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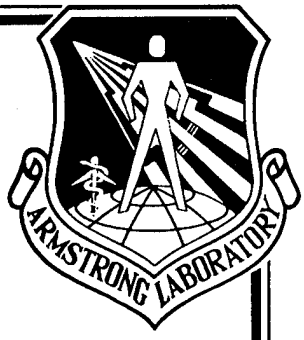

ARMSTRONG LABORATORY

FIT EVALUATION OF TWO AIRCREW COVERALLS

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FINAL REPORT FOR THE PERIOD JULY 1991 TO MARCH 1993

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FOR THE COMMANDER

KENNETH R. BOFF, Chief
Human Engineering Division
Armstrong Laboratory

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This report documents a fit evaluation of two aircrew coveralls: the Modified Enhanced Air Force Flight Suit (MEAFFS) and the CWU-66/P chemical protective coverall. The fit evaluation includes the collection of anthropometry and fit assessment data which is used to recommend anthropometric sizing schemes. Anthropometric sizing provides designers of clothing and personal protective equipment items with information to: 1) proportion the item to achieve a good quality fit for the individual, 2) vary the sizes and other adjustments in the items to achieve a good quality fit for the population, 3) minimize the number of sizes and adjustments and their associated cost, and 4) determine the purchase quantities for each size to minimize waste in the inventory. Results of the fit evaluation indicate that the two coveralls generally fitted well for men and poorly for women. Modification of the coveralls may accommodate women better; however, there may be an equal drawback to the current fit for men. Thus, the recommendation from the fit evaluation was to develop separate sizing systems for men and women which will benefit both users of the coveralls.

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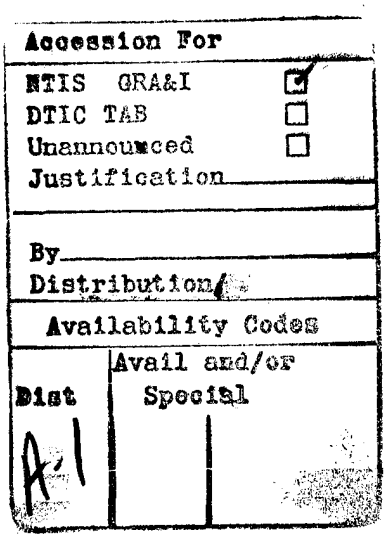
PREFACE

This study was carried out under contract F33615-89-C-0572 with Armstrong Laboratory, Wright-Patterson Air Force Base, Ohio. Several individuals contributed to the success of this study. The authors especially thank Dr. Bruce Bradtmiller, Mr. Henry Case, and Ms. Shirley Kristensen of Anthropology Research Project, Inc. for their outstanding support and anthropometry expertise in data collection and editing. Master Sergeant Greg Chambers and Mr. Al Frechette of Headquarters Human Systems Center provided invaluable assistance in test coordination and the funds necessary to complete the study. The authors are also grateful to all the men and women who participated in this study and to the support staff at the various test sites.



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INTRODUCTION

In 1991 and 1992, investigators from the Human Engineering Division at Armstrong Laboratory and the Clothing Branch at Human Systems Center conducted a fit evaluation of two aircrew coveralls: the Modified Enhanced Air Force Flight Suit (MEAFFS) and the CWU-66/P chemical protective coverall. Although the MEAFFS and CWU-66/P have the same clothing design pattern, each coverall was developed to replace different garments. The MEAFFS (Figure 1) replaces the standard CWU-27/P flight suit while the CWU-66/P (Figure 2) replaces the current aircrew chemical defense ensemble (CWU-27/P flight suit, charcoal undergarment, and long underwear). The objective of the fit evaluation was to assess the anthropometric sizing of the two coveralls as they pertain to the U.S. Air Force aircrew population.

Anthropometric sizing is necessary in the design of items of clothing and personal protective equipment for four basic reasons: 1) to proportion the item to achieve a good quality fit for the individual, 2) to vary the sizes and other adjustments in the items to achieve a good quality fit for the population, 3) to minimize the number of sizes and adjustments and their associated cost, and 4) to determine the purchase quantities for each size to minimize waste in the inventory. Sizing becomes more critical when a design item must accommodate a large diverse user population.

Fit tests conducted on protective equipment ranging from body armor (Zehner et al, 1987) to flight helmets (Blackwell and Robinette, 1993) indicate that regardless of who the item is "designed" or intended to fit, the body size and shape it fits, the quality of fit, and the range of fit cannot be determined until a prototype is tested. The fit of an item is inseparably linked to design; knowledge of anthropometry alone is not adequate for determining fit. Therefore, a fit relationship to the anthropometry for a particular design must be defined in order to determine the optimum number, assortment, and proportioning of sizes.

For example, during evaluation of uniforms for U.S. Navy women (Mellian et al, 1991, and Robinette et al, 1991) investigators discovered that many of the neighboring size patterns were so similar that in reality the patterns were exactly the same! Each size pattern was designed to be different sizes, but in fact, they were not. Furthermore, the full set of sizes did not fit a large segment of the population of women who had a certain type of body proportion. These were women who had comparable waist and bust sizes to existing sizes, but larger hips at those waist and bust sizes. This proportion type was later dubbed "women's."

For most items it is not anticipated that the true overlap would be as significant as in the above example. However, until a prototype is tested it is impossible to determine how wide the range of fit is for a single size, and subsequently, how much overlap (if any) there are among the different sizes. This was exemplified during fit tests of three independently manufactured aircrew helmets. All helmets were designed to be a size "large". Although there were a few cases where a person achieved an acceptable fit in all three helmets, the results more often revealed that a person received an acceptable fit in one helmet but not the others. The optimal fit for each helmet occurred for different head and face proportion. In addition, the ranges of fit were different for each of the three helmets.

FIGURE 1. Modified Enhanced Air Force Flight Suit (MEAFFS)

FIGURE 2. CWU-66/P Chemical Protective Coverall

METHODS

Data Collection

The fit test consisted of two components: 1) anthropometric measurements, and 2) fit assessment. Investigators recorded the fit assessment on a questionnaire-type data form due to the success of previous fit studies (Mellian et al, 1991, and Robinette et al, 1991) using questionnaires. The questionnaire provides a template for consistent recording of data, is easy to code for analysis, and allows the investigator to relate the fit difficulty to a particular area on both the item and the body.

