5	88.2	85.5	82.6	80.8	87.7	86.5	85.7
Weight	252.8	236.7	218.4	153.8	151.7	150.1	184.3	171.6	162.0

Table 24: 98% Multivariate Case Comparisons X, Y, Z

CASE	X Smallest			Y Small/-Limbs/+Mass			Z Medium/+Limbs/+Mass		
	ACSS	JSF	JPATS	ACSS	JSF	JPATS	ACSS	JSF	JPATS
Acromial Height, Sitting	55.1	55.0	55.3	59.2	57.1	56.8	64.8	63.3	63.0
Buttock-Knee Length	55.7	55.0	54.9	60.1	61.4	61.7	58.2	57.8	57.7
Shoulder (Bideltoid) Breadth	43.6	43.5	44.4	53.8	52.7	51.9	49.5	50.7	50.5
Bust/Chest Circumference	87.0	86.8	88.0	116.7	112.8	108.2	102.1	103.4	101.6
Eye Height, Sitting	76.0	74.9	74.0	78.3	76.4	75.4	86.3	84.3	83.0
Hip Circumference, Max	89.5	89.6	86.1	113.3	108.7	102.5	105.5	104.5	100.1
Knee Height, Sitting	50.6	50.2	49.3	52.7	54.8	54.9	52.3	52.7	51.8
Sitting Height	86.9	86.4	85.9	89.6	88.3	87.7	97.9	96.3	95.0
TTR	74.2	73.2	71.8	77.6	80.0	79.2	75.4	76.2	74.2
Weight	118.1	119.3	118.8	217.1	204.3	187.1	186.7	184.4	175.2

Since the correlations, means, and standard deviations between measurements in the three surveys are slightly different, it is not surprising that the Case values are somewhat different. However,

Table 25 shows that the ACSS sample consistently results in larger sizes (max values) than the other two samples. The smallest values were split between the JSF and JPATS samples except for knee height-sitting, which was smaller for the ACSS. Finally, the range from smallest to largest is generally broader in the ACSS.

Table 25: Range from smallest to largest from the 14 Cases

SURVEY	ACSS			JSF			JPATS		
	min	max	range	min	max	range	min	max	range
Acromial Height, Sitting	54.6	68.4	13.8	53.8	67.9	14.1	55.3	67.6	12.3
Buttock-Knee Length	55.2	68.4	12.7	55.0	67.9	12.9	54.9	67.9	13.0
Shoulder (Bideltoid) Breadth	43.3	55.3	12.0	42.4	55.2	12.8	43.4	54.0	10.6
Bust/Chest Circ	85.3	120.5	35.2	83.9	117.2	33.3	85.0	112.0	27.0
Eye-Height, Sitting	74.1	90.8	16.7	74.9	90.2	15.3	72.4	88.9	16.5
Hip-Circ, Max	89.5	118.8	29.3	89.6	111.5	21.9	86.1	108.4	22.3
Knee-Height, Sitting	48.9	62.9	14.0	49.8	62.8	13.0	49.3	62.2	12.9
Sitting Height	85.2	102.7	17.5	84.8	102.2	17.4	84.6	101.0	16.4
TTR	71.5	91.7	20.2	72.9	89.8	16.9	71.4	88.5	17.4
Weight	118.1	252.8	134.7	119.3	230.8	111.5	118.8	218.4	99.6

6.0 CONCLUSION

The results of these comparisons show that the (male-Caucasian) aircrew population is growing heavier and exhibiting larger mass related measurements. This change is important for the design of clothing and protective equipment. There were too few females and non-Caucasian males to adequately describe size and proportional variability for multiple sizes of protective equipment. Hence the JSF Caesar database should be used to supplement the ACSS sample. The ACSS shows slightly larger univariate percentile dimensions but the multivariate Cases developed for JSF were representative of the ACSS distribution.

A future study is planned in 2015 to expand the ACSS dataset with additional female and non-Caucasian male aircrew

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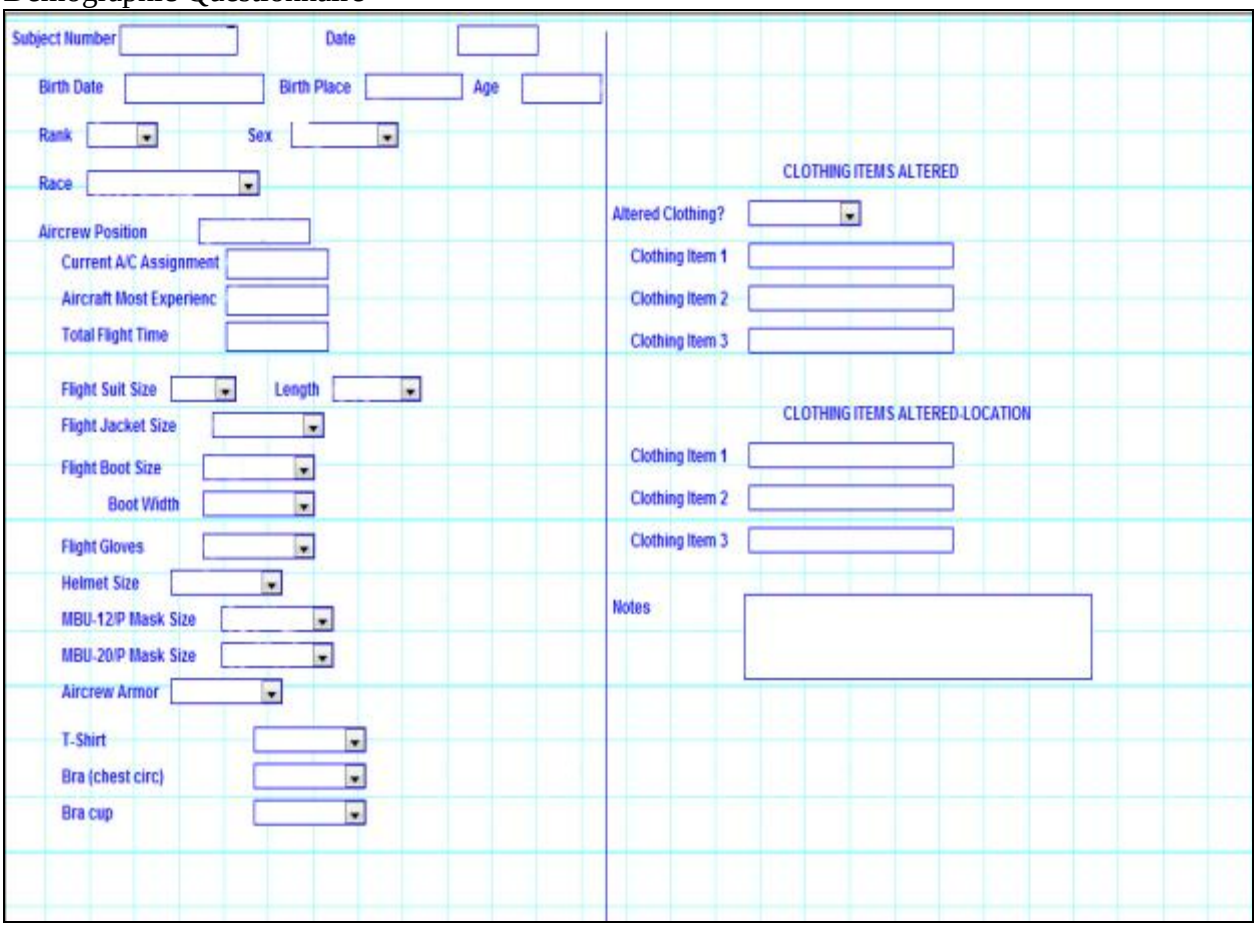
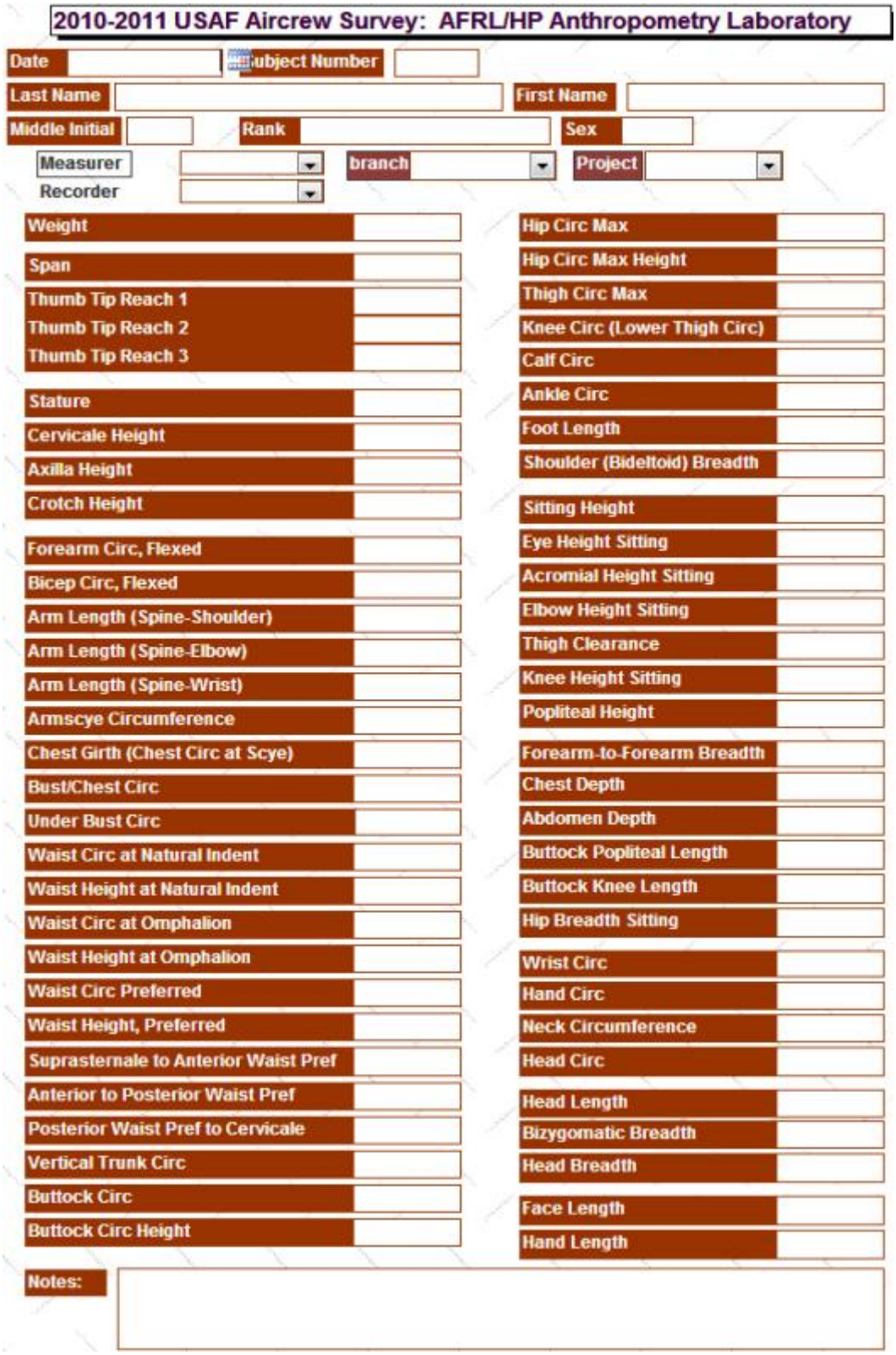
Appendix A: Data forms

Demographic Questionnaire



Traditional Anthropometry Measurement Sheet



2010-2011 USAF Aircrew Survey: AFRL/HP Anthropometry Laboratory

Date | Subject Number | Last Name | First Name | Middle Initial | Rank | Sex | Measurer | Recorder | branch | Project

Weight		Hip Circ Max	
Span		Hip Circ Max Height	
Thumb Tip Reach 1		Thigh Circ Max	
Thumb Tip Reach 2		Knee Circ (Lower Thigh Circ)	
Thumb Tip Reach 3		Calf Circ	
Stature		Ankle Circ	
Cervicale Height		Foot Length	
Axilla Height		Shoulder (Bideltoid) Breadth	
Crotch Height		Sitting Height	
Forearm Circ, Flexed		Eye Height Sitting	
Bicep Circ, Flexed		Acromial Height Sitting	
Arm Length (Spine-Shoulder)		Elbow Height Sitting	
Arm Length (Spine-Elbow)		Thigh Clearance	
Arm Length (Spine-Wrist)		Knee Height Sitting	
Armscye Circumference		Popliteal Height	
Chest Girth (Chest Circ at Scye)		Forearm-to-Forearm Breadth	
Bust/Chest Circ		Chest Depth	
Under Bust Circ		Abdomen Depth	
Waist Circ at Natural Indent		Buttock Popliteal Length	
Waist Height at Natural Indent		Buttock Knee Length	
Waist Circ at Omphalion		Hip Breadth Sitting	
Waist Height at Omphalion		Wrist Circ	
Waist Circ Preferred		Hand Circ	
Waist Height, Preferred		Neck Circumference	
Suprasternale to Anterior Waist Pref		Head Circ	
Anterior to Posterior Waist Pref		Head Length	
Posterior Waist Pref to Cervicale		Bizygomatic Breadth	
Vertical Trunk Circ		Head Breadth	
Buttock Circ		Face Length	
Buttock Circ Height		Hand Length	

Notes:

Appendix B: Aircrew sizing survey 3-D landmarks

For all landmarks below, subject should be standing erect, with weight distributed equally over both feet and head in the Frankfurt plane.

1. Acromion, left and right
   - Description: The point of intersection of the lateral border of the acromial process and line running down the middle of the shoulder from the neck to the tip of the shoulder
   - Procedure: Palpate acromion starting from the posterior edge, finding most prominent point along the middle of the shoulder. Place dot on the lateral edge of the acromion.

2. Axilla point, anterior; left and right
   - Description: Lowest point on the anterior axillary fold (armpit).
   - Procedure: This point can be located using either of the following methods.
     1) Raise the subject's arm to side, determining the lowest point of the axilla using visual inspection. Lower the arm, visually following the lowest point. Place dot at this level on side of arm.
     2) Raise the subject's arm to the side and place a straight, rigid tool (such as a ruler) under the arm. Lower the arm back to the side, making sure the shoulder is relaxed. Align the tool so that it is parallel to the floor and place the dot at this level on the side of the arm.

   - Note: One adhesive dot is placed on the arm at the level of the lowest point on the axillary fold.

3. Axilla point, posterior; left and right
   - Description: Lowest point on the posterior axillary fold (armpit).
   - Procedure: This point can be located using either of the following methods.
     1) Raise the subject's arm to side, determining the lowest point of the axilla using visual inspection. Lower the arm, visually following the lowest point. Place dot at this level on side of arm.
     2) Raise the subject's arm to the side and place a straight, rigid tool (such as a ruler) under the arm. Lower the arm back to the side, making sure the shoulder is relaxed. Align the tool so that it is parallel to the floor and place the dot at this level on the side of the arm.

4. Calcaneus, posterior; left and right
   - Description: Most prominent posterior point of the heel (note: this point may not be on the calcaneus).
   - Procedure: From side of foot, locate the most prominent point of the heel with visual inspection. Place dot on this point.

5. Cervicale
    - Description: Most prominent point of the spinous process of the seventh cervical vertebra (prominent bone at the base of the neck).
    - Procedure: Stand next to subject with fingers on the spinous process of C7. Have the subject drop their chin to their chest and slowly raise their head back to the Frankfurt plane while intermittently tapping the spinous process. You can also have the subject tilt the head back, and then slowly lower back to Frankfurt plane. C7 should move during both of these movements, while T1 will remain stationary. Tapping permits the skin to move relative to the spinous process as the head moves. This process can also be performed with T1 palpated along with C7. With head in Frankfurt plane, place dot over the most prominent point of C7.

6. Clavicale
    - Description: Most prominent point of the superior aspect of the medial end of the clavical at the sterno-clavicular junction.
    - Procedure: Stand in front of participant and palpate the clavicles, starting laterally and continuing medially, until the superior, medial edge is found. Place dots at these points.

7. Dactylion, left and right
    - Description: Tip of the middle finger
    - Procedure: Place dot on the fingernail with the center of the dot corresponding to the tip of the finger.

8. Pedal digit II, left and right
    - Description: Tip of the second toe
    - Procedure: Place dot on the fleshy tip of the toe (not on the toenail).

9. Femoral epicondyle, lateral; left and right
    - Description: Lateral point on the lateral epicondyle of the femur
    - Procedure: Palpate the bony prominences around the knee. Have the subject shift his/ her weight to the opposite leg so you can bend their knee. While holding the leg above the ankle, palpate the knee while moving the leg up and down. Once the landmark is located, slowly lower the leg, following the landmark by releasing and reapplying pressure as the leg moves. The landmark is marked with the subject standing with their weight equally distributed over both feet.

    - Note: Femoral epicondyles are marked while the subject is standing. Dots will need to be adjusted for seated images.

10. Femoral epicondyle, medial; left and right
    - Description: medial point on the medial epicondyle of the femur
    - Procedure: Palpate the bony prominences around the knee. Have the subject shift his/ her weight to the opposite leg so you can bend their knee. While holding the leg above the ankle, palpate the knee while moving the leg up and down. Once the landmark is located, slowly lower the leg, following the landmark by releasing

and reapplying pressure as the leg moves. The landmark is marked with the subject standing with their weight equally distributed over both feet.

- Note: Femoral epicondyles are marked while the subject is standing. Dots will need to be adjusted for seated images.

11. Frontotemporale
    - Description: The point of deepest indentation of the temporal crest of the frontal bone above the browridges.
    - Procedure: Stand in front of the subject and locate the landmarks by palpation along the temporal crest until the point of deepest indentation is found. Place a dot on each landmark.

12. Glabella
    - Description: The most anterior point of the frontal bone in the midsagittal plane between the bony brow ridges.
    - Procedure: Subject stands, looking straight ahead. Stand at the side of the subject and locate the landmark by visual inspection and place dot on landmark. Confirm that dot is in midsagittal plane.