The data collection team conducted three pre-test planning sessions to guide in the establishment of test procedures. Different anthropometric and questionnaire measuring instruments were tested, and the individual duties of the team members were examined.

The data collection team consisted of:

1. Briefer: greets subjects, explains the purpose of the study, gathers biographical data, and has the subjects read and sign the consent form

2. Landmarker/Measurer: locates anthropometric landmarks and measures the subjects

3. Recorder: assists the landmarker/measurer and records anthropometric data

4. Evaluator: assesses and records the fit

5. Fitter: selects the first size to be tested and assists subjects in selecting subsequent sizes

To reduce excess repetitiveness in sizes it is important to test the body size overlap in the sizes of each item. This was accomplished by testing each subject in "neighboring" sizes; i.e., test the subject in the next smaller, larger, shorter, and longer sizes from the size initially selected as the "best fit" size. This is necessary since, regardless of the care taken, the size initially chosen as the best fit may not be correct. Often there is significant fit overlap that sizes can be eliminated and, in some instances, there is not enough overlap so that some people in the center of the size range may not achieve a satisfactory fit. Several examples of these problems were described in the introduction. Furthermore, selecting the initial best fit size becomes easier with practice and the test proceeds faster if there is the opportunity to correct for this after the data has been collected. Testing neighboring sizes provides this opportunity.

Figure 3 is the anthropometry data sheet used in the fit study. Measurement descriptions for the anthropometry can be found in Appendix A. The recorder entered the anthropometry into a laptop computer as it was being collected and a printed record was also made at the end of the measuring session. The computer entry of anthropometry data served as a quality control system during data collection. The laptop software was set-up to check the measurement data to verify that it was within a reasonable range; anthropometry data from surveys were used for comparison. If the

Subject Number: _____ **Date:** _____

Name: _____ **Location:** _____

Rank and Pay Grade: _____ **Race:** _____

Age: _____ **Sex:** _____

Date of Birth: _____ **AFSC:** _____

Place of Birth: _____ **MAJCOM:** _____

Rep. Height: _____ **Rep. Weight:** _____

Suit currently worn: 27P (epaulets) _____ **27P (no epaulets)** _____

Size currently worn: _____

Weight	_____	Acromion Height	_____
Upper Thigh Circ	_____	Neck Height	_____
Buttock Circ	_____	Waist Height, Omph	_____
Hip Circ, Max	_____	Waist Ht, Prefer	_____
Hip Height	_____	Crotch Height	_____
Neck Circ	_____	Biacromial Br	_____
Shoulder Circ	_____	Sitting Height	_____
Chest Circ	_____	Eye Height, Sit	_____
Waist Circ, Omph	_____	Knee Height, Sit	_____
Waist Circ, Prefer	_____	Butt-Knee L (ANSUR)	_____
Waist Back	_____	Butt-Knee L (AF)	_____
Crotch Length	_____	Bideltoid Br	_____
VTC	_____		
Sleeve Length, Total	_____		
Sleeve Outseam	_____		
Sleeve Inseam	_____		
Stature	_____		
Cervicale Ht	_____		

SUBJECT COMMENTS:

INVESTIGATOR COMMENTS:

FIGURE 3. Anthropometry Data Sheet

measurement appeared to be outside the range the computer would sound a "beep." The measurer and recorder would then check the data to ensure that the measurement was taken and entered correctly.

The fit assessment portion of the collection consisted of the following steps: 1) fitter selects the estimated best fit size; 2) evaluator assesses this first size, both overall and by body region; 3) subject assesses the overall fit of the first size; 4) fitter selects the next neighboring size(s); 5) evaluator assesses each size neighboring the first size, both overall and by body region; 6) subject evaluates the overall fit of each neighboring size. Table 1 provides the guidelines for selecting neighboring sizes based on the best fit size. The data sheet used to record the evaluations is shown in Figure 4.

TABLE 1. Best Fit and Adjacent Sizes

BEST FIT	SMALLER	LARGER	SHORTER	LONGER
32 S	-	34 S	-	32 R
32 R	-	34 R	32 S	-
34 S	32 S	36 S	-	34 R
34 R	32 R	36 R	34 S	-
36 S	34 S	38 S	-	36 R
36 R	34 R	38 R	36 S	36 L
36 L	-	38 L	36 R	-
38 S	36 S	40 S	-	38 R
38 R	36 R	40 R	38 S	38 L
38 L	36 L	40 L	38 R	-
40 S	38 S	42 S	-	40 R
40 R	38 R	42 R	40 S	40 L
40 L	38 L	42 L	40 R	-
42 S	40 S	44 S	-	42 R
42 R	40 R	44 R	42 S	42 L
42 L	40 L	44 L	42 R	-
44 S	42 S	46 S	-	44 R
44 R	42 R	46 R	44 S	44 L
44 L	42 L	46 L	44 R	-
46 S	44 S	-	-	46 R
46 R	44 R	48 R	46 S	46 L
46 L	44 L	48 L	46 R	-
48 R	46 R	-	-	48 L
48 L	46 L	-	48 R	-

SUBJECT NUMBER ____

MEAFFS SIZE	BEST FIT ____	SMALLER ____	LARGER ____	SHORTER ____	LONGER ____
COLLAR	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
SHOULDER	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
CHEST	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
SLEEVES	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
SLEEVES	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long
WAIST	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
WAIST	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low
UPPER TORSO	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long
HIPS	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
CROTCH	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low
THIGH	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
LOWER LEG	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
LEG LENGTH OVERALL	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long
	Fitter ____ Subj ____	Fitter ____ Subj ____	Fitter ____ Subj ____	Fitter ____ Subj ____	Fitter ____ Subj ____

CD Coverall SIZE	BEST FIT ____	SMALLER ____	LARGER ____	SHORTER ____	LONGER ____
COLLAR	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
SHOULDER	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
CHEST	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
SLEEVES	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
SLEEVES	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long
WAIST	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
WAIST	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low
UPPER TORSO	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long
HIPS	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
CROTCH	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low	High • OK • Low
THIGH	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
LOWER LEG	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose	Tight • OK • Loose
LEG LENGTH OVERALL	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long	Short • OK • Long
	Fitter ____ Subj ____	Fitter ____ Subj ____	Fitter ____ Subj ____	Fitter ____ Subj ____	Fitter ____ Subj ____

1=Excellent; 2=Good; 3=Fair; 4=Poor; 5=Unable to don

FIGURE 4. Fit Assessment Data Sheet

The investigators pre-determined the body region to be evaluated during the pre-test planning sessions. These regions are shown in the left-hand column of Figure 4. In some instances a body region is listed twice, but the type of response indicated is different. This allows for the evaluator to record two different types of fit behavior; generally, a height-positioning type fit behavior and a tightness-looseness type of fit behavior. The evaluator assessed each garment area region on a five-point scale. The dots between the words on the chart represent the ratings which fall between the levels on either side. For example, for the "collar" region: 1 = tight, 2 = between tight and OK, 3 = OK, 4 = between OK and loose, and 5 = loose.

The column marked "best fit" was usually the first size selected by the fitter. However, if a better fitting size was found during the evaluation, this size became the best fit size and the subsequent neighboring sizes were changed to conform to the new best fit size.

The evaluator recorded the overall ratings in the row marked "OVERALL" for both the evaluator, labeled as "fitter," and for the subject, labeled as "subj." The rating scale is shown at the bottom of the table for this category. To assist in decisions regarding the level of the rating, each rating is defined as: excellent (1) = fits without any need for alterations; good (2) = fits with only minor alterations; fair (3) = might fit with major alterations; and poor (4) = will have to be completely remade in order to fit. In addition, a category of "cannot don (5)" was included after testing revealed that some subjects could not don some of the neighboring sizes. These definitions were repeated to the subjects and the words were tacked on the wall for each subject to see while they made their assessments.

Data Analysis

The analysis methods consisted of two phases: 1) data cleaning and preparation phase, and 2) statistical analysis phase.

Data Cleaning and Preparation Phase

Before statistical analysis for this task began, the data were checked for errors, cleaned, and formatted for analysis. Several procedures were used to check and clean the data. Subject numbers were compared to ensure that each data set (coveralls, anthropometry, and demography) contained the same subjects. The data for every 25th subject were proof-read for all information. Age and birth date discrepancies were found by comparing the differences between the test date and the birth date with the recorded age. All race codes were checked against the log book information. The first two digits of the Air Force specialty code were spot checked, particularly those with one or two digits. Frequency distributions were run to find the lowest and highest values for each dimension. Outliers which appeared were checked to see if these were errors and corrected as necessary.

Any data sheet indicating a pattern of clothing size which was out of the routine (best fit, smaller, larger, shorter, and longer) was proof-read to ensure that the corresponding coding was correctly entered in the data set of the coverall. The recorded clothing sizes for each subject were scanned for discrepancies in pattern by comparing these to computer-generated size pattern using size X as the base size. For example, if the pattern was 38R (best fit), 36R (smaller), 40R (larger), 38S (shorter), and 38L (longer), the data sheet was checked for a data entry error or a comment. If the best fit size was 44S, the column for the "SHORTER" size was checked to verify that no dimension fit data existed in columns where a size was not indicated.

To prepare the data for analysis any zeros in the data which were intended to represent missing values were replaced by missing data codes, either blanks or periods. For example, the scale was not available the first day of testing at Offutt Air Force Base (AFB), Nebraska, and thus no weight measurements were recorded. In addition, a one centimeter correction factor was added to the "Crotch Height" measurement to allow for the width of the anthropometer blade.

In addition to the above preparations, a program was written to create variables for the size which was actually rated as the best fit size. The first size given to the subjects for evaluation was the size the fitter estimated to be the best fit size; however, often times there was another size which received a better rating. The computer program written searched for the best overall rating as rated by the evaluator for all sizes tried on by a subject. Once the best fit rating had been determined it was recorded along with its associated data, such as size and area ratings as the actual "best fit" data. The order that a subject's rating was searched was the originally assigned size, then the next smaller, larger, shorter, and longer. In the case where there was a tie between two or more ratings for the overall best fit rating, the rating that was encountered first was recorded as the overall best fit rating. The other rating(s) that tied were recorded as ratings equal to the best fit rating.

Statistical Analysis Phase

Frequency tables, and summary statistics were compiled to describe the sample and the overall degree of fit for the items. This was followed by several analytical procedures for each item. These procedures included various linear models and multivariate statistics (when there were enough subjects in the sample to give the analysis sufficient statistical power). All of the models used were fixed effects models. The specific models used are described along with the results in the results section. The type IV sums of squares were necessarily used for multivariate testing due to the existence of empty size categories. The first eigenvalue and the first eigenvector which gives the coefficients of the discriminate function (see below) and the Wilks' Lambda and Pillai's Trace statistics for each Multivariate Analysis of Variance (MANOVA) are given in Appendix B.

Multivariate methods were used because important variable combinations cannot be identified if they are examined only one variable at a time (univariately). Univariate tests can lead to the wrong conclusions causing designers to fix one thing only to create another problem, and univariate tests corrected for multiple comparison error will not suffice. For example, suppose that factors contributing to tightness in the hip area of a skirt are of interest. Hip tightness can be measured by rating the hip area of a skirt on a scale from tight to loose while it is being worn by the subject. It

is suspected that the distance from the subject's hip to the waist (hip rise) and the circumference of the subject's hip (hip circumference) may be influential in determining differences between a tight hip circumference rating and a loose one. In other words, the widest portion of the skirt may be too low for some people so that they get a tight fit at the point where their hips are the widest.

Hypothetical data for this example are illustrated in Figure 5. The axes represent frequency distributions for each anthropometric variable. Inspection of each variable univariately leads to the conclusion that the distributions overlap sufficiently and have similar enough means, so that it is possible that a significant effect might not be detected for one or both variables. However, the multivariate case looks at two-dimensional space or greater. Figure 6 illustrates possible bivariate frequency distributions for two-dimensional space. Based on the relatively small amount of overlap between the two groups, it becomes apparent that they are more separated in the two-dimensional space than in either dimension separately. Therefore, in the bivariate case, both variables would more likely be considered influential in explaining hip tightness.