13. Gonion, left and right
    - Description: Inferior, posterior point of the gonial angle (angle of the mandible).
    - Procedure: Subject stands with head in Frankfurt plane with teeth together, but not clenched. Stand in front of subject and locate gonion by palpation. Once located it is helpful to press directly on the landmark (not from below or behind) to make sure you do not have skin movement and are marking the correct location. Mark inferior, posterior point. Place a dot on landmark.

14. Humeral epicondyle, lateral; left and right
    - Description: Lateral point on the lateral epicondyle of the humerus, when the palm is facing the side of the body.
    - Procedure: Palpate the elbow joint to locate the distal end of the humerus and the proximal end of the radius. If difficult to locate due to subject's musculature, bend subject's arm. With subject's arm straight, palpate point to confirm and mark landmark with dot.

15. Humeral epicondyle, medial; left and right
    - Description: Medial point on the medial epicondyle of the humerus, when the palm is facing the side of the body.
    - Procedure: Palpate prominent point on medial epicondyle. If difficult to find, bend subject's arm. As you lower the arm, tap the landmark to follow it while the skin is moving. Once the arm is straight, palpate the location to confirm the point. Mark with dot with subject's arm straight.

16. Iliac spine, anterior, superior; left and right
    - Description: Prominent, anterior point on the anterior rim of the ilium.
    - Procedure: Stand in front of subject. Use thumbs to palpate prominent points of ilium. Place dots over landmark. These points may be beneath the scanning garment. If so, place dots over garment.

17. Iliac spine, posterior, superior; left and right
    - Description: Prominent point on the posterior rim of the ilium; a dimple may overly this point.
    - Procedure: Stand behind subject. Use thumbs to locate prominent points of ilium. If there is difficulty finding these points, have the subject lean forward. Palpate point and have subject stand upright. Place dots over landmark. These points may be beneath the scanning garment. If so, place dots over garment.

18. Iliocristale, left and right
    - Description: Superior most palpable point of the iliac crest in the mid-coronal plane.
    - Procedure: Stand behind subject. Use side of fingers to locate superior point of iliac crest, rolling fingers to do find superior edge. Allow the skin to return so that landmark is in correct location. Place a dot over this landmark.

19. Infraorbitale, left and right
    - Description: Lowest point on the inferior margin of the orbit (the bony eye socket), marked directly inferior to the pupil.
    - Procedure: Subject stands looking straight ahead. Stand in front of subject and palpate the bony eye socket. Place dot on eye socket directly below pupil.

20. Knee crease, left and right
    - Description: Midpoint of the crease that runs medial to lateral on the posterior side of the knee.
    - Procedure: Place dot over center of crease on the posterior side of the knee.

21. Malleolus, lateral; left and right
    - Description: Lateral most point of the lateral malleolus.
    - Procedure: Using visual inspection from the front of the foot, place dot over lateral most point.

22. Malleolus, medial; left and right
    - Description: Medial most point of the medial malleolus.
    - Procedure: Using visual inspection from the front of the foot, place dot over medial most point.

23. Menton
    - Description: The inferior point of the mandible in the midsagittal plane
    - Procedure: Subject stands with head in Frankfurt plane with teeth together but not clenched. Locate landmark and place a dot over it.

24. Metacarpophalangeal II, left and right
    - Description: Prominent point on the lateral surface of the second metacarpophalangeal joint.
    - Procedure: Palpate most protruding point at the second metacarpophalangeal joint. Place dot over this point.

25. Metacarpophalangeal V, left and right
    - Description: Prominent point on the medial surface of the fifth metacarpophalangeal joint.
    - Procedure: Palpate most protruding point at the second metacarpophalangeal joint. Place dot over this point.

26. Metatarsophalangeal I, left and right
    - Description: Maximum protrusion of the medial surface of the foot at the head of metatarsal I.
    - Procedure: Locate the maximum protrusion of the head of metatarsal I by visual inspection. Place dot over this point.

27. Metatarsophalangeal V, left and right
    - Description: Maximum protrusion of the lateral surface of the foot at the head of metatarsal V.
    - Procedure: Locate the maximum protrusion of the head of metatarsal V by visual inspection. Place dot over this point.

28. Nuchale
    - Description: Lowest point of occiput that can be palpated among the nuchal muscles, marked in the midsagittal plane.
    - Procedure: After the wigcap is in place, palpate beginning inferiorly until occipital bone is detected. Place dot on the wigcap at the location of the landmark.

    - Note: This point is often obscured by the hair and cap. It is marked in the midsagittal plane.

29. Olecranon, left and right
    - Description: Posterior point on the olecranon process of the ulna, marked with the elbow bent 90 degrees.
    - Procedure: Position subject's arm so that the elbow is bent at 90°. Place a dot at the posterior point.

30. Pronasale
    - Description: Tip of nose.
    - Procedure: Place dot on tip of the nose.

31. Radial styloid, left and right
    - Description: Distal tip of the radius on the lateral surface.
    - Procedure: Distal end of the radial styloid process is palpated, manipulating the subject's wrist to identify the distal point of the radius. Place a dot over this point.

32. Radiale, left and right
    - Description: The superior point on the outside edge of the radial head.
    - Procedure: Palpate the elbow joint to locate the distal end of the humerus and the proximal end of the radius. Palpate the lateral edge of the radius. Should there be difficulty with this landmark, the grasp the subject's wrist and rotate forearm to feel the rotation of the radial head.

33. Sellion
    - Description: Point of greatest indentation of the nasal root depression; nasion.
    - Procedure: With subject looking straight ahead, stand to the right and place a dot in the deepest point of indentation at the bridge of the nose along the midline.

34. Substernale
    - Description: Inferior-most palpable point on the sternum; xyphoid process.
    - Procedure: Stand in front of subject and palpate superiorly from the abdomen at the bottom of the rib cage to where the bony landmark is first detected. Ask subject to take deep breath to aid in finding landmark. After the subject has released the breath and is breathing normally, confirm the location of the landmark. Place dot over center of landmark.

35. Supramenton
    - Description: Point of greatest indentation of the mandible along the midsagittal plane
    - Procedure: Place dot in the point of greatest indentation above the chin along the midline.

36. Suprasternale
    - Description: The inferior point of the jugular notch of the sternum.
    - Procedure: Palpate superiorly on the sternum until the superior point is found. Place dot over point.

37. Tenth rib, left and right
    - Description: Lowest palpable point on the inferior border of the tenth rib at the bottom of the rib cage.
    - Procedure: Stand in front of subject and palpate rib cage working inferiorly until the lowest point is located. Ask the subject to take a deep breath to better locate the inferior point of the rib cage. Have the subject release the breath. As the subject is breathing out, release and reapply pressure on the landmark location as the ribs move. Once the subject is breathing normally, confirm the location and place dot over inferior point on both sides.

38. Tenth rib, midspine
    - Description: Level on the right tenth rib (landmark), marked on the spine.
    - Procedure: Take height of 10^{th} rib with anthropometer. Place dot at this height on the spine.

39. Thelion/ bustpoint, left and right
    - Description: Most anterior protrusion of the bra cup on women. Center of the nipple on men.
    - Procedure: Place dot over center of nipple on men. For women, ask subject to place dot over nipple.

40. Tragion, left and right
    - Description: notch just above the tragus (the cartilaginous flap in front of the ear hole).
    - Procedure: Place dot in notch above tragus.

41. Trochanterion, left and right
    - Description: The superior point of the greater trochanter of the femur.
    - Procedure: Smooth out the scanning shorts to remove any wrinkles. Stand behind the subject. Use pads of fingers to simultaneously locate the highest point of both greater trochanters. Ask subject to sway hips. Ask subject to place one foot forward on the heel and rotate foot back and forth. Have the subject balance his/her weight on both feet and confirm the location of the landmark. Place dot over superior point on top of scanning garment.

42. Ulnar styloid, left and right
    - Description: Distal tip of the ulna on the medial side
    - Procedure: Distal end of the ulnar styloid process is palpated, manipulating the subject's wrist to identify the distal point of the ulna. Place a dot over this point.

43. Waist, preferred, posterior
    - Description: Level of the waist as marked on the subject's back in the midsagittal plane.
    - Procedure: Subject is asked to position a waistband where their preferred waist is for a favorite pair of pants. Anterior, posterior, and right sides of band are marked with a pencil. Place a dot over posterior pencil mark.

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Appendix C

Traditional anthropometrics for USAF 2011: Training manual listed in order of sequence (methods, descriptions and landmark definitions were coordinated with the US Army ANSURII, the Air Standardization Coordinating Committee methods in AIR-STD - taken from CAESAR unless otherwise noted)

1. Weight

Description: Weight of the subject.

Method: Subject stands on the scale fully erect with the weight distributed equally on both feet. Weight is measured with subject wearing measuring garment only.

Instrument: Scale

The Summary Statistics
Weight

Pounds (lbs)		Kilograms (kg)
185.39	**Mean**	84.09
0.98	**SE (mean)**	0.45
24.86	**St Dev**	11.28
129.00	**Minimum**	58.51
285.40	**Maximum**	129.46

Coeff. Of Variation	13.41
Symmetry – BETA I	0.43
Kurtosis – BETA II	0.28
Number of Subjects	640

Pounds	Percentiles	Kilograms
134.70	**1st**	61.10
139.20	**2nd**	63.14
141.60	**3rd**	64.23
147.20	**5th**	66.77
155.05	**10th**	70.33
160.30	**15th**	72.71
163.80	**20th**	74.30
166.45	**25th**	75.50
170.80	**30th**	77.47
175.35	**35th**	79.54
178.50	**40th**	80.97
181.05	**45th**	82.12
183.80	**50th**	83.37
186.05	**55th**	84.39
189.70	**60th**	86.05
192.95	**65th**	87.52
196.70	**70th**	89.22
201.45	**75th**	91.38
204.95	**80th**	92.96
210.05	**85th**	95.28
220.35	**90th**	99.90
231.35	**95th**	104.94
236.70	**97th**	107.37
239.80	**98th**	108.77
247.00	**99th**	112.04

2. Span

Description: The distance between the tips of the middle fingers of horizontally outstretched arms.

Undrawn Landmarks: Dactylion III, right and left.

Method: Participant stands erect with their left arm outstretched (palm facing forward and fingers straight) and the fingertip of their middle finger (i.e. Dactylion III) against the wall and the feet together. The right arm is outstretched in the opposite direction. Standing behind the subject the measurer holds up the anthropometer with the base resting against the wall. The anthropometer should be level and parallel to the outstretched arms of the subject. After the recorder has checked the subject's posture, and corrected it if necessary, the recorder then takes the measurement by moving the blade to the fingertip of the right middle finger.

Instruments: Anthropometer

The Summary Statistics
Span

Centimeters		Inches
182.24	**Mean**	71.75
0.29	**SE (mean)**	0.11
7.23	**St Dev**	2.85
160.00	**Minimum**	62.99
203.90	**Maximum**	80.28

Coeff. Of Variation	3.97
Symmetry – BETA I	-0.05
Kurtosis – BETA II	-0.09
Number of Subjects	640

Percentiles

Centimeters		Inches
164.90	**1st**	64.92
167.10	**2nd**	65.79
169.00	**3rd**	66.54
169.70	**5th**	66.81
173.00	**10th**	68.11
175.40	**15th**	69.06
176.25	**20th**	69.39
177.30	**25th**	69.80
178.35	**30th**	70.22
179.60	**35th**	70.71
180.50	**40th**	71.06
181.10	**45th**	71.30
182.00	**50th**	71.65
183.00	**55th**	72.05
184.15	**60th**	72.50
185.00	**65th**	72.83
186.20	**70th**	73.31
187.50	**75th**	73.82
188.55	**80th**	74.23
189.70	**85th**	74.69
191.50	**90th**	75.39
194.00	**95th**	76.38
195.60	**97th**	77.01
196.60	**98th**	77.40
198.30	**99th**	78.07

3. **<u>Thumb Tip Reach</u>** (ANSURII)

Description: Maximum horizontal reach measured from the back (the wall surface) to the juncture of the index finger and thumb, right.

Method: Subject stands with shoulders and back against a wall. Heels are 10 centimeters from the wall, approximately shoulder-width apart. Arm is raised forward with the index finger and thumb touching. Arm is held perpendicular to the wall (horizontal).

Instrument: Anthropometer

The Summary Statistics
Thumb Tip Reach

Centimeters		Inches
81.47	**Mean**	32.07
0.15	**SE (mean)**	0.06
3.73	**St Dev**	1.47
71.00	**Minimum**	27.95
92.90	**Maximum**	36.57

Coeff. Of Variation	4.57
Symmetry – BETA I	-0.09
Kurtosis – BETA II	-0.08
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
72.70	**1st**	28.62
73.63	**2nd**	28.99
74.00	**3rd**	29.13
75.13	**5th**	29.58
76.52	**10th**	30.13
77.62	**15th**	30.56
78.43	**20th**	30.88
79.13	**25th**	31.15
79.67	**30th**	31.36
79.95	**35th**	31.48
80.50	**40th**	31.70
81.12	**45th**	31.94
81.75	**50th**	32.19
82.20	**55th**	32.36
82.50	**60th**	32.48
82.90	**65th**	32.64
83.50	**70th**	32.88
84.02	**75th**	33.08
84.70	**80th**	33.35
85.29	**85th**	33.58
86.22	**90th**	33.95
87.35	**95th**	34.39
88.00	**97th**	34.65
88.83	**98th**	34.97
90.03	**99th**	35.45

4. **Stature** (Body height)

Description: Vertical distance from the standing surface to the highest point of the head (vertex).

Method: Subject stands fully erect looking straight ahead with the weight distributed equally on both feet and the arms hanging freely downwards and their palms facing their thighs (for purposes herein, this posture is defined as the 'anthropometric standing position'). The subject's feet are placed in footprints adhered to the standing surface (the footprints are positioned 10 cm apart at the heels and rotated 33º at the toes) with the heels on the back edge and the line going down the middle of the second toe; and the head held in the Frankfurt plane. This is a plane passing through the inferior margin of the eye orbit (the point called the orbitale) and the upper margin of the tragus of the ear (the point called the tragion). This is close to the position the head is normally carried in a living subject.

Instrument: Anthropometer

The Summary Statistics
Stature

Centimeters		Inches
178.52	**Mean**	70.28
0.26	**SE (mean)**	0.10
6.47	**St Dev**	2.55
161.10	**Minimum**	63.43
198.00	**Maximum**	77.95

Coeff. Of Variation	3.62
Symmetry – BETA I	0.08
Kurtosis – BETA II	0.04
Number of Subjects	640

Percentiles

Centimeters		Inches
163.40	**1st**	64.33
164.40	**2nd**	64.72
165.80	**3rd**	65.28
168.15	**5th**	66.20
170.60	**10th**	67.17
172.00	**15th**	67.72
173.30	**20th**	68.23
174.10	**25th**	68.54
174.90	**30th**	68.86
175.80	**35th**	69.21
176.60	**40th**	69.53
177.70	**45th**	69.96
178.40	**50th**	70.24
179.20	**55th**	70.55
180.25	**60th**	70.96
181.00	**65th**	71.26
182.15	**70th**	71.71
182.90	**75th**	72.01
183.70	**80th**	72.32
184.95	**85th**	72.82
186.45	**90th**	73.41
189.60	**95th**	74.65
191.00	**97th**	75.20
193.60	**98th**	76.22
194.70	**99th**	76.65

5. **<u>Cervicale Height</u>** (ANSURII)

Description: The vertical distance between a standing surface and the cervicale landmark at the base of the neck.
Drawn Landmark: Cervicale

Method: Participant stands erect with the feet placed in footprints adhered to the standing surface with the head held in the Frankfurt plane. The measurement is taken at the maximum point of quiet respiration.
Instrument: Anthropometer

The Summary Statistics
Cervicale Height

Centimeters		Inches
152.76	**Mean**	60.14
0.24	**SE (mean)**	0.09
6.05	**St Dev**	2.38
134.50	**Minimum**	52.95
171.00	**Maximum**	67.32

Coeff. Of Variation	3.96
Symmetry – BETA I	0.03
Kurtosis – BETA II	0.05
Number of Subjects	640

Percentiles

Centimeters		Inches
138.40	**1st**	54.49
139.60	**2nd**	54.96
140.70	**3rd**	55.39
143.05	**5th**	56.32
145.10	**10th**	57.13
146.65	**15th**	57.74
147.40	**20th**	58.03
148.65	**25th**	58.52
149.50	**30th**	58.86
150.40	**35th**	59.21
151.20	**40th**	59.53
152.20	**45th**	59.92
152.90	**50th**	60.20
153.55	**55th**	60.45
154.40	**60th**	60.79
155.40	**65th**	61.18
155.95	**70th**	61.40
156.80	**75th**	61.73
157.50	**80th**	62.01
158.65	**85th**	62.46
160.10	**90th**	63.03
162.95	**95th**	64.15
164.30	**97th**	64.69
166.30	**98th**	65.47
167.80	**99th**	66.06

6. **<u>Axilla Height</u>** (ANSURII actually uses the anterior (front) scye)

Description: The vertical distance between a standing surface and the right axillary fold, as designated by the posterior scye landmark on the torso.
Drawn Landmark: Posterior (back) scye on the arm, right

Method: Participant is in the anthropometric standing position. Stand behind the participant and use an anthropometer to measure the vertical distance between the standing surface and the axillary fold as designated by the drawn posterior (back) scye landmark on the torso. The measurement is taken at the maximum point of quiet respiration.
Instrument: Anthropometer

The Summary Statistics
Axilla Height

Centimeters		Inches
132.98	**Mean**	52.35
0.22	**SE (mean)**	0.08
5.62	**St Dev**	2.21
117.70	**Minimum**	46.34
147.90	**Maximum**	58.23

Coeff. Of Variation	4.23
Symmetry – BETA I	0.02
Kurtosis – BETA II	-0.04
Number of Subjects	640

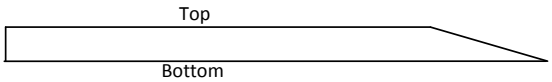
	Percentiles	
Centimeters		**Inches**
119.60	**1st**	47.09
121.30	**2nd**	47.76
122.30	**3rd**	48.15
123.65	**5th**	48.68
125.60	**10th**	49.45
127.40	**15th**	50.16
128.45	**20th**	50.57
129.45	**25th**	50.96
130.10	**30th**	51.22
130.75	**35th**	51.48
131.60	**40th**	51.81
132.20	**45th**	52.05
132.90	**50th**	52.32
133.50	**55th**	52.56
134.30	**60th**	52.87
135.35	**65th**	53.29
135.95	**70th**	53.52
136.65	**75th**	53.80
137.65	**80th**	54.19
138.55	**85th**	54.55
139.85	**90th**	55.06
142.10	**95th**	55.94
144.20	**97th**	56.77
145.70	**98th**	57.36
146.70	**99th**	57.76

7. Crotch Height

Description: Vertical distance from the standing surface to the crotch. The anthropometer blade is placed between the thighs and raised by the measurer to the point where it touches the highest point of the crotch.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely. Subject's feet are placed in footprints adhered to the standing surface.[1]
Instrument: Anthropometer.