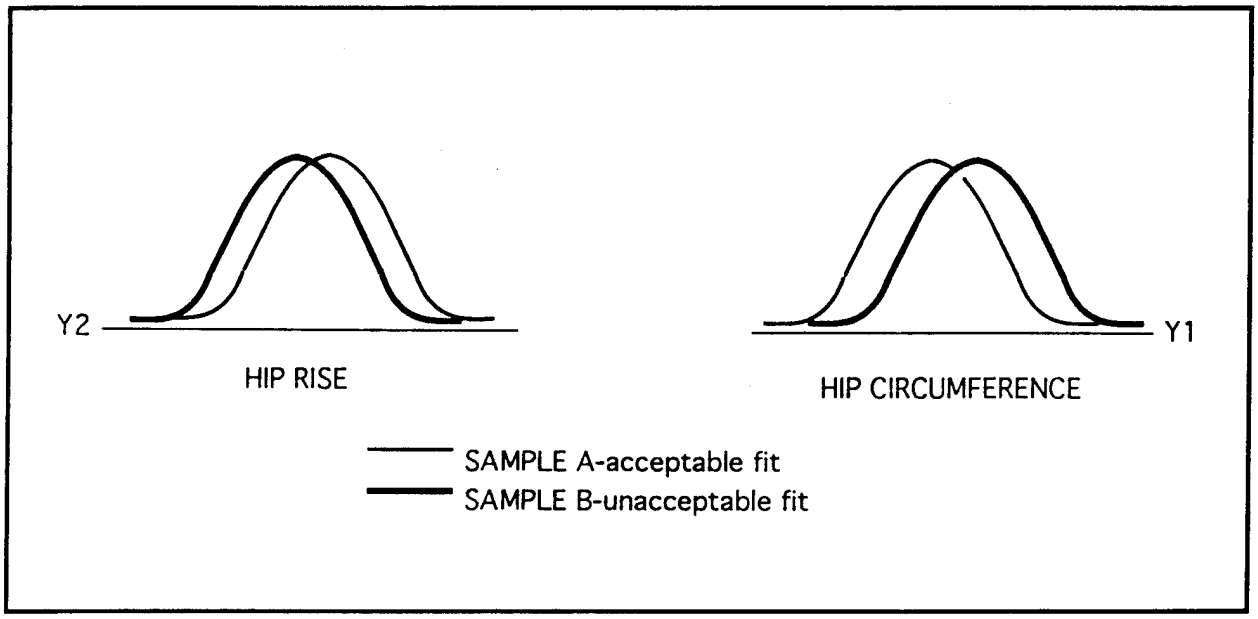

FIGURE 5. Univariate Frequency Distribution

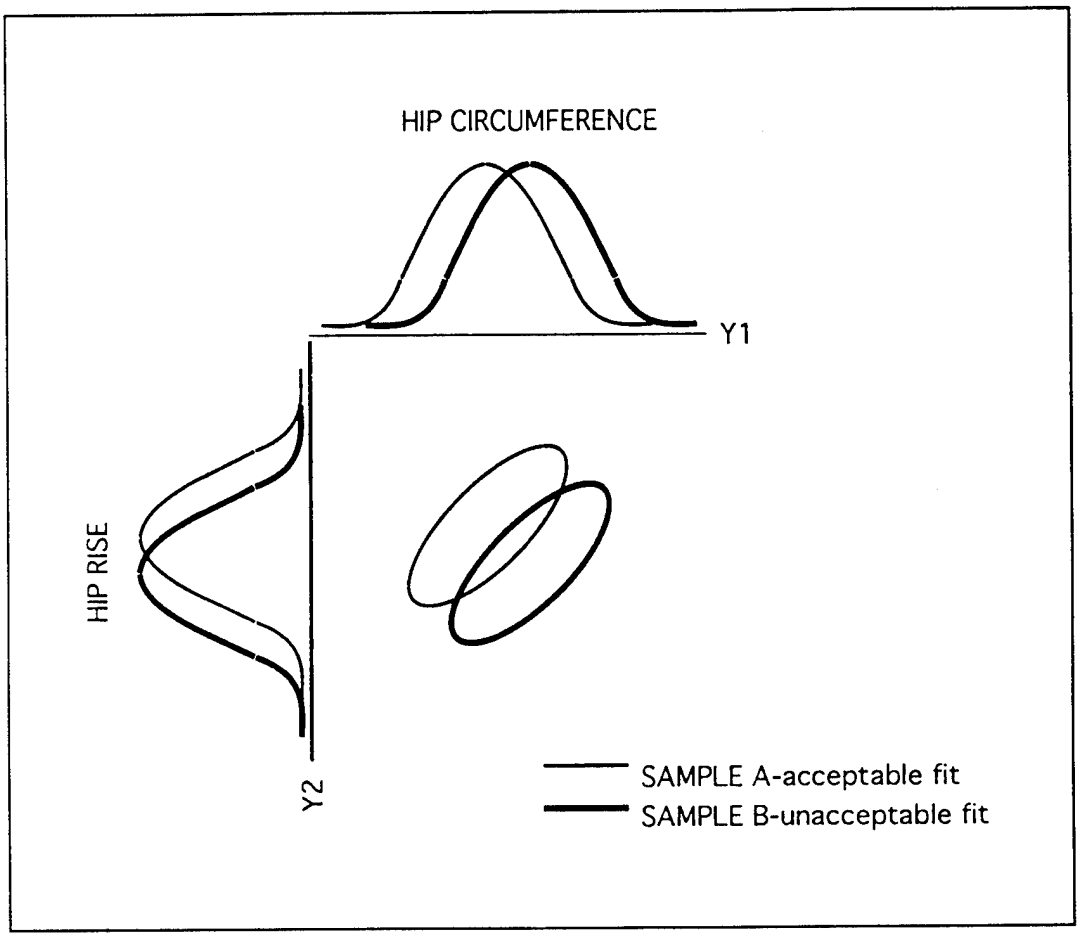

FIGURE 6. Bivariate Frequency Distributions

Multivariate methods establish what dependent variables are influential to a significant effect, because there is a relationship between the variables that is responsible for the significance. This relationship is revealed by creating a new variable for each subject that is a linear combination of the existing dependent variables. This new variable maximizes the differences between groups. In the bivariate case, the new variable is called the discriminate function and is of the form:

$$V_{ij} = k_1 Y_1 + k_2 Y_2$$

where k_1 is the weight for the variable Y_1 and k_2 is the weight for the variable Y_2. The magnitude of the weight of each variable can be used to interpret its importance in determining the reasons for group differences. Referring to the hip tightness example, univariate analyses may indicate that only hip circumference is significant. Multivariate analyses, on the other hand, may reveal that although hip circumference is influential, hip tightness is primarily due to the hip rise. In general terms, the use of univariate methods in a multivariate environment can lead to misleading or incorrect results.