[1]For most dimensions found using the anthropometer, the bottom of the blade is used. However, for crotch, elbow and popliteal heights the top of the blade is used. The resulting value is adjusted afterward.



The Summary Statistics
Crotch Height

Centimeters		Inches
80.24	**Mean**	31.60
0.17	**SE (mean)**	0.07
4.30	**St Dev**	1.70
69.20	**Minimum**	27.24
92.00	**Maximum**	36.22

Coeff. Of Variation	5.36
Symmetry – BETA I	0.06
Kurtosis – BETA II	-0.18
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
70.20	**1st**	27.64
71.40	**2nd**	28.11
72.10	**3rd**	28.39
73.20	**5th**	28.82
74.60	**10th**	29.37
75.80	**15th**	29.84
76.60	**20th**	30.16
77.40	**25th**	30.47
78.00	**30th**	30.71
78.50	**35th**	30.91
79.20	**40th**	31.18
79.60	**45th**	31.34
80.10	**50th**	31.54
80.80	**55th**	31.81
81.30	**60th**	32.01
81.85	**65th**	32.22
82.40	**70th**	32.44
83.15	**75th**	32.74
83.75	**80th**	32.97
84.50	**85th**	33.27
85.70	**90th**	33.74
87.85	**95th**	34.59
89.20	**97th**	35.12
89.40	**98th**	35.20
90.00	**99th**	35.43

8. **<u>Forearm Circumference</u>,** flexed

Description: The maximum circumference of the flexed right forearm.

Method: Participant stands with the upper arm extended forward horizontally, the elbow flexed 90 degrees, and the fist is clenched and held facing posterior. Stand at the right of the participant and use a tape to determine the maximum circumference of the flexed forearm. The measurement is made in a plane perpendicular to the long axis of the forearm. Exert only enough tension on the tape to maintain contact between the tape and the skin.
Instrument: Steel tape measure

The Summary Statistics
Forearm Circumference, Flexed

Centimeters		Inches
30.57	**Mean**	12.04
0.07	**SE (mean)**	0.03
1.86	**St Dev**	0.73
22.30	**Minimum**	8.78
36.00	**Maximum**	14.17

Coeff. Of Variation	6.07
Symmetry – BETA I	-0.06
Kurtosis – BETA II	0.43
Number of Subjects	640

Centimeters	Percentiles	Inches
26.10	**1st**	10.28
26.90	**2nd**	10.59
27.10	**3rd**	10.67
27.55	**5th**	10.85
28.35	**10th**	11.16
28.75	**15th**	11.32
29.10	**20th**	11.46
29.30	**25th**	11.54
29.60	**30th**	11.65
29.75	**35th**	11.71
30.00	**40th**	11.81
30.30	**45th**	11.93
30.60	**50th**	12.05
30.80	**55th**	12.13
31.00	**60th**	12.20
31.20	**65th**	12.28
31.50	**70th**	12.40
31.70	**75th**	12.48
32.00	**80th**	12.60
32.50	**85th**	12.80
33.10	**90th**	13.03
33.85	**95th**	13.33
34.10	**97th**	13.43
34.30	**98th**	13.50
34.80	**99th**	13.70

9. **<u>Bicep Circumference, flexed</u>** (ANSURII)

Description: The circumference of the right upper arm at the biceps point landmark when flexed.
Undrawn Landmark: Biceps point, right

Method: Participant stands. The right upper arm is extended forward horizontally and the elbow is flexed about 90 degrees. Visual inspection will often suggest the approximate area of the maximum circumference. Place a tape around the upper arm at the region of the maximum circumference. The fist is clenched and held facing posterior. The participant is urged to exert maximum effort in "making a muscle." Stand at the right of the participant and use a tape to find the greatest circumference of the upper arm. Move the tape right and left of the sighted maximum to check that indeed it is the maximum circumference. The tape should be in a plane perpendicular to the long axis of the upper arm. Exert only enough tension on the tape to maintain contact between the tape and the skin.
Instrument: Steel tape measure

The Summary Statistics
Bicep Circumference, Flexed

Centimeters		Inches
35.60	**Mean**	14.02
0.11	**SE (mean)**	0.05
2.91	**St Dev**	1.14
27.20	**Minimum**	10.71
45.50	**Maximum**	17.91

Coeff. Of Variation	8.17
Symmetry – BETA I	0.22
Kurtosis – BETA II	0.35
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
28.90	**1st**	11.38
29.80	**2nd**	11.73
30.00	**3rd**	11.81
30.85	**5th**	12.15
32.20	**10th**	12.68
32.80	**15th**	12.91
33.25	**20th**	13.09
33.80	**25th**	13.31
34.10	**30th**	13.43
34.50	**35th**	13.58
34.80	**40th**	13.70
35.00	**45th**	13.78
35.40	**50th**	13.94
35.70	**55th**	14.06
36.15	**60th**	14.23
36.50	**65th**	14.37
37.00	**70th**	14.57
37.40	**75th**	14.72
37.85	**80th**	14.90
38.50	**85th**	15.16
39.25	**90th**	15.45
40.90	**95th**	16.10
41.60	**97th**	16.38
42.10	**98th**	16.57
43.30	**99th**	17.05

10. **<u>Arm Length 1</u>** (spine-shoulder)

Description: Surface distance measured from cervicale to acromion
Drawn landmarks: cervicale and acromion, right

Method: Subject stands erect with the arm bent and fist placed on the hip.
Instrument: Steel tape measure

The Summary Statistics
Arm Length, Spine to Shoulder

Centimeters		Inches
21.74	**Mean**	8.56
0.05	**SE (mean)**	0.02
1.16	**St Dev**	0.46
18.60	**Minimum**	7.32
26.20	**Maximum**	10.31

Coeff. Of Variation	5.35
Symmetry – BETA I	0.14
Kurtosis – BETA II	0.10
Number of Subjects	640

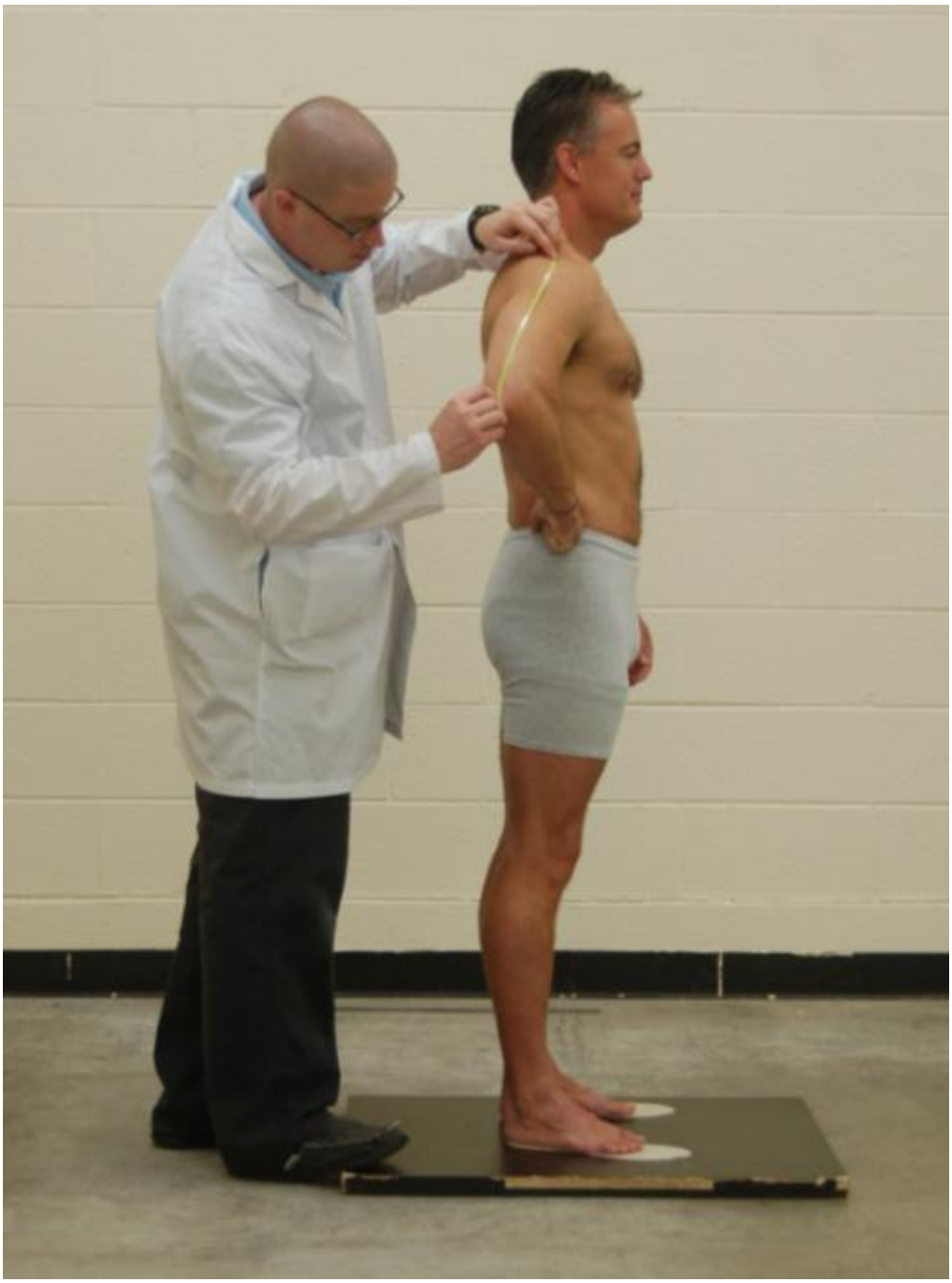
Percentiles

Centimeters		Inches
19.20	**1st**	7.56
19.30	**2nd**	7.60
19.50	**3rd**	7.68
19.85	**5th**	7.82
20.20	**10th**	7.95
20.50	**15th**	8.07
20.80	**20th**	8.19
21.00	**25th**	8.27
21.10	**30th**	8.31
21.30	**35th**	8.39
21.40	**40th**	8.43
21.60	**45th**	8.50
21.70	**50th**	8.54
21.90	**55th**	8.62
22.00	**60th**	8.66
22.10	**65th**	8.70
22.30	**70th**	8.78
22.45	**75th**	8.84
22.70	**80th**	8.94
23.00	**85th**	9.06
23.20	**90th**	9.13
23.70	**95th**	9.33
24.00	**97th**	9.45
24.20	**98th**	9.53
24.50	**99th**	9.65

11. **<u>Arm Length 2</u>** (spine-elbow)

Description: Surface distance measured from cervicale through acromion to olecranon.
Drawn landmarks: cervicale and olecranon, right

Method: Subject stands erect with the arm bent and fist placed on the hip.
Instrument: Steel tape measure



The Summary Statistics
Arm Length, Spine to Elbow

Centimeters		Inches
56.47	**Mean**	22.23
0.09	**SE (mean)**	0.04
2.27	**St Dev**	0.89
50.00	**Minimum**	19.69
63.50	**Maximum**	25.00

Coeff. Of Variation	4.02
Symmetry – BETA I	0.01
Kurtosis – BETA II	-0.05
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
51.30	**1st**	20.20
51.60	**2nd**	20.31
51.90	**3rd**	20.43
52.50	**5th**	20.67
53.50	**10th**	21.06
54.20	**15th**	21.34
54.60	**20th**	21.50
55.00	**25th**	21.65
55.40	**30th**	21.81
55.60	**35th**	81.89
55.90	**40th**	22.01
56.10	**45th**	22.09
56.45	**50th**	22.22
56.70	**55th**	22.32
57.00	**60th**	22.44
57.30	**65th**	22.56
57.60	**70th**	22.68
57.90	**75th**	22.80
58.50	**80th**	23.03
58.90	**85th**	23.19
59.40	**90th**	23.39
60.05	**95th**	23.64
60.70	**97th**	23.90
61.30	**98th**	24.13
61.70	**99th**	24.29

12. **<u>Arm Length 3</u>** (spine-wrist)

Description: Surface distance measured from cervicale through acromion and then olecranon to a wrist band placed at the ulnar styloid landmark.
Drawn landmarks: Cervicale and radial and ulnar styloids (an elastic band is placed around the wrist overlaying these two landmarks), right

Method: Subject stands erect with the arm bent and fist placed on the hip.
Instrument: Steel tape measure

The Summary Statistics
Arm Length, Spine to Wrist

Centimeters		Inches
86.62	**Mean**	33.99
0.13	**SE (mean)**	0.05
3.32	**St Dev**	1.31
77.30	**Minimum**	30.43
96.20	**Maximum**	37.87

Coeff. Of Variation	3.84
Symmetry – BETA I	-0.01
Kurtosis – BETA II	-0.08
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
78.20	**1st**	30.79
79.10	**2nd**	31.14
80.20	**3rd**	31.57
81.00	**5th**	31.89
82.10	**10th**	32.32
83.00	**15th**	32.68
83.70	**20th**	32.95
84.20	**25th**	33.15
84.50	**30th**	33.27
85.00	**35th**	33.46
85.40	**40th**	33.62
85.80	**45th**	33.78
86.25	**50th**	33.96
86.70	**55th**	34.13
87.20	**60th**	34.33
87.60	**65th**	34.49
88.00	**70th**	34.65
88.45	**75th**	34.82
89.05	**80th**	35.06
90.00	**85th**	34.43
90.70	**90th**	35.71
91.80	**95th**	36.14
92.50	**97th**	36.42
93.00	**98th**	36.61
94.20	**99th**	37.09

13. **<u>Armscye Circumference</u>** (scye-circumference over acromion)

Description: Distance from acromion through the armpit, and back to acromion.
Drawn landmark: acromion, right

Method: Subject stands erect with arm bent and fist placed on hip. Tape is placed though armpit, then relaxes the arm at the side so arm hangs freely downward. Dimension is measured from acromion, through the front-break point (i.e. the location on the front of the body where the arm separates from the body), through the armpit, through the back-break point (i.e. the location on the back of the body where the arm separates from the body), to acromion.
Instrument: Steel tape measure

The Summary Statistics
Armscye Circumference

Centimeters		Inches
45.68	**Mean**	17.98
0.12	**SE (mean)**	0.05
2.91	**St Dev**	1.15
38.20	**Minimum**	15.04
57.10	**Maximum**	22.48

Coeff. Of Variation	6.37
Symmetry – BETA I	0.39
Kurtosis – BETA II	0.44
Number of Subjects	640

Percentiles

Centimeters		Inches
39.80	**1st**	15.67
40.10	**2nd**	15.79
40.60	**3rd**	15.98
41.00	**5th**	16.14
42.20	**10th**	16.61
42.70	**15th**	16.81
43.30	**20th**	17.05
43.70	**25th**	17.20
44.10	**30th**	17.36
44.50	**35th**	17.52
44.70	**40th**	17.60
45.20	**45th**	17.80
45.50	**50th**	17.91
45.90	**55th**	18.07
46.20	**60th**	18.19
46.65	**65th**	18.37
47.00	**70th**	18.50
47.50	**75th**	18.70
48.00	**80th**	18.90
48.60	**85th**	19.13
49.30	**90th**	19.41
50.80	**95th**	20.00
51.40	**97th**	20.24
52.30	**98th**	20.59
53.60	**99th**	21.10

14. **<u>Chest Girth</u>** (chest circumference at right and left armscye)

Description: Maximum circumference of the body is measured over the shoulder blades, under the arms, and across the upper chest.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Circumference is measured parallel to the standing surface and is taken at the maximum point of quiet respiration.
Instrument: Steel tape measure

The Summary Statistics
Chest Circumference, at Scye

Centimeters		Inches
107.05	**Mean**	42.15
0.28	**SE (mean)**	1.11
7.02	**St Dev**	2.76
89.40	**Minimum**	35.20
130.50	**Maximum**	51.38

Coeff. Of Variation	6.56
Symmetry – BETA I	0.30
Kurtosis – BETA II	0.26
Number of Subjects	640

Percentiles

Centimeters		Inches
91.70	**1st**	36.10
93.70	**2nd**	36.89
94.40	**3rd**	37.17
95.85	**5th**	37.74
97.90	**10th**	38.54
100.25	**15th**	39.47
101.45	**20th**	39.94
102.40	**25th**	40.31
103.20	**30th**	40.63
104.45	**35th**	41.12
105.30	**40th**	41.46
106.00	**45th**	41.73
106.70	**50th**	42.01
107.40	**55th**	42.28
108.25	**60th**	42.62
109.40	**65th**	43.07
110.40	**70th**	43.46
111.20	**75th**	43.78
112.75	**80th**	44.39
114.10	**85th**	44.92
116.15	**90th**	45.73
119.55	**95th**	47.07
120.90	**97th**	47.60
122.10	**98th**	48.07
125.70	**99th**	49.49

15. Bust/Chest Circumference

Description: Circumference of the torso measured at level of nipple.
Undrawn landmarks: For males, right and left thelion; for females, right and left bust-point.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Subject's feet are placed in footprints adhered to the standing surface.
Instrument: Steel tape measure

Note: Males are shirtless; females wear their usual brassiere under the measuring garment top.

The Summary Statistics
Chest Circumference, at Bust

Centimeters		Inches
102.87	**Mean**	40.50
0.29	**SE (mean)**	0.11
7.25	**St Dev**	2.85
86.70	**Minimum**	34.13
130.00	**Maximum**	51.18

Coeff. Of Variation	7.05
Symmetry – BETA I	0.46
Kurtosis – BETA II	0.43
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
88.40	**1st**	34.80
89.50	**2nd**	35.24
90.00	**3rd**	35.43
91.50	**5th**	36.02
93.80	**10th**	36.93
95.70	**15th**	37.68
97.00	**20th**	38.19
98.20	**25th**	38.66
99.00	**30th**	38.98
100.00	**35th**	39.37
100.75	**40th**	39.67
101.70	**45th**	40.04
102.50	**50th**	40.35
103.30	**55th**	40.67
103.95	**60th**	40.93
104.85	**65th**	41.28
105.80	**70th**	41.65
107.00	**75th**	42.13
108.70	**80th**	42.80
110.20	**85th**	43.39
112.50	**90th**	44.29
115.80	**95th**	45.59
117.40	**97th**	46.22
119.00	**98th**	46.85
123.60	**99th**	48.66

16. **<u>Under Bust Circumference</u>** (females only)

Description: Horizontal circumference of the torso is measured on female subjects just below the cups of the bra.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Subject's feet are placed in footprints adhered to the standing surface.
Instrument: Steel tape measure

Notes: Only 60 women

All the percentile charts are for males only.

17. **<u>Waist Circumference at Natural Indentation</u>** (ANSUR)

Description: The horizontal circumference of the waist at the level of the right and left natural indentations.

Drawn landmarks: Points of greatest indentation (or concavity) on the right and left sides of the subject.

Method: Participant is in the anthropometric standing position. Stand in front of the participant and use a steel tape to measure the horizontal distance around the torso at the level of the natural indentation. Exert only enough tension on the tape to maintain contact between the tape and the body. The measurement is made at the maximum point of quiet respiration.
Instrument: Steel tape measure

The Summary Statistics
Waist Circumference, Natural

Centimeters		Inches
87.88	**Mean**	34.60
0.31	**SE (mean)**	0.12
7.74	**St Dev**	3.05
68.30	**Minimum**	26.89
117.00	**Maximum**	46.06

Coeff. Of Variation	8.81
Symmetry – BETA I	0.40
Kurtosis – BETA II	0.06
Number of Subjects	640

Percentiles

Centimeters		Inches
72.90	**1st**	28.70
74.30	**2nd**	29.25
75.20	**3rd**	29.61
76.40	**5th**	30.08
78.30	**10th**	30.83
79.75	**15th**	31.40
80.95	**20th**	31.87
82.25	**25th**	32.38
83.20	**30th**	32.76
84.40	**35th**	33.23
85.25	**40th**	33.56
86.45	**45th**	34.04
87.35	**50th**	34.39
88.40	**55th**	34.80
89.50	**60th**	35.24
90.50	**65th**	35.63
91.70	**70th**	36.10
93.05	**75th**	36.63
94.25	**80th**	37.11
95.75	**85th**	37.70
98.30	**90th**	38.70
101.95	**95th**	40.14
103.00	**97th**	40.55
104.10	**98th**	40.98
106.60	**99th**	41.97

18. **<u>Waist Height at Natural Indentation</u>** (ANSUR)

Description: The vertical distance between a standing surface and the right natural indentation.

Drawn landmarks: Points of greatest indentation (or concavity) on the right and left sides of the subject's torso.

Method: Participant is in the anthropometric standing position. Stand in front of the participant and use an anthropometer to measure the vertical distance between the standing surface and the right natural indentation. The measurement is made at the maximum point of quiet respiration.

Instrument: Anthropometer

The Summary Statistics
Waist Height, Natural

Centimeters		Inches
114.47	**Mean**	45.07
0.19	**SE (mean)**	0.08
4.92	**St Dev**	1.94
97.50	**Minimum**	38.39
128.60	**Maximum**	50.63

Coeff. Of Variation	4.30
Symmetry – BETA I	-0.01
Kurtosis – BETA II	-0.03
Number of Subjects	640

Percentiles

Centimeters		Inches
103.20	**1st**	40.63
104.00	**2nd**	40.94
105.30	**3rd**	41.46
106.50	**5th**	41.93
108.40	**10th**	42.68
109.55	**15th**	43.13
110.40	**20th**	43.46
111.30	**25th**	43.82
111.70	**30th**	43.98
112.30	**35th**	44.21
113.00	**40th**	44.49
113.80	**45th**	44.80
114.40	**50th**	45.04
115.20	**55th**	45.35
115.70	**60th**	45.55
116.40	**65th**	45.83
117.20	**70th**	46.14
117.85	**75th**	46.40
118.60	**80th**	46.69
119.65	**85th**	47.11
120.90	**90th**	47.60
122.60	**95th**	48.27
124.10	**97th**	48.86
124.80	**98th**	49.13
125.40	**99th**	49.37

19. <u>Waist Circumference at Omphalion</u> (ANSURII)

Description: The horizontal circumference of the waist at the level of omphalion encompassing the waist (omphalion) landmark.
Undrawn Landmark: Omphalion

Method: Participant is in the anthropometric standing position. Stand in front of the participant and use a tape to measure the horizontal distance around the torso at the level of the center of the navel. Exert only enough tension on the tape to maintain contact between the tape and the body. The measurement is made at the maximum point of quiet respiration.
Instrument: Steel tape measure

The Summary Statistics
Waist Circumference, Omphalion

Centimeters		Inches
91.66	**Mean**	36.09
0.33	**SE (mean)**	0.13
8.43	**St Dev**	3.32
72.60	**Minimum**	28.58
121.60	**Maximum**	47.87

Coeff. Of Variation	9.19
Symmetry – BETA I	0.33
Kurtosis – BETA II	-0.09
Number of Subjects	640

Percentiles

Centimeters		Inches
75.30	**1st**	29.65
76.00	**2nd**	29.92
77.30	**3rd**	30.43
78.50	**5th**	30.91
81.25	**10th**	31.99
83.00	**15th**	32.68
84.15	**20th**	33.13
85.25	**25th**	33.56
86.80	**30th**	34.17
87.80	**35th**	34.57
89.10	**40th**	35.08
90.20	**45th**	35.51
91.35	**50th**	35.96
92.20	**55th**	36.30
93.30	**60th**	36.73
94.50	**65th**	37.20
95.85	**70th**	37.74
97.40	**75th**	38.35
99.00	**80th**	39.98
100.60	**85th**	39.61
103.20	**90th**	40.63
106.35	**95th**	41.87
107.50	**97th**	42.32
109.60	**98th**	43.15
111.20	**99th**	43.78

20. <u>Waist Height at Omphalion</u> (ANSURII)

Description: The vertical distance between a standing surface and omphalion.
Undrawn Landmark: Omphalion

Method: Participant is in the anthropometric standing position. Stand in front of the participant and use an anthropometer to measure the vertical distance between the standing surface and the center of the navel. The measurement is made at the maximum point of quiet respiration.
Instrument: Anthropometer

The Summary Statistics
Waist Height, Omphalion

Centimeters		Inches
107.88	**Mean**	42.47
0.19	**SE (mean)**	0.08
4.83	**St Dev**	1.90
93.30	**Minimum**	36.73
121.80	**Maximum**	47.95

Coeff. Of Variation	4.48
Symmetry – BETA I	0.02
Kurtosis – BETA II	0.01
Number of Subjects	640

Percentiles

Centimeters		Inches
97.10	**1st**	38.23
97.70	**2nd**	38.46
98.80	**3rd**	38.90
99.90	**5th**	39.33
102.00	**10th**	40.16
103.00	**15th**	40.55
103.95	**20th**	40.925
104.60	**25th**	41.18
105.35	**30th**	41.48
106.10	**35th**	41.77
106.70	**40th**	42.01
107.20	**45th**	42.20
107.70	**50th**	42.40
108.50	**55th**	42.72
109.00	**60th**	42.91
109.75	**65th**	43.21
110.30	**70th**	43.43
111.10	**75th**	43.74
112.00	**80th**	44.09
112.75	**85th**	44.39
114.15	**90th**	44.94
115.80	**95th**	45.59
117.70	**97th**	46.34
118.50	**98th**	46.65
119.10	**99th**	46.89

21. Waist Circumference, Preferred

Description: Maximum circumference of the waist at the subject's "preferred" waist level.
Drawn Landmarks: Anterior (front) preferred waist, Lateral (right) preferred waist and Posterior (back) preferred waist.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. The subject's feet are placed in footprints adhered to the standing surface. The subject's preferred waist level is determine by the subject using an elastic band. The anterior and posterior preferred waist landmarks are marked in the mid-sagittal plane under the band

Instrument: Steel tape measure

NOTE: Preferred waist level is established by the subject, who places an elastic band at the level they would prefer to wear the waist of their pants.

The Summary Statistics
Waist Circumference, Preferred

Centimeters		Inches
89.86	**Mean**	35.38
0.28	**SE (mean)**	0.11
7.15	**St Dev**	2.81
71.60	**Minimum**	28.19
119.40	**Maximum**	47.01

Coeff. Of Variation	7.96
Symmetry – BETA I	0.32
Kurtosis – BETA II	0.40
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
74.40	**1st**	29.29
76.20	**2nd**	30.00
76.90	**3rd**	30.28
79.05	**5th**	31.12
80.80	**10th**	31.81
82.50	**15th**	32.48
83.60	**20th**	32.91
84.75	**25th**	33.37
85.95	**30th**	33.84
87.20	**35th**	34.33
87.95	**40th**	34.63
88.65	**45th**	34.90
89.50	**50th**	35.24
90.40	**55th**	35.59
91.20	**60th**	35.91
92.30	**65th**	36.34
93.50	**70th**	36.81
94.50	**75th**	37.20
95.80	**80th**	37.72
97.10	**85th**	38.23
99.10	**90th**	39.02
102.15	**95th**	40.22
104.10	**97th**	40.98
104.90	**98th**	41.30
105.70	**99th**	41.61

22. Waist Height, Preferred

Description: Vertical distance from the standing surface to the level of the preferred waist.

Drawn Landmarks: Lateral (right) preferred waist

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Subject's feet are placed in footprints adhered to the standing surface. Distance is measured on subject's right side, from the standing surface to right preferred waist landmark.
Instrument: Anthropometer

NOTE: Preferred waist level is established by the subject, who places and elastic band at the level he or she would prefer to wear the waist of their pants.

The Summary Statistics
Waist Height, Preferred

Centimeters		Inches
103.33	**Mean**	40.68
0.19	**SE (mean)**	0.07
4.75	**St Dev**	1.87
89.40	**Minimum**	35.20
118.60	**Maximum**	46.69

Coeff. Of Variation	4.60
Symmetry – BETA I	0.00
Kurtosis – BETA II	-0.22
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
92.60	**1st**	36.46
93.50	**2nd**	36.81
94.50	**3rd**	37.20
95.50	**5th**	37.60
97.00	**10th**	38.19
98.15	**15th**	38.64
99.20	**20th**	39.06
100.05	**25th**	39.39
100.80	**30th**	39.69
101.50	**35th**	39.96
102.15	**40th**	40.22
102.75	**45th**	40.45
103.30	**50th**	40.67
103.80	**55th**	40.87
104.60	**60th**	41.18
105.30	**65th**	41.46
106.00	**70th**	41.73
106.70	**75th**	42.01
107.50	**80th**	42.32
108.30	**85th**	42.64
109.35	**90th**	43.05
111.30	**95th**	43.82
112.30	**97th**	44.21
112.90	**98th**	44.45
114.20	**99th**	44.96

23. Suprasternale to Anterior Waist Preferred

Description: The vertical distance from the anterior preferred waist to suprasternale.

Drawn Landmarks: Suprasternale and Anterior preferred waist

Method: The subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. The subject's feet are placed in footprints adhered to the standing surface. The subject's preferred waist level is determined by the subject using an elastic band. Measure the surface distance from suprasternale to the drawn landmark in the mid-sagittal plane.

Instrument: Steel tape measure

The Summary Statistics
Waist Front Length

Centimeters		Inches
46.39	**Mean**	18.27
0.13	**SE (mean)**	0.05
3.26	**St Dev**	1.280
37.60	**Minimum**	14.80
56.70	**Maximum**	22.32

Coeff. Of Variation	7.02
Symmetry – BETA I	0.29
Kurtosis – BETA II	0.06
Number of Subjects	640

Percentiles

Centimeters		Inches
39.30	**1st**	15.47
40.20	**2nd**	15.83
40.60	**3rd**	15.98
41.40	**5th**	16.30
42.40	**10th**	16.69
43.00	**15th**	16.93
43.65	**20th**	17.19
44.10	**25th**	17.36
44.50	**30th**	17.52
45.00	**35th**	17.72
45.50	**40th**	17.91
45.90	**45th**	18.07
46.20	**50th**	18.19
46.70	**55th**	18.39
47.00	**60th**	18.50
47.50	**65th**	18.70
48.00	**70th**	18.90
48.50	**75th**	19.09
49.00	**80th**	19.29
49.80	**85th**	19.61
50.50	**90th**	19.88
52.20	**95th**	20.55
53.10	**97th**	20.91
54.00	**98th**	21.26
55.00	**99th**	21.65

24. <u>Anterior to Posterior Waist Preferred</u> (i.e. total crotch length)

Description: The distance between the anterior to posterior preferred waist landmarks.
Drawn landmarks: Anterior and Posterior preferred landmarks in the mid-sagittal plane

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Subject's feet are placed in footprints adhered to the standing surface. An elastic band is used to mark the anterior and posterior preferred waist landmarks. Anterior preferred waist is a point on the subject's abdomen at the level of preferred waist in the mid-sagittal plane. Measurement is taken from the anterior preferred waist through the crotch to the posterior preferred waist landmark.
Instrument: Steel tape measure

The Summary Statistics
Total Crotch Length

Centimeters		Inches
63.98	**Mean**	25.19
0.17	**SE (mean)**	0.07
4.24	**St Dev**	1.67
51.00	**Minimum**	20.08
81.50	**Maximum**	32.09

Coeff. Of Variation	6.62
Symmetry – BETA I	0.09
Kurtosis – BETA II	0.33
Number of Subjects	640

Percentiles

Centimeters		Inches
54.10	**1st**	21.30
55.60	**2nd**	21.89
56.20	**3rd**	22.13
56.95	**5th**	22.42
58.80	**10th**	23.15
59.80	**15th**	23.54
60.45	**20th**	23.80
61.20	**25th**	24.09
61.90	**30th**	24.37
62.40	**35th**	24.57
62.80	**40th**	24.72
63.40	**45th**	24.96
63.85	**50th**	25.14
64.40	**55th**	25.35
64.90	**60th**	25.55
65.60	**65th**	25.83
66.20	**70th**	26.06
66.80	**75th**	26.30
67.60	**80th**	26.61
68.50	**85th**	26.97
69.35	**90th**	27.30
70.80	**95th**	27.87
71.50	**97th**	28.15
73.10	**98th**	28.78
74.50	**99th**	29.33

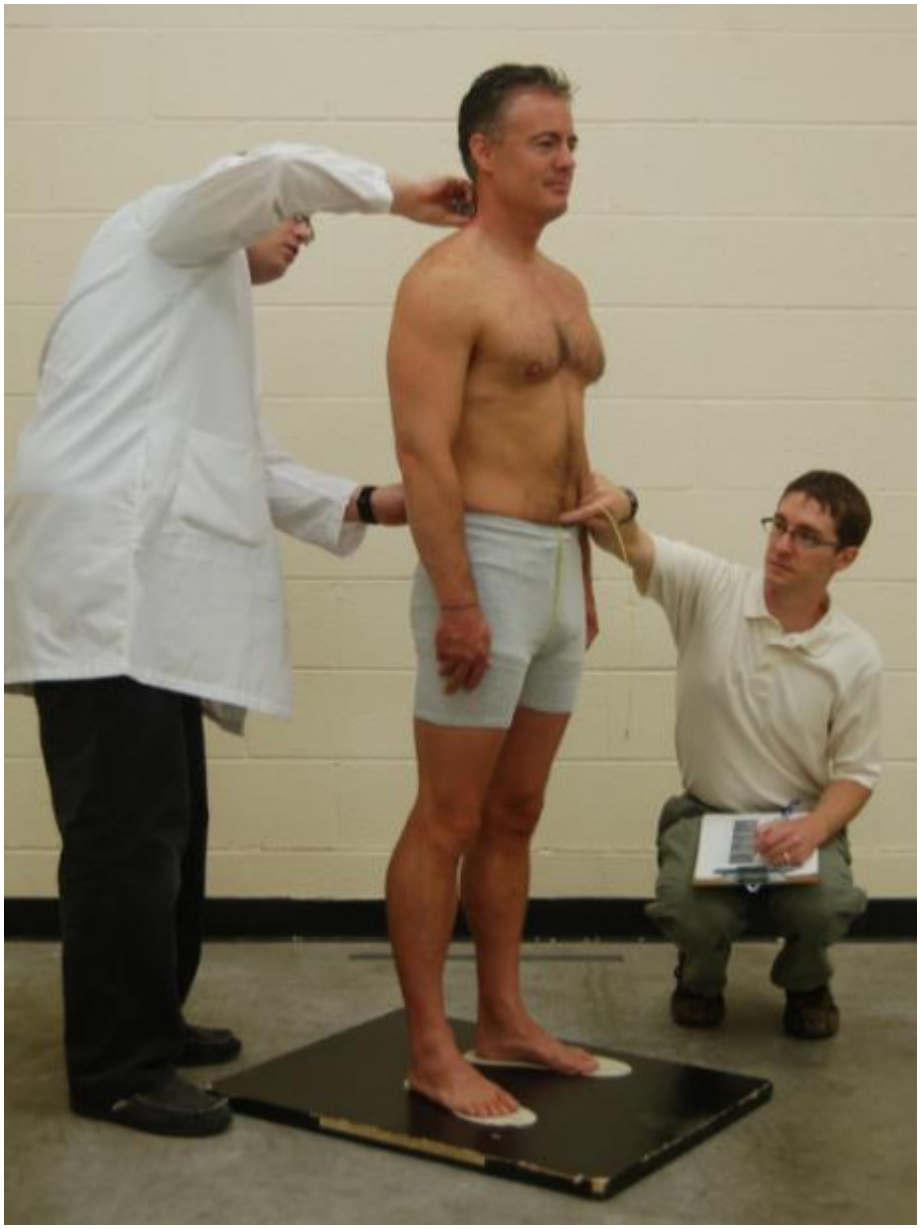
25. Posterior Waist Preferred to Cervicale

Description: The vertical distance from the posterior preferred waist landmark to cervicale.