RESULTS

The data sheet uses the term "upper torso" to refer to the entire torso. Note that it does not refer to the area of the torso that is above the waist as the term implies. As such, in this analysis, "upper torso" is replaced by "torso"; "upper torso" refers to the area of the torso above the waist, and "lower torso" refers to the area below the waist.

A total of 476 males and 71 females were measured. Tables 2 through 6 show the frequency distributions for location, major command, race, age, and rank, respectively, for males and females. Table 3 shows that there is a good representation of Air Combat Command (ACC), Air Mobility Command (AMC), and Air Education and Training Command (AETC) with males and females best represented in the ACC and AMC. As shown in Table 4, a total of 42 minority males and 10 minority females were evaluated. Tables 2, 5, and 6 indicate a broad distribution of locations, age, and rank.

TABLE 2. Distribution of Subjects by Test Location

	MALE		FEMALE	
LOCATION	FREQUENCY	PERCENT	FREQUENCY	PERCENT
Wright-Patterson AFB OH	47	9.9	5	7.0
Travis AFB CA	74	15.5	11	15.5
Mather AFB CA	63	13.2	6	8.5
Offutt AFB NE	75	15.8	11	15.5
Tinker AFB OK	61	12.8	29	40.8
Shaw AFB SC	64	13.4	0	0.0
Charleston AFB SC	92	19.3	9	12.7
TOTAL	476	100.0	71	100.0

TABLE 3. Distribution of Subjects by Major Command

	MALE		FEMALE	
MAJOR COMMANDS	FREQUENCY	PERCENT	FREQUENCY	PERCENT
Air Combat Command (ACC)	201		40	
Air Mobility Command (AMC)	164	34.4	18	25.4
AF Material Command (AFMC)	48		5	
Air Training Command (ATC)	61	1	6	8.4
No Response	2	0.4	2	2.8
TOTAL	476	100.0	71	100.0

TABLE 4. Distribution of Subjects by Race

	MALE		FEMALE	
RACE	FREQUENCY	PERCENT	FREQUENCY	PERCENT
Asian	4	0.8	0	0.0
Black	26	5.5	6	8.5
Caucasian (non-Hispanic)	432	90.8	61	85.9
Hispanic	12	2.5	4	5.6
No Response	2	0.4	0	0.0
TOTAL	476	100.0	71	100.0

TABLE 5. Distribution of Subjects by Age

	MALE			FEMALE		
AGE	FREQUENCY	PERCENT	CUMULATIVE PERCENT	FREQUENCY	PERCENT	CUMULATIVE PERCENT
18	3	0.6	0.6	1	1.4	1.4
19	6	1.3	1.9	2	2.8	4.2
20	12	2.5	4.4	7	9.9	14.1
21	7	1.5	5.9	7	9.9	23.9
22	8	1.7	7.6	4	5.6	29.6
23	21	4.4	12.0	2	2.8	32.4
24	33	6.9	18.9	5	7.0	39.4
25	26	5.5	24.4	2	2.8	42.3
26	26	5.5	29.8	8	11.3	53.5
27	37	7.8	37.6	4	5.6	59.2
28	34	7.1	44.7	3	4.2	63.4
29	43	9.0	53.8	3	4.2	67.6
30	35	7.4	61.1	1	1.4	69.0
31	25	5.3	66.4	5	7.0	76.1
32	25	5.3	71.6	2	2.8	78.9
33	18	3.8	75.4	2	2.8	81.7
34	14	2.9	78.6	5	7.0	88.7
35	21	4.4	83.0	2	2.8	91.5
36	16	3.4	86.3	1	1.4	93.0
37	14	2.9	89.3	1	1.4	94.4
38	14	2.9	92.2	2	2.8	97.2
39	12	2.5	94.7	1	1.4	98.6
40	5	1.1	95.8	1	1.4	100.0
41	3	0.6	96.4	0	0	-
42	5	1.1	97.5	0	0	-
43	2	0.4	97.9	0	0	-
44	8	1.7	99.6	0	0	-
45	1	0.2	99.8	0	0	-
46-48	0	0	-	0	0	-
49	1	0.2	100.0	0	0	-
TOTAL	476	100.0	-	71	100.0	-

TABLE 6. Distribution of Subjects by Rank

	MALE			FEMALE		
PAY GRADE	FREQUENCY	PERCENT	CUMULATIVE PERCENT	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Airman Basic	1	0.2	0.2	1	1.4	1.4
Airman	11	2.3	2.5	8	11.3	12.7
Airman 1st Class	25	5.3	7.8	11	15.5	28.2
Sr Airman	44	9.2	17.0	10	14.1	42.3
Staff Sergeant	55	11.6	28.6	6	8.5	50.7
Technical Sergeant	30	6.3	34.9	3	4.2	54.9
Master Sergeant	22	4.6	39.5	2	2.8	57.7
Sr Master Sergeant	6	1.3	40.8	0	0.0	57.7
Chief Master Sergeant	0	0.0	40.8	0	0.0	57.7
2d Lieutenant	25	5.3	46.0	2	2.8	60.6
1st Lieutenant	59	12.4	58.4	4	5.6	66.2
Captain	157	33.0	91.4	18	25.4	91.5
Major	30	6.3	97.7	3	4.2	95.8
Lt Colonel	8	1.7	99.4	1	1.4	97.2
Colonel	1	0.2	99.6	0	0.0	97.2
Civilian	2	0.4	100.0	2	2.8	100.0
TOTAL	476	100.0	-	71	100.0	-

Summary statistics describing the anthropometry for the samples appear in Tables 7 and 8. A visual comparison of the data sets with other similar data sets was done using joint bivariate frequency plots of stature and weight. The male and female samples are compared to the U.S. Army Anthropometric Survey (ANSUR) sample from 1988 (Gordon et. al., 1989). Additionally, the male sample is compared to the 1967 U.S. Air Force (Grunhofer and Kroh, 1975), and the female sample is compared to the Air Force women's uniform fit test sample from 1990 (Robinette et. al., in press). Figures 7 and 8 show that the male sample is quite similar in stature and weight to the ANSUR and Air Force male populations. Figure 9 suggests that the female sample is somewhat heavier than the Air Force females; although they are similar in stature. Figure 10 shows that the female sample is similar in both stature and weight to the ANSUR females.