Drawn Landmarks: Posterior preferred waist and cervicale

Method: The subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. The subject's feet are placed in footprints adhered to the standing surface. The subject's preferred waist level is determined by the subject using an elastic band. Measure the surface distance from cervicale to the drawn landmark in the mid-sagittal plane.

Instrument: Steel tape measure



The Summary Statistics
Waist Back Length

Centimeters		Inches
50.20	**Mean**	19.76
0.12	**SE (mean)**	0.05
3.11	**St Dev**	1.22
40.00	**Minimum**	15.75
60.60	**Maximum**	23.86

Coeff. Of Variation	6.19
Symmetry – BETA I	0.18
Kurtosis – BETA II	0.33
Number of Subjects	640

Centimeters	Percentiles	Inches
42.90	**1st**	16.89
44.00	**2nd**	17.32
44.70	**3rd**	17.60
45.25	**5th**	17.82
46.20	**10th**	18.19
46.90	**15th**	18.46
47.60	**20th**	18.74
48.00	**25th**	18.90
48.50	**30th**	19.09
49.00	**35th**	19.29
49.40	**40th**	19.45
49.80	**45th**	19.61
50.20	**50th**	19.76
50.60	**55th**	19.92
50.95	**60th**	20.06
51.40	**65th**	20.24
51.80	**70th**	20.39
52.30	**75th**	20.59
52.60	**80th**	20.71
53.25	**85th**	20.96
54.05	**90th**	21.28
55.10	**95th**	21.69
56.30	**97th**	22.17
57.40	**98th**	22.60
58.30	**99th**	22.95

26. Vertical Trunk Circumference

Description: Vertical circumference of the torso is measured from the right shoulder, through the crotch, and back to the right shoulder.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Subject's feet are placed in footprints adhered to the standing surface. Distance measured from a point on the right shoulder midway between the neck base and the acromion, down the back, through the crotch, across the right bust point or thelion landmark, to the starting point.
Instrument: Steel tape measure

NOTE: Care must be taken to avoid constriction in the crotch; and the steel tape may span the back (*i.e. the tape is not resting exactly on the skin*).

The Summary Statistics
Vertical Trunk Circumference

Centimeters		Inches
170.92	**Mean**	67.29
0.31	**SE (mean)**	0.12
7.73	**St Dev**	3.04
149.50	**Minimum**	58.86
196.00	**Maximum**	77.17

Coeff. Of Variation	4.52
Symmetry – BETA I	0.28
Kurtosis – BETA II	0.19
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
154.60	**1st**	60.87
156.30	**2nd**	61.54
157.70	**3rd**	62.09
158.60	**5th**	62.44
161.25	**10th**	63.48
162.80	**15th**	64.09
164.40	**20th**	64.72
165.50	**25th**	65.16
166.80	**30th**	65.67
167.70	**35th**	66.02
169.00	**40th**	66.54
169.90	**45th**	66.89
170.70	**50th**	67.20
171.65	**55th**	67.58
172.30	**60th**	67.83
173.45	**65th**	68.29
174.70	**70th**	68.78
175.90	**75th**	69.25
177.20	**80th**	69.76
178.65	**85th**	70.33
180.90	**90th**	71.22
183.60	**95th**	72.28
185.60	**97th**	73.07
187.60	**98th**	73.86
192.40	**99th**	75.75

27. <u>Buttock Circumference</u> (ANSURII)

Description: The horizontal circumference of the trunk at the level of the maximum protrusion of the right buttock.
Undrawn landmark: Buttock point

Method: Participant stands erect with the feet placed in footprints adhered to the standing surface. Stand at the participant's right and use a tape to measure the horizontal circumference of the trunk at the level of the maximum protrusion of the right buttock. If necessary, ask male participants to adjust their genitalia so as to not interfere with the tape. Exert only enough tension on the tape to maintain contact between the tape and the skin.
Instrument: Steel tape measure

The Summary Statistics
Buttock Circumference

Centimeters		Inches
102.80	**Mean**	40.47
0.24	**SE (mean)**	0.10
6.13	**St Dev**	2.41
87.00	**Minimum**	34.25
129.90	**Maximum**	51.14

Coeff. Of Variation	5.97
Symmetry – BETA I	0.28
Kurtosis – BETA II	0.48
Number of Subjects	640

Percentiles

Centimeters		Inches
89.50	**1st**	35.24
90.90	**2nd**	35.79
91.90	**3rd**	36.18
93.00	**5th**	36.61
94.85	**10th**	37.34
96.30	**15th**	37.91
97.35	**20th**	38.33
98.60	**25th**	38.82
99.55	**30th**	39.19
100.50	**35th**	39.57
101.25	**40th**	39.86
102.15	**45th**	40.22
102.70	**50th**	40.43
103.60	**55th**	40.79
104.20	**60th**	41.02
105.15	**65th**	41.40
105.80	**70th**	41.65
106.70	**75th**	42.01
107.50	**80th**	42.32
108.65	**85th**	42.78
110.10	**90th**	43.35
113.20	**95th**	44.57
114.80	**97th**	45.20
116.20	**98th**	45.75
119.00	**99th**	46.85

28. <u>Buttock Circumference Height</u> (ANSURII)

Description: Vertical distance from the standing surface to the level of the maximum Buttock Circumference.

Method: Subject stands erect, looking straight ahead with the weight distributed equally on both feet. Subject's feet are placed in footprints adhered to the standing surface. Height is measured to the level of the maximum Buttock Circumference in the right mid-lateral line.
Instrument: Steel tape measure

The Summary Statistics
Buttock Circumference Height

Centimeters		Inches
91.61	**Mean**	36.07
0.17	**SE (mean)**	0.67
4.29	**St Dev**	1.69
79.00	**Minimum**	31.10
103.10	**Maximum**	40.59

Coeff. Of Variation	4.69
Symmetry – BETA I	0.00
Kurtosis – BETA II	-0.14
Number of Subjects	639

Percentiles

Centimeters		Inches
81.80	**1st**	32.20
82.50	**2nd**	32.48
83.40	**3rd**	32.83
84.40	**5th**	33.23
86.00	**10th**	33.86
87.20	**15th**	34.33
88.10	**20th**	34.69
88.80	**25th**	34.96
89.50	**30th**	35.24
90.00	**35th**	35.43
90.40	**40th**	35.59
90.90	**45th**	35.79
91.50	**50th**	36.02
92.30	**55th**	36.34
92.70	**60th**	36.50
93.20	**65th**	36.69
93.80	**70th**	36.93
94.50	**75th**	37.20
95.20	**80th**	37.48
96.00	**85th**	37.80
97.20	**90th**	38.27
99.00	**95th**	38.98
99.70	**97th**	39.25
100.00	**98th**	39.37
101.80	**99th**	40.08

29. Hip Circumference, Maximum

Description: Maximum hip circumference is measured parallel to the standing surface.

Method: Subject stands erect, looking straight ahead. Subject's feet are placed in footprints adhered to the standing surface.

Instrument: Steel tape measure

***Note**: Measurer and Recorder take this measurement as a team. The tape is placed around the subject's torso approximately 2 cm above the maximum protrusion of the buttocks* (*visual inspection will often suggest the approximate area of the maximum circumference*). *The measurer and recorder use each other to establish that the plane of the tape is horizontal at all times. The tape is moved down from the starting point at approximately 1 cm intervals as directed by the measurer, who reads the tape and tracks each measurement until the maximum circumference is located.*

In some cases, the maximum circumference will occur over a fairly broad area of the torso. In such cases, the level is defined as the midpoint of the area at which the maximum circumference occurs.

The Summary Statistics
Hip Circumference, Max

Centimeters		Inches
104.16	**Mean**	41.01
0.24	**SE (mean)**	0.10
6.12	**St Dev**	2.41
87.80	**Minimum**	34.57
131.10	**Maximum**	51.61

Coeff. Of Variation	5.87
Symmetry – BETA I	0.24
Kurtosis – BETA II	0.48
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
90.50	**1st**	35.63
91.70	**2nd**	36.10
93.20	**3rd**	36.69
94.40	**5th**	37.17
96.45	**10th**	37.97
97.70	**15th**	38.46
98.70	**20th**	38.86
99.95	**25th**	39.35
101.00	**30th**	39.76
101.80	**35th**	40.08
102.80	**40th**	40.47
103.55	**45th**	40.77
104.30	**50th**	41.06
105.00	**55th**	41.34
105.60	**60th**	41.57
106.60	**65th**	41.97
107.30	**70th**	42.24
108.00	**75th**	42.52
108.80	**80th**	42.83
109.80	**85th**	43.23
111.65	**90th**	43.96
114.65	**95th**	45.14
116.20	**97th**	45.75
117.70	**98th**	46.34
119.50	**99th**	47.05

30. Hip Circumference Height

Description: Vertical distance from the standing surface to the level of the maximum Hip Circumference.

Method: Subject stands erect, looking straight ahead with the weight distributed equally on both feet. Subject's feet are placed in footprints adhered to the standing surface. Height is measured to the level of the maximum hip circumference in the right mid-lateral line.

Instrument: Anthropometer

Note: *The height of this circumference is taken in conjunction with the hip circumference measure, and is measured at this time, before the tape is removed.*

The Summary Statistics
Hip Circumference Max Height

Centimeters		Inches
88.51	**Mean**	34.85
0.17	**SE (mean)**	0.07
4.26	**St Dev**	1.68
76.90	**Minimum**	30.28
102.40	**Maximum**	40.31

Coeff. Of Variation	4.81
Symmetry – BETA I	0.01
Kurtosis – BETA II	-0.27
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
78.90	**1st**	31.06
79.50	**2nd**	31.30
80.60	**3rd**	31.73
81.50	**5th**	32.09
83.00	**10th**	32.68
84.00	**15th**	33.07
84.80	**20th**	33.39
85.50	**25th**	33.66
86.10	**30th**	33.90
86.70	**35th**	34.13
87.50	**40th**	34.45
88.00	**45th**	34.65
88.65	**50th**	34.90
89.10	**55th**	35.08
89.50	**60th**	35.24
90.15	**65th**	35.49
90.70	**70th**	35.71
91.40	**75th**	35.98
92.10	**80th**	36.26
92.95	**85th**	36.59
94.20	**90th**	37.09
95.70	**95th**	37.68
96.40	**97th**	37.95
97.10	**98th**	38.23
97.60	**99th**	38.43

31. Thigh Circumference Maximum

Description: Maximum circumference of the thigh.

Method: Subject stands fully erect with the weight distributed equally on both feet and the arms hanging freely downwards. Maximum is established by placing the tape measure around the thigh at its proximal end (at the thigh/buttock juncture) and moving the tape measure down the thigh in one-centimeter increments until the maximum circumference is reached.

Instrument: Steel tape measure

Note: *Maximum circumference is not necessarily located immediately below the gluteal furrow (at the thigh/buttock juncture).*

The Summary Statistics
Thigh Circumference, Max

Centimeters		Inches
62.02	**Mean**	24.42
0.17	**SE (mean)**	0.07
4.42	**St Dev**	1.74
50.80	**Minimum**	20.00
76.80	**Maximum**	30.24

Coeff. Of Variation	7.12
Symmetry – BETA I	0.145
Kurtosis – BETA II	0.04
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
52.30	**1st**	20.59
52.90	**2nd**	20.83
53.80	**3rd**	21.18
54.75	**5th**	21.56
56.50	**10th**	22.24
57.40	**15th**	22.60
58.20	**20th**	22.91
58.90	**25th**	23.19
59.70	**30th**	23.50
60.20	**35th**	23.70
60.80	**40th**	23.94
61.50	**45th**	24.21
62.05	**50th**	24.43
62.80	**55th**	24.72
63.20	**60th**	24.88
63.70	**65th**	25.08
64.30	**70th**	25.31
64.90	**75th**	25.55
65.60	**80th**	25.83
66.55	**85th**	26.20
67.30	**90th**	26.50
69.20	**95th**	27.24
70.80	**97th**	27.87
72.20	**98th**	28.43
73.30	**99th**	28.86

32. <u>Knee Circumference</u> (i.e. Lower Thigh Circumference, ANSURII)

Description: The horizontal circumference of the right thigh at the level of the suprapatella landmark.
Drawn Landmark: Suprapatella, right

Method: Participant stands erect with the feet about 10 cm apart and the weight distributed equally on both feet. Stand at the right of the participant and use a tape to measure the horizontal circumference of the thigh at the level of the suprapatella landmark at the top of the knee. The bottom of the tape follows the top of the landmark. Exert only enough tension on the tape to maintain contact between the tape and the skin.
Instrument: Steel tape measure

The Summary Statistics
Knee Circumference, Lower Thigh

Centimeters		Inches
40.39	**Mean**	15.90
0.11	**SE (mean)**	0.04
2.33	**St Dev**	0.92
34.20	**Minimum**	13.46
48.10	**Maximum**	18.94

Coeff. Of Variation	5.78
Symmetry – BETA I	0.11
Kurtosis – BETA II	-0.21
Number of Subjects	430

Percentiles

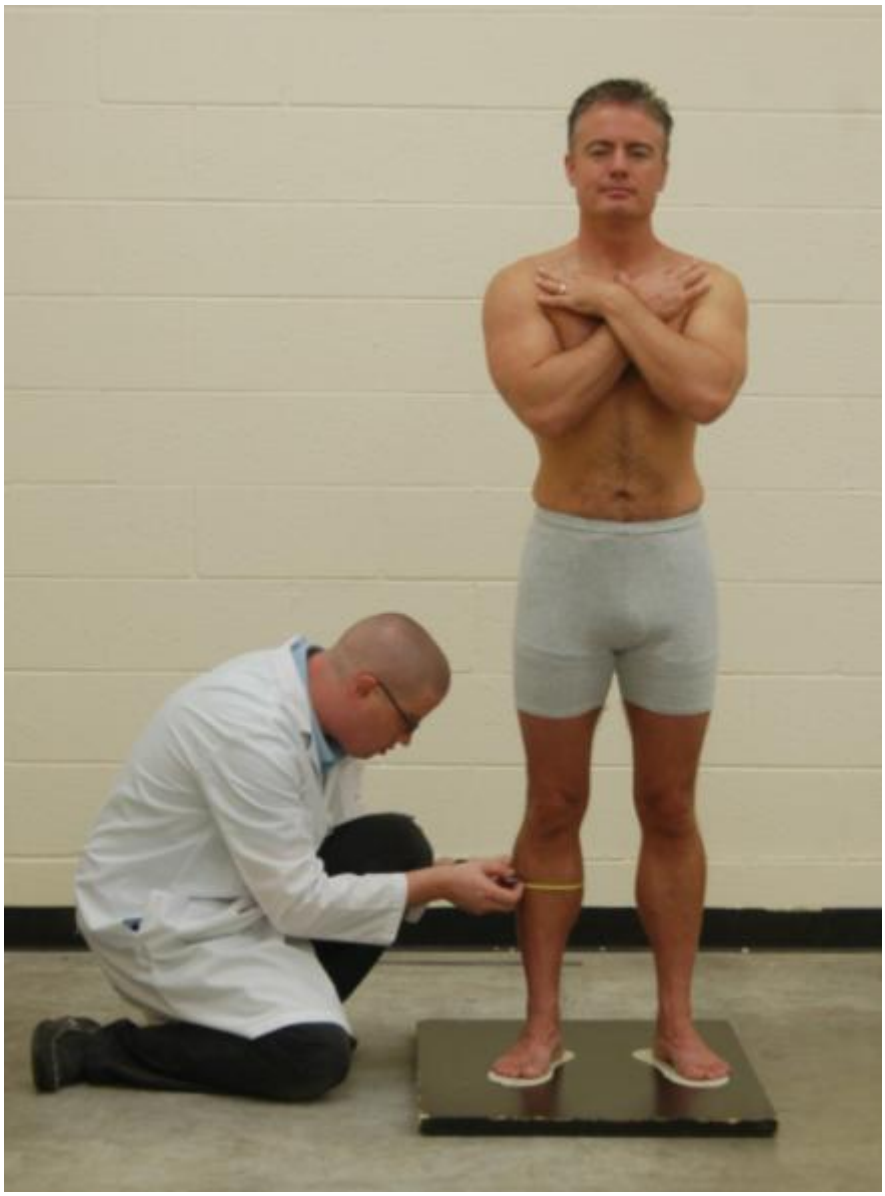
Centimeters		Inches
35.60	**1st**	14.02
36.00	**2nd**	14.17
36.30	**3rd**	14.29
36.60	**5th**	14.41
37.20	**10th**	14.65
38.00	**15th**	14.96
38.30	**20th**	15.08
38.70	**25th**	15.24
39.05	**30th**	15.37
39.50	**35th**	15.55
39.80	**40th**	15.67
40.10	**45th**	15.79
40.50	**50th**	15.94
40.80	**55th**	16.06
41.00	**60th**	16.14
41.30	**65th**	16.26
41.50	**70th**	16.34
41.80	**75th**	16.46
42.35	**80th**	16.67
42.90	**85th**	16.89
43.40	**90th**	17.09
44.20	**95th**	17.40
44.90	**97th**	17.68
45.20	**98th**	17.80
45.80	**99th**	18.03

33. <u>Calf Circumference</u> (ANSURII)