In the analysis of each flight suit there is a common nomenclature used for many of the variables. The term "best fit" is always referred to as "BF." The individual best fit sizes have two size components, a number component (32 through 48) and a length component (S, R, and L). A nomenclature was established to distinguish the two components, "NUM" referring to the number size and "LTH" referring to the length size. Therefore, when referring to the numeric size component for the best fit size the variable is called "BFNUM," and when referring to the length component for the best fit size the variable is called "BFLTH."

TABLE 7. Summary Statistics of Anthropometric Dimensions for Male Subjects (weight in pounds, all others in inches) (N = 476)

DIMENSION	MEAN	STD DEV.	MIN.	MAX.	SKEWNESS	KURTOSIS
STATURE	69.6	2.6	61.4	79.1	0.2	0.1
WEIGHT (N=469)	175.0	23.8	112.4	263.5	0.4	0.4
ACROMION HEIGHT	56.9	2.4	48.9	66.3	0.1	0.2
BIACROMIAL BREADTH	16.2	0.7	14.2	18.6	0.0	-0.1
BIDELTOID BREADTH (N=320)	19.4	1.0	16.8	22.4	0.2	0.2
BUTTOCK CIRCUMFERENCE	39.4	2.4	33.1	46.9	0.2	0.0
BUTT-KNEE LGTH (ANSUR) (N=320)	24.3	1.1	21.3	27.3	0.0	-0.3
BUTT-KNEE LGTH (USAF) (N=320)	24.3	1.0	21.5	27.5	0.1	-0.3
CERVICALE HEIGHT	59.9	2.4	52.2	68.6	0.1	0.1
CHEST CIRCUMFERENCE	39.4	2.6	32.1	50.6	0.3	0.3
CROTCH HEIGHT	32.5	1.7	27.4	38.0	0.2	0.3
CROTCH LENGTH	25.5	1.9	20.7	32.4	0.4	0.2
EYE HEIGHT, SITTING (N=320)	31.9	1.3	28.9	36.0	0.2	-0.1
HIP CIRCUMFERENCE, MAX	39.6	2.4	32.9	47.3	0.2	0.1
HIP HEIGHT	34.6	1.8	29.8	40.9	0.3	0.2
KNEE HEIGHT, SITTING (N=320)	21.8	1.0	19.3	25.6	0.3	0.4
NECK CIRCUMFERENCE	16.4	0.8	14.5	19.5	0.3	0.3
NECK HEIGHT	57.5	2.4	50.4	66.5	0.2	0.2
SHOULDER CIRCUMFERENCE	46.5	2.4	39.0	54.9	0.1	0.4
SITTING HEIGHT (N=320)	36.6	1.3	33.2	40.9	0.1	-0.2
SLEEVE INSEAM	18.4	0.9	15.7	20.8	0.0	-0.1
SLEEVE LENGTH TOTAL	34.8	1.4	31.1	38.8	0.1	0.0
SLEEVE OUTSEAM	23.4	1.1	20.0	27.0	0.0	0.0
UPPER THIGH CIRCUMFERENCE	23.3	1.8	18.5	29.0	0.2	0.1
VERT. TRUNK CIRCUMFERENCE	65.9	3.0	58.1	74.7	0.1	-0.2
WAIST BACK	19.1	1.2	14.4	23.5	0.0	0.4
WAIST CIRCUM., OMPHALION	35.0	3.3	26.4	45.1	0.2	-0.2
WAIST CIRCUM., PREFERRED	34.7	3.1	27.0	45.4	0.3	-0.2
WAIST HEIGHT, OMPHALION	41.8	2.0	35.8	48.7	0.3	0.2
WAIST HEIGHT, PREFERRED	40.1	2.0	34.9	46.4	0.2	0.0

TABLE 8. Summary Statistics of Anthropometric Dimensions for Female Subjects (weight in pounds, all others in inches) (N = 71)

DIMENSION	MEAN	STD DEV.	MIN.	MAX.	SKEWNESS	KURTOSIS
STATURE	65.0	2.4	59.0	70.0	-0.3	-0.1
WEIGHT	141.1	20.3	101.4	198.4	0.7	0.7
ACROMION HEIGHT	53.2	2.1	47.5	57.2	-0.5	0.4
BIACROMIAL BREADTH	14.4	0.7	12.8	16.0	0.0	-0.3
BIDELTOID BREADTH (N=63)	17.3	0.9	15.3	19.3	0.1	-0.3
BUTTOCK CIRCUMFERENCE	39.1	2.7	33.9	46.0	0.4	0.1
BUTT-KNEE LGTH (ANSUR) (N=63)	23.1	1.0	21.1	25.5	0.2	-0.4
BUTT-KNEE LGTH (USAF) (N=63)	23.2	1.0	21.1	25.8	0.3	-0.2
CERVICALE HEIGHT	55.7	2.3	49.6	60.1	-0.4	0.1
CHEST CIRCUMFERENCE	36.6	2.8	30.5	43.2	0.4	0.1
CROTCH HEIGHT	30.5	1.6	27.0	33.4	-0.2	-0.3
CROTCH LENGTH	26.7	1.8	21.8	31.1	0.2	0.3
EYE HEIGHT, SITTING (N=63)	30.0	1.2	26.7	32.5	-0.2	-0.2
HIP CIRCUMFERENCE, MAX	39.5	2.8	34.0	47.2	0.4	0.2
HIP HEIGHT	31.6	1.8	28.0	35.8	0.0	-0.6
KNEE HEIGHT, SITTING (N=63)	20.2	1.0	18.0	22.5	0.1	-0.2
NECK CIRCUMFERENCE	13.9	0.7	12.6	15.6	0.2	-0.8
NECK HEIGHT	53.6	2.2	47.8	57.8	-0.4	0.0
SHOULDER CIRCUMFERENCE	41.0	2.3	36.6	47.3	0.3	0.0
SITTING HEIGHT (N=63)	34.4	1.3	31.4	36.8	-0.1	-0.4
SLEEVE INSEAM	17.3	1.0	15.2	19.3	-0.3	-0.6
SLEEVE LENGTH TOTAL	31.5	1.3	28.4	34.3	-0.2	0.1
SLEEVE OUTSEAM	21.7	1.0	19.4	23.3	-0.4	-0.7
UPPER THIGH CIRCUMFERENCE	23.3	1.8	19.2	28.5	0.1	0.4
VERT. TRUNK CIRCUMFERENCE	60.3	2.8	52.6	66.7	-0.1	0.1
WAIST BACK	15.7	1.1	12.0	17.7	-0.4	0.1
WAIST CIRCUM., OMPHALION	31.6	3.2	24.9	40.9	0.5	0.2
WAIST CIRCUM., PREFERRED	30.0	2.8	25.1	37.5	0.5	0.2
WAIST HEIGHT, OMPHALION	39.0	1.7	35.0	42.5	-0.2	-0.1
WAIST HEIGHT, PREFERRED	39.7	1.8	35.9	43.7	-0.1	-0.7