Description: The maximum horizontal circumference of the right calf

Method: Participant stands erect with the feet about 10 cm apart and the weight distributed equally on both feet. Stand at the right of the participant. With a tape held in the horizontal plane measure the maximum circumference of the calf. Exert only enough tension on the tape to maintain contact between the tape and the skin.
Instrument: Steel tape measure

Note: *The tape is placed around the subject's calf at the approximate location of the maximum circumference based on visual inspection. The measurer and recorder use each other to establish that the plane of the tape is horizontal at all times. The tape is moved up and down from the starting point until the maximum value is determined.*



The Summary Statistics
Calf Circumference

Centimeters		Inches
38.58	**Mean**	15.19
0.10	**SE (mean)**	0.04
2.45	**St Dev**	0.96
31.70	**Minimum**	12.48
46.80	**Maximum**	18.43

Coeff. Of Variation	6.34
Symmetry – BETA I	0.31
Kurtosis – BETA II	0.39
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
33.40	**1st**	13.15
33.90	**2nd**	13.35
34.20	**3rd**	13.46
34.70	**5th**	13.66
35.60	**10th**	14.02
36.10	**15th**	14.21
36.50	**20th**	14.37
36.95	**25th**	14.55
37.30	**30th**	14.69
37.60	**35th**	14.80
37.90	**40th**	14.92
38.20	**45th**	15.04
38.60	**50th**	15.20
38.80	**55th**	15.28
39.20	**60th**	15.43
39.40	**65th**	15.51
39.70	**70th**	15.63
40.10	**75th**	15.79
40.50	**80th**	15.94
41.10	**85th**	16.18
41.70	**90th**	16.42
42.70	**95th**	16.81
43.70	**97th**	17.20
44.20	**98th**	17.40
45.40	**99th**	17.87

34. Ankle Circumference

Description: Circumference of the ankle measured across the lateral and medial malleoli

Drawn landmarks: Lateral malleolus (distal fibular protrusion) and Medial malleolus (distal tibial protrusion), right

Method: Subject stands erect with the weight distributed equally on both feet.
Instrument: Steel tape measure

The Summary Statistics
Ankle Circumference

Centimeters		Inches
26.91	**Mean**	10.60
0.05	**SE (mean)**	0.02
1.23	**St Dev**	0.48
22.80	**Minimum**	8.98
30.60	**Maximum**	12.05

Coeff. Of Variation	4.57
Symmetry – BETA I	0.48
Kurtosis – BETA II	0.29
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
24.10	**1st**	9.49
24.50	**2nd**	9.65
24.80	**3rd**	9.76
25.00	**5th**	9.84
25.40	**10th**	10.00
25.60	**15th**	10.08
25.90	**20th**	10.20
26.10	**25th**	10.28
26.30	**30th**	10.35
26.50	**35th**	10.43
26.60	**40th**	10.47
26.70	**45th**	10.51
26.90	**50th**	10.59
27.05	**55th**	10.65
27.20	**60th**	10.71
27.30	**65th**	10.75
27.50	**70th**	10.83
27.70	**75th**	10.91
27.90	**80th**	10.98
28.20	**85th**	11.10
28.50	**90th**	11.22
29.00	**95th**	11.42
29.40	**97th**	44.57
29.60	**98th**	11.65
30.20	**99th**	11.89

35. Foot Length

Description: Maximum distance from the rear of the heel to the tip the longest (first or second) toe, measured parallel to the long axis of the foot.

Undrawn landmarks: Acropodion (tip of first or second toe, which is greater) and Pternion (most posterior point of heel), right

Method: Subject stands with weight equally distributed on both feet.

Instrument: Beam caliper

The Summary Statistics
Foot Length

Centimeters		Inches
26.93	**Mean**	10.60
0.05	**SE (mean)**	0.02
1.28	**St Dev**	0.50
23.40	**Minimum**	9.21
30.50	**Maximum**	12.01

Coeff. Of Variation	4.74
Symmetry – BETA I	0.15
Kurtosis – BETA II	-0.27
Number of Subjects	640

Percentiles

Centimeters		Inches
24.30	**1st**	6.57
24.50	**2nd**	9.65
24.80	**3rd**	9.76
24.90	**5th**	9.80
25.30	**10th**	9.96
25.50	**15th**	10.04
25.80	**20th**	10.16
26.00	**25th**	10.24
26.20	**30th**	10.31
26.40	**35th**	10.39
26.55	**40th**	10.45
26.70	**45th**	10.51
26.90	**50th**	10.59
27.10	**55th**	10.67
27.30	**60th**	10.75
27.40	**65th**	10.79
27.70	**70th**	10.91
27.80	**75th**	10.94
28.00	**80th**	11.02
28.20	**85th**	11.10
28.60	**90th**	11.26
29.00	**95th**	11.42
29.30	**97th**	11.54
29.70	**98th**	11.69
30.20	**99th**	11.89

36. Shoulder (Bideltoid) Breadth

Description: Distance across the maximum protrusions of the right and left deltoid muscles.

Method: Subjects stands fully erect with shoulders relaxed.

Instrument: Beam caliper

The Summary Statistics
Bideltoid Breadth

Centimeters		Inches
49.37	**Mean**	19.44
0.10	**SE (mean)**	0.04
2.58	**St Dev**	1.02
42.00	**Minimum**	16.54
58.20	**Maximum**	22.91

Coeff. Of Variation	5.23
Symmetry – BETA I	0.35
Kurtosis – BETA II	0.13
Number of Subjects	640

Percentiles

Centimeters		Inches
44.20	**1st**	17.40
44.80	**2nd**	17.64
45.10	**3rd**	17.76
45.40	**5th**	17.87
46.15	**10th**	18.17
46.55	**15th**	18.33
47.10	**20th**	18.54
47.60	**25th**	18.74
47.95	**30th**	18.88
48.30	**35th**	19.02
48.60	**40th**	19.13
48.90	**45th**	19.25
49.15	**50th**	19.35
49.60	**55th**	19.53
49.85	**60th**	19.63
50.30	**65th**	19.80
50.70	**70th**	19.96
51.00	**75th**	20.08
51.60	**80th**	20.31
52.00	**85th**	20.47
52.60	**90th**	20.71
53.90	**95th**	21.22
54.40	**97th**	21.42
55.10	**98th**	21.69
56.20	**99th**	22.13

Seated Measurements: Have the subject sit on the table with their feet on the block; check for 90° on the legs; add/remove blocks as needed. Have the subject sit up nice and tall (but shoulders relaxed) and looking straight ahead; check Frankfurt plane, instructing subject to move chin up or down, place left hand on back, right hand on right shoulder to make sure the subject not slouching.

37. Sitting Height

Description: Vertical distance from a horizontal sitting surface to the highest point of the head (vertex).
Method: Subject sits erect on a flat surface, looking straight ahead. Knees are bent at right angles and the feet are supported. Thighs are parallel to each other, the feet are in line with the thighs, and the knees are bent 90º. Upper arms hang freely downwards and forearms are horizontal.

Instrument: Anthropometer

The Summary Statistics
Sitting Height

Centimeters		Inches
93.74	**Mean**	39.91
0.13	**SE (mean)**	0.05
3.32	**St Dev**	1.31
84.40	**Minimum**	33.23
104.00	**Maximum**	40.94

Coeff. Of Variation	3.54
Symmetry – BETA I	0.08
Kurtosis – BETA II	0.03
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
86.00	**1st**	33.86
87.20	**2nd**	34.33
87.50	**3rd**	34.45
88.10	**5th**	34.69
89.55	**10th**	35.26
90.30	**15th**	35.55
90.90	**20th**	35.79
91.60	**25th**	36.06
91.90	**30th**	36.18
92.40	**35th**	36.38
92.90	**40th**	36.57
93.30	**45th**	36.73
93.90	**50th**	36.97
94.10	**55th**	37.05
94.50	**60th**	37.20
94.90	**65th**	37.36
95.40	**70th**	37.56
95.90	**75th**	37.76
96.50	**80th**	37.99
97.20	**85th**	38.27
97.80	**90th**	38.50
99.35	**95th**	39.11
100.20	**97th**	39.45
101.10	**98th**	39.80
101.70	**99th**	40.04

38. Eye Height

Description: Vertical distance from a horizontal sitting surface to the outer corner of the eye.
Undrawn landmark: Ectocanthus, right

Method: Subject sits erect on a flat surface, looking straight ahead. Knees are bent at right angles and feet are supported. Thighs are parallel to each other, feet are in line with the thighs, and knees are bent 90 degrees. Upper arms hang freely downwards and forearms are horizontal.

Instrument: Anthropometer

The Summary Statistics
Eye Height, Sitting

Centimeters		Inches
82.28	**Mean**	32.39
0.12	**SE (mean)**	0.05
3.10	**St Dev**	1.22
73.60	**Minimum**	28.98
91.40	**Maximum**	35.98

Coeff. Of Variation	3.77
Symmetry – BETA I	0.06
Kurtosis – BETA II	-0.03
Number of Subjects	640

	Percentiles	
Centimeters		Inches
75.10	**1st**	29.57
75.80	**2nd**	29.84
76.90	**3rd**	30.28
77.30	**5th**	30.43
78.35	**10th**	30.85
79.10	**15th**	31.14
79.70	**20th**	31.38
80.10	**25th**	31.54
80.60	**30th**	31.73
81.00	**35th**	31.89
81.50	**40th**	32.09
81.90	**45th**	32.24
82.30	**50th**	32.40
82.70	**55th**	32.56
83.05	**60th**	32.70
83.50	**65th**	32.87
83.80	**70th**	32.99
84.30	**75th**	33.19
84.90	**80th**	33.43
85.45	**85th**	33.64
86.25	**90th**	33.96
87.50	**95th**	34.45
88.10	**97th**	34.69
88.60	**98th**	34.88
89.80	**99th**	35.35

39. Acromial Height

Description: Vertical distance from a horizontal sitting surface to acromion.
Landmark: Acromion, right

Method: Subject sits erect on a flat surface, looking straight ahead. Knees are bent at right angles and the feet are supported. Thighs are parallel to each other, the feet are in line with the thighs, and the knees are bent 90 degrees.

Instrument: Anthropometer

The Summary Statistics
Acromial Height, Sitting

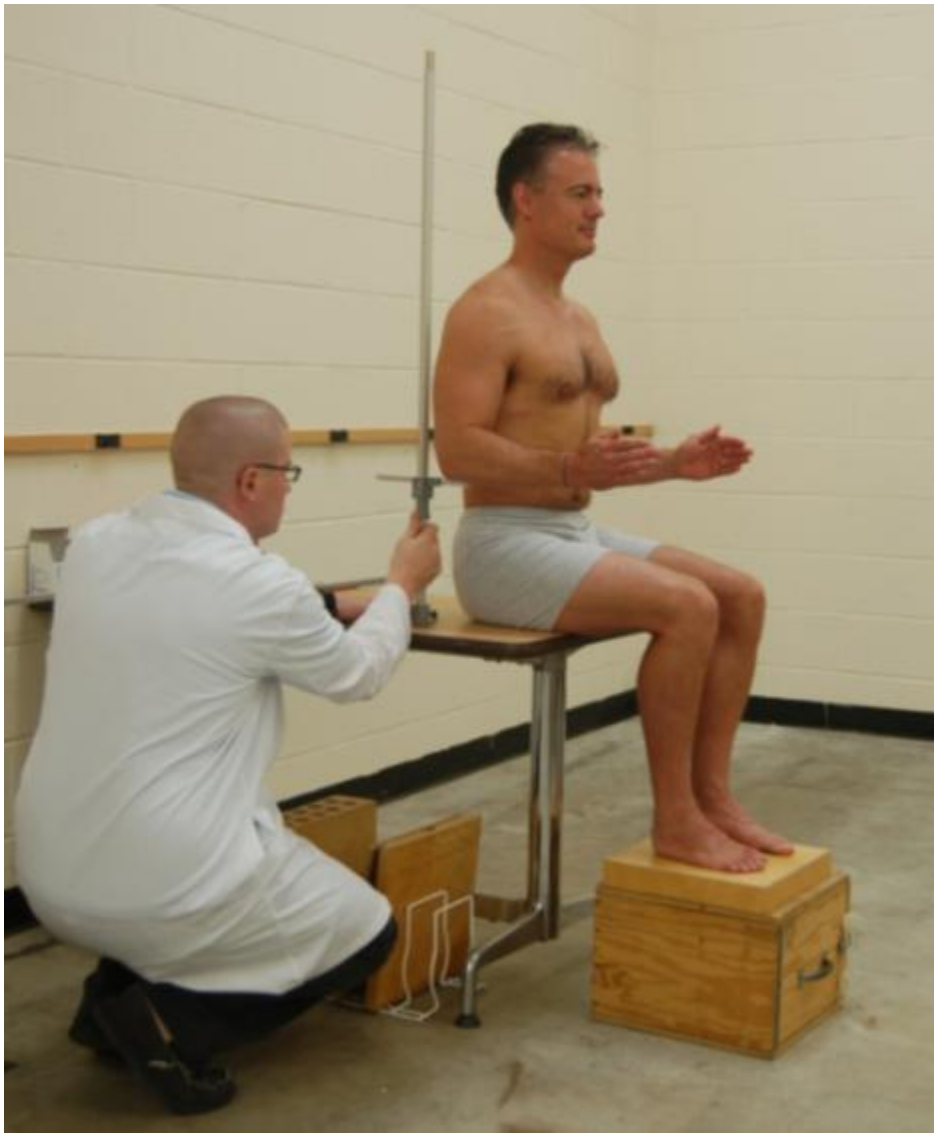
Centimeters		Inches
61.37	**Mean**	24.16
0.11	**SE (mean)**	0.04
2.85	**St Dev**	1.12
53.30	**Minimum**	20.98
70.10	**Maximum**	27.60

Coeff. Of Variation	4.64
Symmetry – BETA I	0.15
Kurtosis – BETA II	-0.09
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
55.20	**1st**	21.73
55.70	**2nd**	21.93
56.40	**3rd**	22.20
56.95	**5th**	22.42
57.70	**10th**	22.72
58.40	**15th**	22.99
59.00	**20th**	23.23
59.40	**25th**	23.39
59.90	**30th**	23.58
60.20	**35th**	23.70
60.50	**40th**	23.82
60.90	**45th**	23.98
61.20	**50th**	24.09
61.60	**55th**	24.25
62.00	**60th**	24.41
62.40	**65th**	24.57
62.70	**70th**	24.69
63.30	**75th**	24.92
63.80	**80th**	25.12
64.40	**85th**	25.35
65.10	**90th**	25.63
66.20	**95th**	56.06
67.20	**97th**	26.46
67.70	**98th**	26.65
68.00	**99th**	26.77

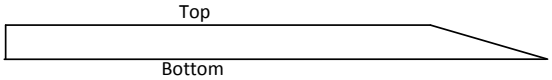
40. Elbow Height

Description: Vertical distance from a horizontal sitting surface to the lowest bony point of the elbow bent at a right angle with the forearm horizontal.
Drawn Landmark: Olecranon, right
Method: Subject sits erect on a flat surface, looking straight ahead. Knees are bent at right angles and feet are supported. Thighs are parallel to each other, feet are in line with the thighs, and knees are bent 90 degrees. Upper arms hang freely downwards and forearms are horizontal. [2]
Instrument: Anthropometer



The Summary Statistics

[2]For most dimensions found using the anthropometer, the bottom of the blade is used. However, for crotch, elbow and popliteal heights the top of the blade is used. The resulting value is adjusted afterward.



Elbow Height, Sitting

Centimeters		Inches
25.03	**Mean**	9.85
0.10	**SE (mean)**	0.04
2.64	**St Dev**	1.04
17.20	**Minimum**	6.77
33.60	**Maximum**	13.23

Coeff. Of Variation	10.56
Symmetry – BETA I	0.15
Kurtosis – BETA II	0.01
Number of Subjects	640

Centimeters	Percentiles	Inches
19.00	**1st**	7.48
19.60	**2nd**	7.72
20.00	**3rd**	7.87
20.80	**5th**	8.19
21.70	**10th**	8.54
22.45	**15th**	8.84
22.90	**20th**	9.02
23.30	**25th**	9.17
23.70	**30th**	9.33
23.90	**35th**	9.41
24.20	**40th**	9.53
24.60	**45th**	9.69
24.90	**50th**	9.80
25.30	**55th**	9.96
25.55	**60th**	10.06
25.90	**65th**	10.20
26.30	**70th**	10.35
26.70	**75th**	10.51
27.20	**80th**	10.71
27.80	**85th**	10.94
28.60	**90th**	11.26
29.55	**95th**	11.63
30.20	**97th**	11.89
30.50	**98th**	12.01
31.60	**99th**	12.44

41. <u>Thigh Clearance</u> (ANSURII)

Description: The vertical distance between a sitting surface and the highest point on top of the right thigh.
Undrawn Landmark: Thigh point, top, right

Method: Participant sits with the thighs parallel; knees flexed 90 degrees, and the feet in line with the thighs. The arms are relaxed on the lap. Stand at the right of the participant and use an anthropometer to measure the vertical distance between the sitting surface and the highest point on the top of the thigh (thigh point, top).Brush the blade of the anthropometer back and forth across the top of the thigh to locate its highest point.

Instrument: Anthropometer

The Summary Statistics
Thigh Clearance

Centimeters		Inches
17.24	**Mean**	6.79
0.05	**SE (mean)**	0.02
1.28	**St Dev**	0.50
13.20	**Minimum**	5.20
22.10	**Maximum**	8.70

Coeff. Of Variation	7.43
Symmetry – BETA I	0.05
Kurtosis – BETA II	0.30
Number of Subjects	640

Percentiles

Centimeters		Inches
14.30	**1st**	5.63
14.60	**2nd**	5.75
15.00	**3rd**	5.91
15.10	**5th**	5.94
15.60	**10th**	6.14
15.90	**15th**	6.26
16.20	**20th**	6.38
16.40	**25th**	6.46
16.60	**30th**	6.54
16.80	**35th**	6.61
16.90	**40th**	6.65
17.10	**45th**	6.73
17.30	**50th**	6.81
17.40	**55th**	6.85
17.60	**60th**	6.93
17.80	**65th**	7.01
17.90	**70th**	7.05
18.00	**75th**	7.09
18.30	**80th**	7.20
18.50	**85th**	7.28
18.80	**90th**	7.40
19.30	**95th**	7.60
19.70	**97th**	7.76
19.90	**98th**	7.83
20.40	**99th**	8.03

42. Knee Height

Description: Vertical distance from the foot support surface to the highest point of the border of the patella.