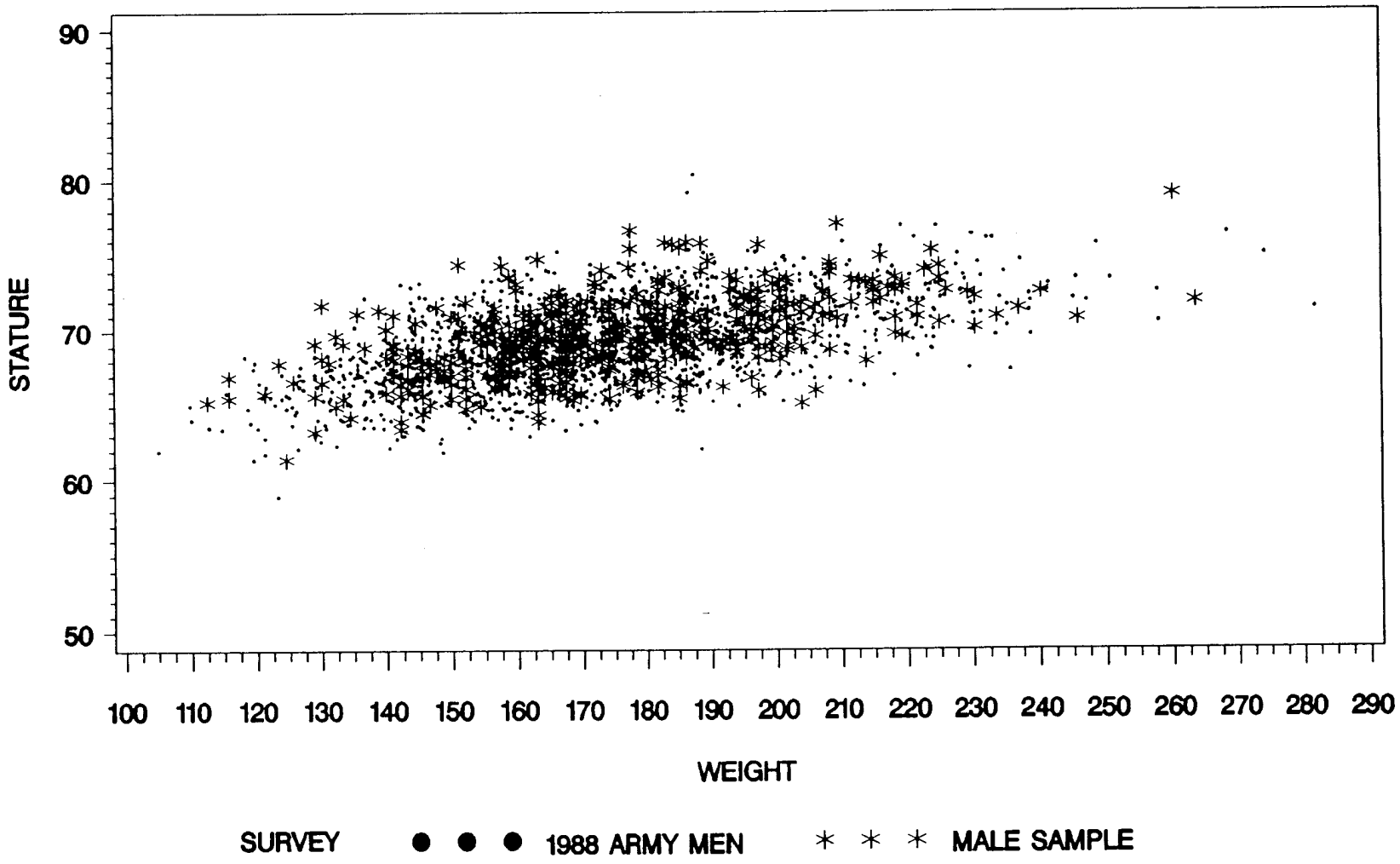

FIGURE 7. Male Subjects Compared with the 1988 U.S. Army ANSUR Males
(weight in pounds and stature in inches)