Drawn Landmark: Suprapatella, right

Method: Subject sits erect on a flat surface with knees bent at right angles and the feet supported.

Instrument: Anthropometer

The Summary Statistics
Knee Height, Sitting

Centimeters		Inches
55.76	**Mean**	21.95
0.10	**SE (mean)**	0.04
2.54	**St Dev**	1.00
48.40	**Minimum**	19.06
63.00	**Maximum**	24.80

Coeff. Of Variation	4.56
Symmetry – BETA I	0.04
Kurtosis – BETA II	-0.19
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
49.90	**1st**	19.65
50.60	**2nd**	19.92
50.90	**3rd**	20.04
51.75	**5th**	20.37
52.60	**10th**	20.71
53.10	**15th**	20.91
53.70	**20th**	21.14
54.00	**25th**	21.26
54.30	**30th**	21.38
54.70	**35th**	21.54
55.10	**40th**	21.69
55.40	**45th**	21.81
55.70	**50th**	21.93
56.00	**55th**	22.05
56.40	**60th**	22.20
56.70	**65th**	22.32
57.10	**70th**	22.48
57.50	**75th**	22.64
57.95	**80th**	22.82
58.60	**85th**	23.07
59.10	**90th**	23.27
60.05	**95th**	23.64
60.60	**97th**	23.86
31.10	**98th**	24.06
61.50	**99th**	24.21

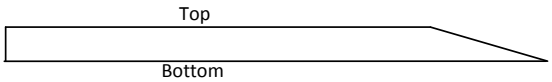
43. <u>Popliteal Height</u> (ANSURII)

Description: The vertical distance from a footrest to the back of the right knee (the popliteal fossa at the dorsal juncture of the calf and thigh).

Undrawn Landmark: Popliteal fossa at the dorsal juncture of the calf and thigh, right

Method: Participant sits with the thighs parallel, the knees flexed 90 degrees. The feet are in line with the thighs, and the arms folded across the chest. Stand to the right of the participant and use an anthropometer to measure the distance between the footrest surface and the bottom surface of the thigh just behind the knee (dorsal juncture of the calf and thigh).[3]
Instrument: Anthropometer

[3]For most dimensions found using the anthropometer, the bottom of the blade is used. However, for crotch, elbow and popliteal heights the top of the blade is used. The resulting value is adjusted afterward.



The Summary Statistics
Popliteal Height

Centimeters		Inches
43.68	**Mean**	17.20
0.09	**SE (mean)**	0.04
2.35	**St Dev**	0.92
36.80	**Minimum**	14.49
49.30	**Maximum**	19.41

Coeff. Of Variation	5.37
Symmetry – BETA I	-0.21
Kurtosis – BETA II	-0.15
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
37.80	**1st**	14.88
38.20	**2nd**	15.04
39.00	**3rd**	15.35
39.70	**5th**	15.63
40.70	**10th**	16.02
41.30	**15th**	16.26
41.70	**20th**	16.42
42.05	**25th**	16.56
42.50	**30th**	16.73
42.80	**35th**	16.85
43.10	**40th**	16.97
43.50	**45th**	17.13
43.70	**50th**	17.20
44.00	**55th**	17.32
44.40	**60th**	17.48
44.60	**65th**	17.56
44.90	**70th**	17.68
45.30	**75th**	17.83
45.70	**80th**	17.99
46.30	**85th**	18.23
46.85	**90th**	18.45
47.50	**95th**	18.70
47.70	**97th**	18.78
48.00	**98th**	18.90
48.60	**99th**	19.13

44. <u>Forearm-to-Forearm Breadth</u> (ANSURII)

Description: The maximum horizontal distance between the outer sides of the forearms.

Method: Participant is in the anthropometric sitting position. Stand behind the participant and use a beam caliper to measure the maximum horizontal distance across the upper body between the outsides of the forearms. Brush the blades back and forth to ensure that the maximum breadth is attained. Exert only enough pressure to ensure that the caliper blades are on the lateral points of the forearms. The measurement is taken at the maximum point of quiet respiration.

Instrument: Beam caliper

The Summary Statistics
Forearm to Forearm Breadth

Centimeters		Inches
56.07	**Mean**	22.07
0.21	**SE (mean)**	0.08
4.39	**St Dev**	1.73
42.80	**Minimum**	16.85
69.10	**Maximum**	27.20

Coeff. Of Variation	7.83
Symmetry – BETA I	0.14
Kurtosis – BETA II	0.12
Number of Subjects	430

Percentiles

Centimeters		Inches
46.20	**1st**	18.19
47.60	**2nd**	18.74
47.90	**3rd**	18.86
48.90	**5th**	19.25
50.50	**10th**	19.88
51.60	**15th**	20.31
52.35	**20th**	20.61
53.20	**25th**	20.94
53.80	**30th**	21.18
54.40	**35th**	21.42
54.75	**40th**	21.56
55.40	**45th**	21.81
56.00	**50th**	22.05
56.30	**55th**	22.17
57.10	**60th**	22.48
57.70	**65th**	22.72
58.25	**70th**	22.93
59.00	**75th**	23.23
59.50	**80th**	23.43
60.70	**85th**	23.90
61.90	**90th**	24.37
63.40	**95th**	24.96
65.00	**97th**	25.59
66.10	**98th**	26.02
67.00	**99th**	26.38

45. <u>Chest Depth</u> (ANSURII)

Description: The horizontal distance between the right chest point anterior landmark and the back at the same level.

Undrawn landmarks: Chest point, anterior, right.

Method: Participant is in the anthropometric sitting position. Stand at the right of the participant and use a beam caliper to measure the horizontal distance between the chest at the level of the right chest point anterior landmark and the back at the same level. Place the fixed blade of the caliper on the back. This measurement is taken at the maximum point of quiet respiration. Exert only enough pressure to maintain contact between the caliper and the skin (or bra).

Instrument: Beam caliper

The Summary Statistics
Chest Depth

Centimeters		Inches
25.19	**Mean**	9.92
0.09	**SE (mean)**	0.03
2.24	**St Dev**	0.88
19.00	**Minimum**	7.48
33.20	**Maximum**	13.07

Coeff. Of Variation	8.91
Symmetry – BETA I	0.27
Kurtosis – BETA II	0.38
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
20.30	**1st**	7.99
20.70	**2nd**	8.15
20.90	**3rd**	8.23
21.50	**5th**	8.46
22.35	**10th**	8.80
23.00	**15th**	9.06
23.45	**20th**	9.23
23.70	**25th**	9.33
24.00	**30th**	9.45
24.30	**35th**	9.57
24.55	**40th**	9.67
24.80	**45th**	9.76
25.20	**50th**	9.92
25.40	**55th**	10.00
25.70	**60th**	10.12
25.90	**65th**	10.20
26.10	**70th**	10.28
26.50	**75th**	10.43
27.00	**80th**	10.63
27.50	**85th**	10.83
28.10	**90th**	11.06
29.15	**95th**	11.48
29.60	**97th**	11.65
30.00	**98th**	11.81
30.40	**99th**	11.97

46. <u>Abdomen Depth</u> (ANSURII)

Description: The maximum depth of the abdomen when participant is sitting.

Undrawn landmark: Abdominal point, anterior

Method: Participant is in the anthropometric sitting position but the right hand is placed on the chest. Stand at the participant's right and use a beam caliper to measure the horizontal distance between the anterior point of the abdomen and the back at the same level. The fixed blade of the caliper is placed on the back. The measurement is made at the maximum point of quiet respiration, with the blades of the instrument just touching the skin.

Instrument: Beam caliper

The Summary Statistics
Abdomen Depth

Centimeters		Inches
24.77	**Mean**	9.75
0.11	**SE (mean)**	0.05
2.76	**St Dev**	1.09
18.40	**Minimum**	7.24
37.30	**Maximum**	14.69

Coeff. Of Variation	11.13
Symmetry – BETA I	0.59
Kurtosis – BETA II	0.87
Number of Subjects	640

Percentiles

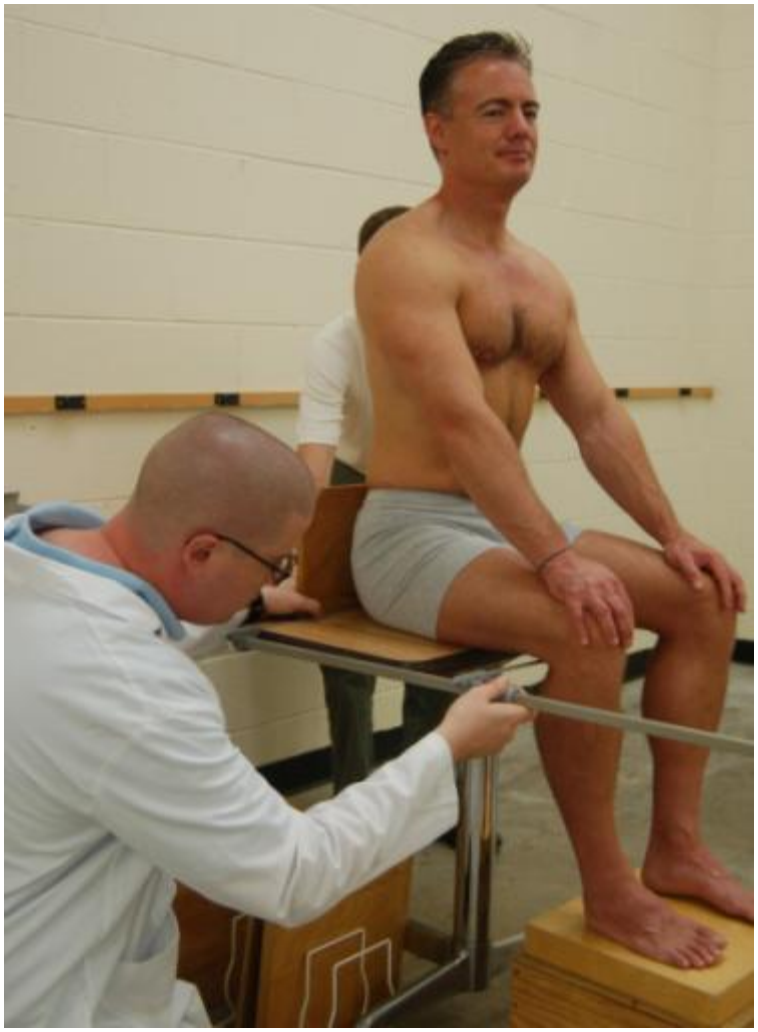
Centimeters		Inches
19.30	**1st**	7.60
19.90	**2nd**	7.83
20.20	**3rd**	7.95
20.60	**5th**	8.11
21.55	**10th**	8.48
22.00	**15th**	8.66
22.40	**20th**	8.82
22.70	**25th**	8.94
23.10	**30th**	9.09
23.40	**35th**	9.21
23.75	**40th**	9.35
24.20	**45th**	9.53
24.50	**50th**	9.65
24.95	**55th**	9.82
25.40	**60th**	10.00
25.70	**65th**	10.12
26.10	**70th**	10.28
26.50	**75th**	10.43
27.00	**80th**	10.63
27.50	**85th**	10.83
28.20	**90th**	11.10
29.50	**95th**	11.61
30.40	**97th**	11.97
31.00	**98th**	12.20
32.20	**99th**	12.68

47. <u>Buttock Popliteal Length</u> (ANSURII)

Description: The horizontal distance between a buttock plate placed at the most posterior point of either buttock and the back of the right knee (the popliteal fossa at the dorsal juncture of the calf and thigh).
Undrawn Landmark: Popliteal fossa at the dorsal juncture of the calf and thigh, right

Method: Participant is sitting with the arms folded across the chest. Stand at the right of the participant and slide the buttock plate toward the participant until it makes light contact with the most posterior point on either buttock. Use an anthropometer to measure the horizontal distance from the buttock plate to the back of the knee. This is done in such a way that the blade of the anthropometer is placed as high and as far forward as possible in the popliteal fossa behind the knee (dorsal juncture of the calf and thigh) without compressing tissue. Exert only enough pressure on the instrument to attain contact between the anthropometer blade and the skin.

Instruments: Beam caliper and Buttock plate



The Summary Statistics
Buttock Popliteal Length

Centimeters		Inches
50.34	**Mean**	19.82
0.10	**SE (mean)**	0.04
2.51	**St Dev**	0.99
42.60	**Minimum**	16.77
59.40	**Maximum**	23.39

Coeff. Of Variation	4.98
Symmetry – BETA I	0.13
Kurtosis – BETA II	0.28
Number of Subjects	640

Percentiles

Centimeters		Inches
44.80	**1st**	17.64
45.00	**2nd**	17.72
45.40	**3rd**	17.87
46.25	**5th**	18.21
47.30	**10th**	18.62
47.80	**15th**	18.82
48.30	**20th**	19.02
48.65	**25th**	19.15
49.10	**30th**	19.33
49.30	**35th**	19.41
49.60	**40th**	19.53
49.90	**45th**	19.65
50.30	**50th**	19.80
50.60	**55th**	19.92
50.95	**60th**	20.06
51.20	**65th**	20.16
51.70	**70th**	20.35
52.00	**75th**	20.47
52.40	**80th**	20.63
52.90	**85th**	20.83
53.40	**90th**	21.02
54.45	**95th**	21.44
55.30	**97th**	21.77
55.70	**98th**	21.93
56.50	**99th**	22.24

48. **<u>Buttock Knee Length</u>** (ANSURII)

Description: Horizontal distance from the foremost point of the kneecap to the rearmost point of the buttock.

Method: Subject sits erect on a flat surface, looking straight ahead. Knees are bent at right angles and the feet are supported. Thighs are parallel to each other, the feet are in line with the thighs, and knees are bent 90 degrees. Upper arms hang freely downwards and forearms are folded across chest.

Instruments: Beam caliper

The Summary Statistics
Buttock Knee Length

Centimeters		Inches
61.74	**Mean**	24.31
0.11	**SE (mean)**	0.04
2.72	**St Dev**	1.07
53.60	**Minimum**	21.10
70.00	**Maximum**	27.56

Coeff. Of Variation	4.40
Symmetry – BETA I	0.10
Kurtosis – BETA II	-0.02
Number of Subjects	640

Percentiles

Centimeters		Inches
55.60	**1st**	21.89
56.10	**2nd**	22.09
56.70	**3rd**	22.32
57.50	**5th**	22.64
58.40	**10th**	22.99
59.20	**15th**	23.31
59.55	**20th**	23.45
60.00	**25th**	23.62
60.20	**30th**	23.70
60.50	**35th**	23.82
60.90	**40th**	23.98
61.30	**45th**	24.13
61.60	**50th**	24.25
61.95	**55th**	24.39
62.30	**60th**	24.53
62.70	**65th**	24.69
63.20	**70th**	24.88
63.60	**75th**	25.04
64.00	**80th**	25.20
64.50	**85th**	25.39
65.30	**90th**	25.71
66.40	**95th**	26.14
67.20	**97th**	26.46
67.60	**98th**	26.61
68.10	**99th**	26.81

49. Hip Breadth

Description: Breadth of the body measured across the widest portion of the hips.

Method: Subject sits erect on a flat surface, looking straight ahead. Knees are bent at right angles and the feet are supported. Thighs, knees, and feet are kept together (touching). Knees are bent 90º. Measurement is taken without pressing into the flesh of the hips.

Instrument: Beam caliper

The Summary Statistics
Hip Breadth, Sitting

Centimeters		Inches
38.22	**Mean**	15.05
0.10	**SE (mean)**	0.04
2.46	**St Dev**	0.97
31.70	**Minimum**	12.48
47.90	**Maximum**	18.86

Coeff. Of Variation	6.43
Symmetry – BETA I	0.43
Kurtosis – BETA II	0.51
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
33.40	**1st**	13.15
33.80	**2nd**	13.31
34.20	**3rd**	13.46
34.45	**5th**	13.56
35.00	**10th**	13.78
35.60	**15th**	14.02
36.15	**20th**	14.23
36.60	**25th**	14.41
36.90	**30th**	14.53
37.20	**35th**	14.65
37.50	**40th**	14.76
37.80	**45th**	14.88
38.10	**50th**	15.00
38.40	**55th**	15.12
38.70	**60th**	15.24
39.10	**65th**	15.39
39.40	**70th**	15.51
39.70	**75th**	15.63
40.10	**80th**	15.79
40.60	**85th**	15.98
41.25	**90th**	16.24
42.45	**95th**	16.71
43.10	**97th**	16.97
44.10	**98th**	17.36
45.10	**99th**	17.76

50. Wrist Circumference

Description: The circumference of the wrist at the level of stylion and perpendicular to the long axis of the forearm.
Drawn Landmarks: Radial and Ulnar Stylion, right

Method: Participant sits with the upper arm relaxed and the elbow flexed 90° with the palm down. Stand in front of the participant and use a tape to measure the circumference of the wrist perpendicular to the long axis of the forearm. When correctly placed, the upper edge of the tape will run just below the bony prominence at stylion**,** and the lower edge of the tape will run just above the pisiform bone at the bottom of the little finger side of the hand. Exert only enough tension on the tape to maintain contact between the tape and the skin.

Instrument: Steel tape measure

The Summary Statistics
Wrist Circumference

Centimeters		Inches
17.47	**Mean**	6.88
0.04	**SE (mean)**	0.01
0.77	**St Dev**	0.30
15.20	**Minimum**	5.98
19.80	**Maximum**	7.80

Coeff. Of Variation	4.41
Symmetry – BETA I	0.06
Kurtosis – BETA II	-0.06
Number of Subjects	430

Percentiles

Centimeters		Inches
15.80	**1st**	6.22
15.90	**2nd**	6.26
16.00	**3rd**	6.30
16.10	**5th**	6.34
16.50	**10th**	6.50
16.70	**15th**	6.57
16.90	**20th**	6.65
17.00	**25th**	6.69
17.10	**30th**	6.73
17.20	**35th**	6.77
17.30	**40th**	6.81
17.40	**45th**	6.85
17.50	**50th**	6.89
17.60	**55th**	6.93
17.70	**60th**	6.97
17.80	**65th**	7.01
17.80	**70th**	7.01
18.00	**75th**	7.09
18.10	**80th**	7.13
18.30	**85th**	7.20
18.50	**90th**	7.28
18.80	**95th**	7.40
19.00	**97th**	7.48
19.00	**98th**	7.48
19.30	**99th**	7.60

51. Hand Circumference

Description: Circumference of the hand is measured across knuckles of the index and little ("pinky") fingers at the point of each knuckle's greatest protrusion.

Drawn landmarks: Metacarpal phalangeal protrusion II and V, right

Method: Hand is held palm down with the fingers together and straight, and with thumb held away from the side of the hand.

Instrument: Steel tape measure

The Summary Statistics
Hand Circumference

Centimeters		Inches
21.30	**Mean**	8.39
0.04	**SE (mean)**	0.01
0.96	**St Dev**	0.38
18.20	**Minimum**	7.17
24.90	**Maximum**	9.80

Coeff. Of Variation	4.50
Symmetry – BETA I	0.21
Kurtosis – BETA II	0.30
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
19.30	**1st**	7.60
19.40	**2nd**	7.64
19.60	**3rd**	7.72
19.80	**5th**	7.80
20.10	**10th**	7.91
20.30	**15th**	7.99
20.50	**20th**	8.07
20.60	**25th**	8.11
20.80	**30th**	8.19
20.90	**35th**	8.23
21.00	**40th**	8.27
21.10	**45th**	8.31
21.30	**50th**	8.39
21.40	**55th**	8.43
21.50	**60th**	8.46
21.60	**65th**	8.50
21.80	**70th**	8.58
21.90	**75th**	8.62
22.10	**80th**	8.70
22.30	**85th**	8.78
22.50	**90th**	8.86
22.95	**95th**	9.04
23.30	**97th**	9.17
23.40	**98th**	9.21
23.60	**99th**	9.29

52. <u>Neck Circumference</u> (ANSURII)

Description: The circumference of the neck at the level of the infrathyroid landmark (Adam's apple).

Undrawn landmark: Infrathyroid

Method: Participant is sitting with the head in the Frankfurt plane. Stand at the right of the participant and use a tape to measure the circumference of the neck at the level of the drawn infrathyroid landmark. The plane of the measurement is perpendicular to the long axis of the neck. Exert only enough tension on the tape to maintain contact between the tape and the skin.

Instrument: Steel tape measure

The Summary Statistics
Neck Circumference

Centimeters		Inches
38.87	**Mean**	15.30
0.08	**SE (mean)**	0.03
2.00	**St Dev**	0.79
33.40	**Minimum**	13.15
45.50	**Maximum**	17.91

Coeff. Of Variation	5.14
Symmetry – BETA I	0.23
Kurtosis – BETA II	-0.03
Number of Subjects	640

Percentiles

Centimeters		Inches
34.70	**1st**	13.66
35.10	**2nd**	16.82
35.50	**3rd**	13.98
35.70	**5th**	14.06
36.40	**10th**	14.33
36.70	**15th**	14.45
37.20	**20th**	14.65
37.50	**25th**	14.76
37.70	**30th**	14.84
38.00	**35th**	14.96
38.30	**40th**	15.08
38.50	**45th**	15.16
38.80	**50th**	15.28
39.10	**55th**	15.39
39.40	**60th**	15.51
39.70	**65th**	15.63
39.95	**70th**	15.73
40.20	**75th**	15.83
40.50	**80th**	15.94
40.90	**85th**	16.10
41.50	**90th**	16.34
42.20	**95th**	16.61
42.60	**97th**	16.77
43.10	**98th**	16.97
43.90	**99th**	17.28

53. Head Circumference

Description: Maximum, approximately horizontal circumference of head measured above the glabella and crossing the rearmost point of the skull.

Method: Tape measure is held at mid-forehead and led around the head so as to pass over the rearmost point of the skull. Hair shall be included in the measurement. Position of head has no influence on the measurement.

Instrument: Steel tape measure

The Summary Statistics
Head Circumference

Centimeters		Inches
57.46	**Mean**	22.62
0.06	**SE (mean)**	0.02
1.44	**St Dev**	0.57
53.50	**Minimum**	21.06
61.70	**Maximum**	24.29

Coeff. Of Variation	2.50
Symmetry – BETA I	0.22
Kurtosis – BETA II	-0.17
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
54.50	**1st**	21.46
54.70	**2nd**	21.54
55.00	**3rd**	21.65
55.30	**5th**	21.77
55.70	**10th**	21.93
55.95	**15th**	22.03
56.20	**20th**	22.13
56.50	**25th**	22.24
56.60	**30th**	22.28
56.80	**35th**	22.36
57.00	**40th**	22.44
57.20	**45th**	22.52
57.40	**50th**	22.60
57.50	**55th**	22.64
57.75	**60th**	22.74
58.00	**65th**	22.83
58.20	**70th**	22.91
58.50	**75th**	23.03
58.70	**80th**	23.11
59.00	**85th**	23.23
59.30	**90th**	23.35
59.95	**95th**	23.60
60.20	**97th**	23.70
60.70	**98th**	23.90
61.20	**99th**	24.09

54. Head Length

Description: Distance along a straight line between the glabella and the rearmost point of the skull.

Drawn landmark: Glabella

Undrawn landmark: Opisthocranion

Method: Position of head has no influence on the measurement.

Instrument: Spreading caliper

The Summary Statistics
Head Length

Centimeters		Inches
20.15	**Mean**	7.93
0.03	**SE (mean)**	0.01
0.64	**St Dev**	0.25
18.20	**Minimum**	7.17
21.80	**Maximum**	8.58

Coeff. Of Variation	3.18
Symmetry – BETA I	0.02
Kurtosis – BETA II	-0.02
Number of Subjects	640

	Percentiles	
Centimeters		Inches
18.60	**1st**	7.32
18.80	**2nd**	7.40
19.00	**3rd**	7.48
19.10	**5th**	7.52
19.35	**10th**	7.62
19.50	**15th**	7.68
19.60	**20th**	7.72
19.70	**25th**	7.76
19.80	**30th**	7.80
19.90	**35th**	7.83
20.00	**40th**	7.87
20.10	**45th**	7.91
20.20	**50th**	7.95
20.20	**55th**	7.95
20.30	**60th**	7.99
20.40	**65th**	8.03
20.50	**70th**	8.07
20.60	**75th**	8.11
20.70	**80th**	8.15
20.80	**85th**	8.19
21.00	**90th**	8.27
21.30	**95th**	8.39
21.40	**97th**	8.43
21.60	**98th**	8.50
21.60	**99th**	8.50

55. Bizygomatic Breadth

Description: Maximum horizontal distance is measured across the face between the zygomatic arches (cheekbones).
Undrawn landmarks: Right and Left Zygion

Method: Subject faces straight ahead with teeth lightly closed but not clenched.

Instrument: Spreading caliper

The Summary Statistics
Bizygomatic Breadth

Centimeters		Inches
14.22	**Mean**	5.60
0.02	**SE (mean)**	0.01
0.58	**St Dev**	0.23
12.40	**Minimum**	4.88
15.70	**Maximum**	6.18

Coeff. Of Variation	4.07
Symmetry – BETA I	-0.06
Kurtosis – BETA II	-0.30
Number of Subjects	640

Percentiles

Centimeters		Inches
12.90	**1st**	5.08
13.00	**2nd**	5.12
13.10	**3rd**	5.16
13.25	**5th**	5.22
13.50	**10th**	5.31
13.60	**15th**	5.35
13.70	**20th**	5.39
13.80	**25th**	5.43
13.90	**30th**	5.47
14.00	**35th**	5.51
14.10	**40th**	5.55
14.20	**45th**	5.59
14.20	**50th**	5.59
14.30	**55th**	5.63
14.40	**60th**	5.67
14.50	**65th**	5.71
14.50	**70th**	5.71
14.60	**75th**	5.75
14.70	**80th**	5.79
14.80	**85th**	5.83
15.00	**90th**	5.91
15.20	**95th**	5.98
15.30	**97th**	6.02
15.40	**98th**	6.06
15.40	**99th**	6.06

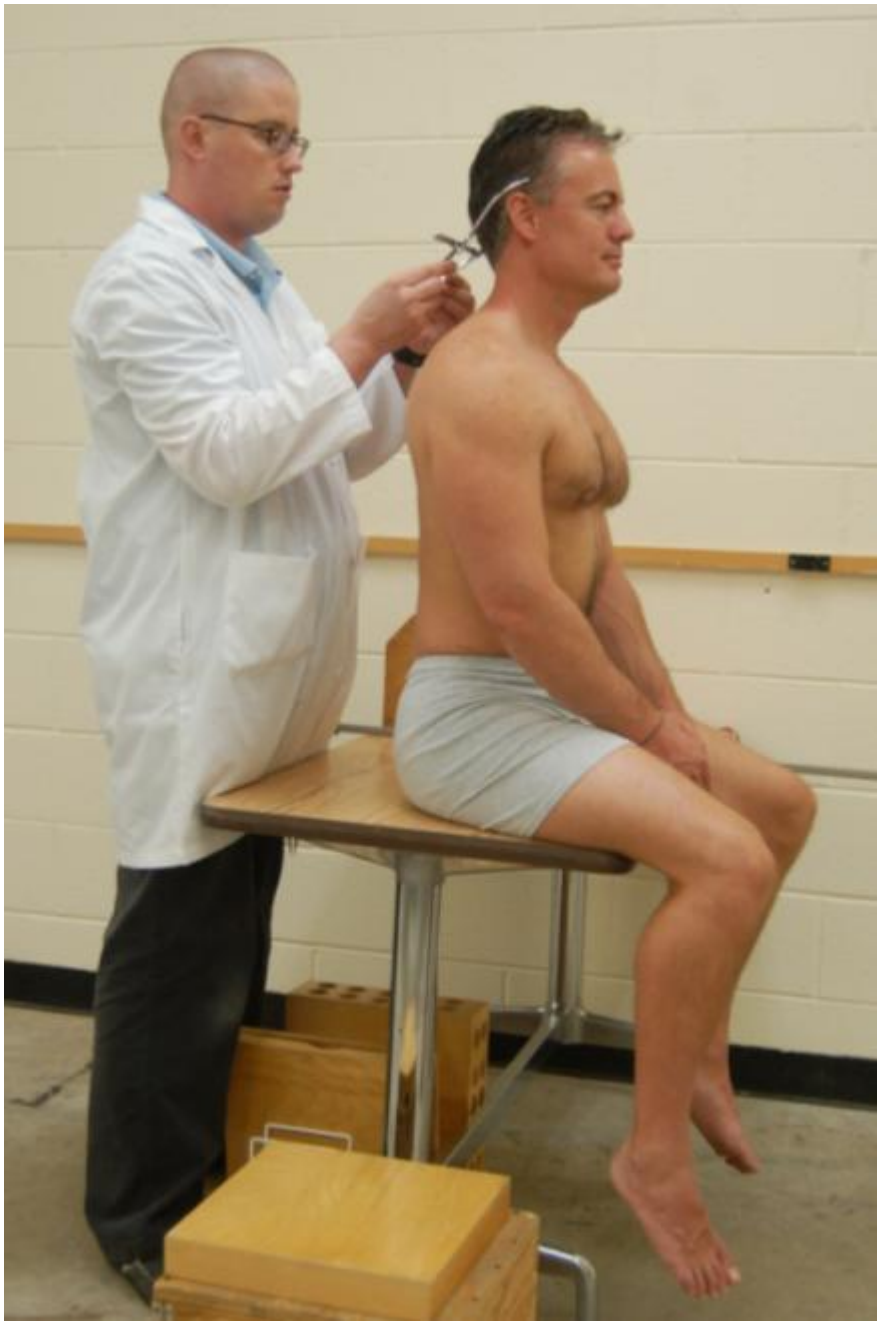
56. Head Breadth

Description: Maximum breadth of head above the ears [measured perpendicular to the mid-sagittal plane.]

Undrawn landmarks: Right and Left Euryon

Method: Position of head has no influence on the measurement.

Instrument: Spreading caliper



The Summary Statistics
Head Breadth

Centimeters		Inches
15.48	**Mean**	6.09
0.02	**SE (mean)**	0.01
0.53	**St Dev**	0.21
14.20	**Minimum**	5.59
17.20	**Maximum**	6.77

Coeff. Of Variation	3.41
Symmetry – BETA I	0.34
Kurtosis – BETA II	0.03
Number of Subjects	640

	Percentiles	
Centimeters		**Inches**
14.40	**1st**	5.67
14.50	**2nd**	5.71
14.50	**3rd**	5.71
14.65	**5th**	5.77
14.80	**10th**	5.83
14.90	**15th**	5.87
15.00	**20th**	5.91
15.10	**25th**	5.94
15.20	**30th**	5.98
15.30	**35th**	6.02
15.30	**40th**	6.02
15.40	**45th**	6.06
15.40	**50th**	6.06
15.50	**55th**	6.10
15.60	**60th**	6.14
15.70	**65th**	6.18
15.70	**70th**	6.18
15.80	**75th**	6.22
15.90	**80th**	6.26
16.00	**85th**	6.30
16.20	**90th**	6.38
16.40	**95th**	6.46
16.60	**97th**	6.54
16.70	**98th**	6.57
16.80	**99th**	6.61

57. Face Length

Description: Distance between sellion and menton.

Drawn landmarks: Sellion and menton

Method: Subject looks straight ahead, keeps mouth closed, teeth together but not clenched and eyes closed.
Instrument: Sliding caliper

The Summary Statistics
Face Length

Centimeters		Inches
12.08	**Mean**	4.76
0.03	**SE (mean)**	0.01
0.65	**St Dev**	0.25
10.10	**Minimum**	3.98
14.20	**Maximum**	5.59

Coeff. Of Variation	5.34
Symmetry – BETA I	0.15
Kurtosis – BETA II	-0.08
Number of Subjects	640

Percentiles

Centimeters		Inches
10.70	**1st**	4.21
10.80	**2nd**	4.25
10.90	**3rd**	4.29
11.00	**5th**	4.33
11.30	**10th**	4.45
11.40	**15th**	4.49
11.50	**20th**	4.53
11.60	**25th**	4.57
11.70	**30th**	4.61
11.80	**35th**	4.65
11.90	**40th**	4.69
12.00	**45th**	4.72
12.00	**50th**	4.72
12.10	**55th**	4.76
12.20	**60th**	4.80
12.30	**65th**	4.84
12.40	**70th**	4.88
12.50	**75th**	4.92
12.60	**80th**	4.96
12.70	**85th**	5.00
13.00	**90th**	5.12
13.20	**95th**	5.20
13.30	**97th**	5.24
13.50	**98th**	5.31
13.60	**99th**	5.35

58. Hand Length

Description: Perpendicular distance from the elastic band that passes over the styloid process to the tip of the middle finger.

Drawn Landmarks: Radial and Ulnar stylion (with an elastic band covering each), right

Undrawn landmarks: Dactylion III (tip of third finger)

Method: Subject holds the forearm horizontal with hand stretched out flat, palm up.

Instrument: Sliding caliper

The Summary Statistics
Hand Length

Centimeters		Inches
20.19	**Mean**	7.95
0.04	**SE (mean)**	0.01
0.94	**St Dev**	0.37
17.50	**Minimum**	6.89
23.90	**Maximum**	9.41

Coeff. Of Variation	4.67
Symmetry – BETA I	0.13
Kurtosis – BETA II	0.41
Number of Subjects	640

Percentiles

Centimeters		Inches
18.00	**1st**	7.09
18.20	**2nd**	7.17
18.40	**3rd**	7.24
18.60	**5th**	7.32
19.00	**10th**	7.48
19.30	**15th**	7.60
19.40	**20th**	7.64
19.60	**25th**	7.72
19.70	**30th**	7.76
19.80	**35th**	7.80
20.00	**40th**	7.87
20.10	**45th**	7.91
20.20	**50th**	7.95
20.30	**55th**	7.99
20.40	**60th**	8.03
20.50	**65th**	8.07
20.70	**70th**	8.15
20.80	**75th**	8.19
20.90	**80th**	8.23
21.20	**85th**	8.35
21.40	**90th**	8.43
21.75	**95th**	8.56
21.90	**97th**	8.62
22.20	**98th**	8.74
22.60	**99th**	8.90

Appendix D: Marked Landmarks for traditional anthropometry

Glabella: Most anterior point of the forehead between the brow ridges in the midsagittalplane.

Sellion: Point of greatest indentation of the nasal root depression.

Menton: Lowest point of the tip of the chin in the midsagittal plane.

Cervicale: Prominent bone at the base of the back of the neck (spinous process of the seventh cervical vertebra).

Suprasternale: Highest palpable point on the sternum (breastbone).

Acromion: Most lateral point of the lateral edge of the spine of the scapula.

Posterior Axilla point: Lowest point on the posterior axillary fold (armpit).

Olecranon: Posterior point on the olecranon process of the ulna, marked with the elbow bent 90 degrees.

Radial styloid: Distal tip of the radius.

Ulnar styloid: Distal point of the ulna.

Metacarpal phalangeal II point: Prominent point on the lateral surface of the second metacarpal-phalangeal joint.

Metacarpal phalangeal V point: Prominent point on the medial surface of the fifth metacarpal-phalangeal joint.

Waist preferred - Front (anterior): Level of the waist as marked on the subject's front in the midsagittal plane.

Waist preferred - Right side (lateral): Level of the waist as marked on the subject's right side.

Waist preferred - Back (posterior): Level of the waist as marked on the subject's back in the midsagittal plane.

Suprapatella: Top of the kneecap; the superior point on the patella while it is in the relaxed (loose) position.

Medial malleolus: Medial point on the distal tibial protrusion of the ankle.

Lateral malleolus: Lateral point on the distal fibular protrusion of the ankle.