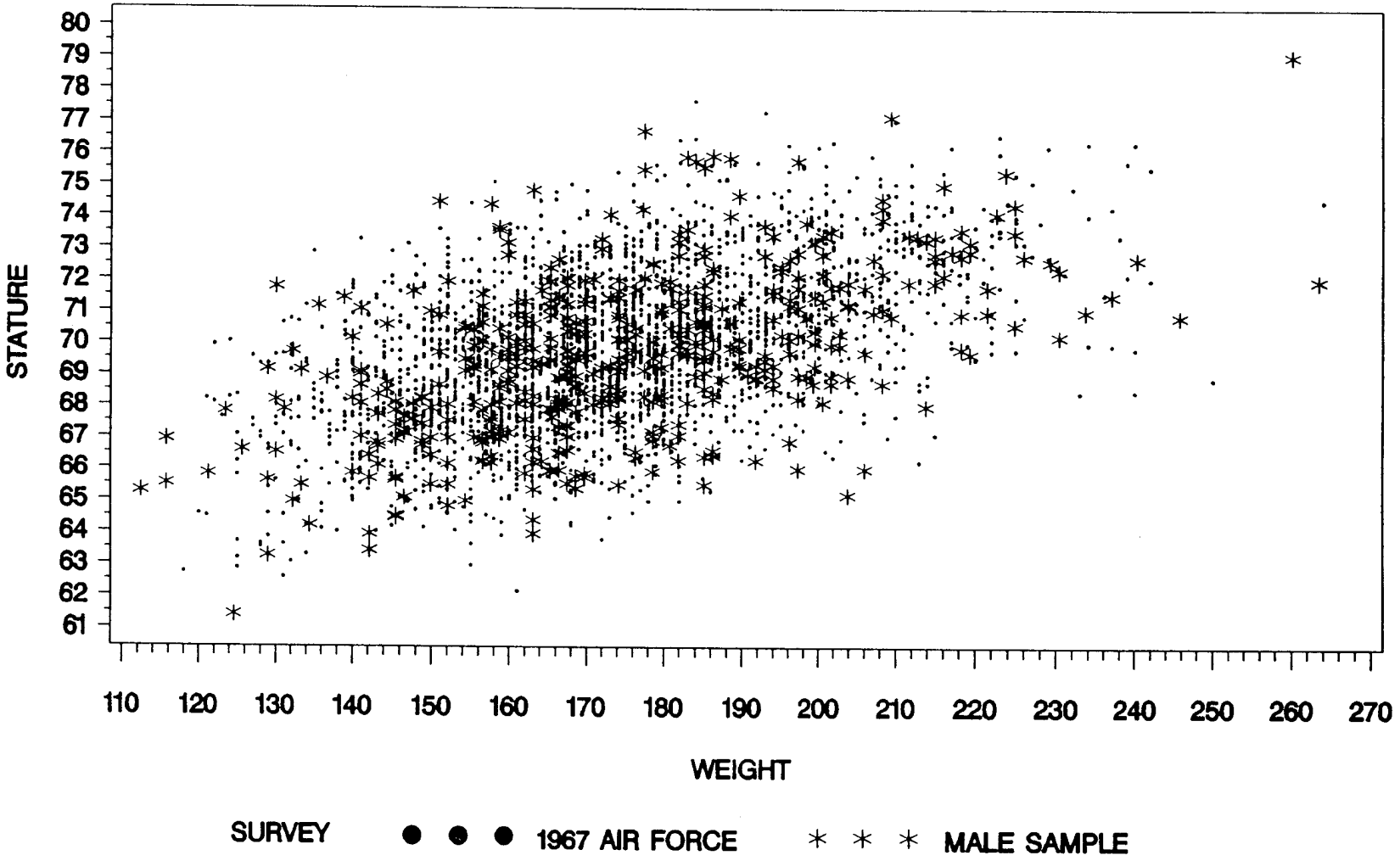

FIGURE 8. Male Subjects Compared with the 1967 U.S. Air Force Males
(weight in pounds and stature in inches)

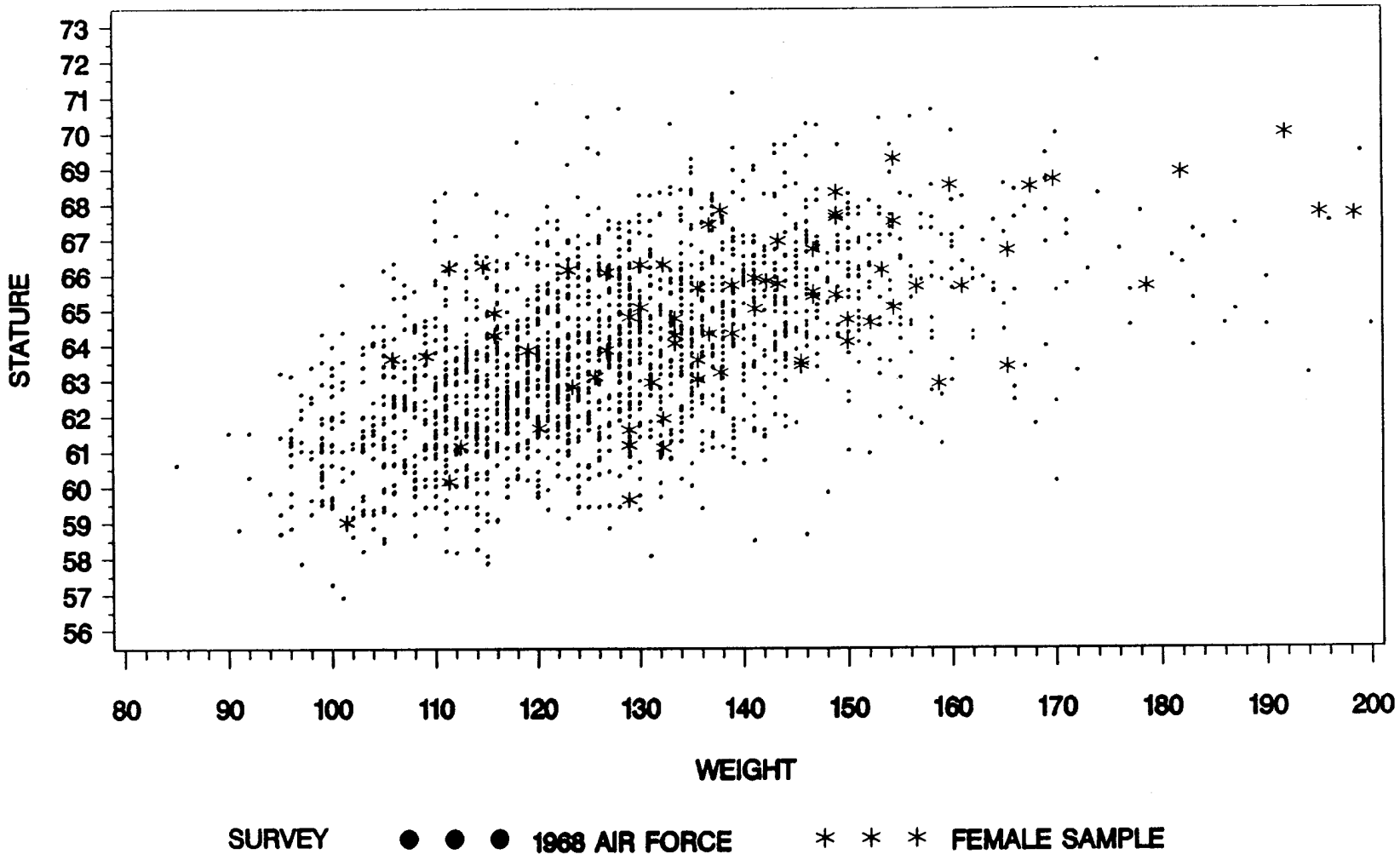

FIGURE 9. Female Subjects Compared with the 1968 U.S. Air Force Females
(weight in pounds and stature in inches)

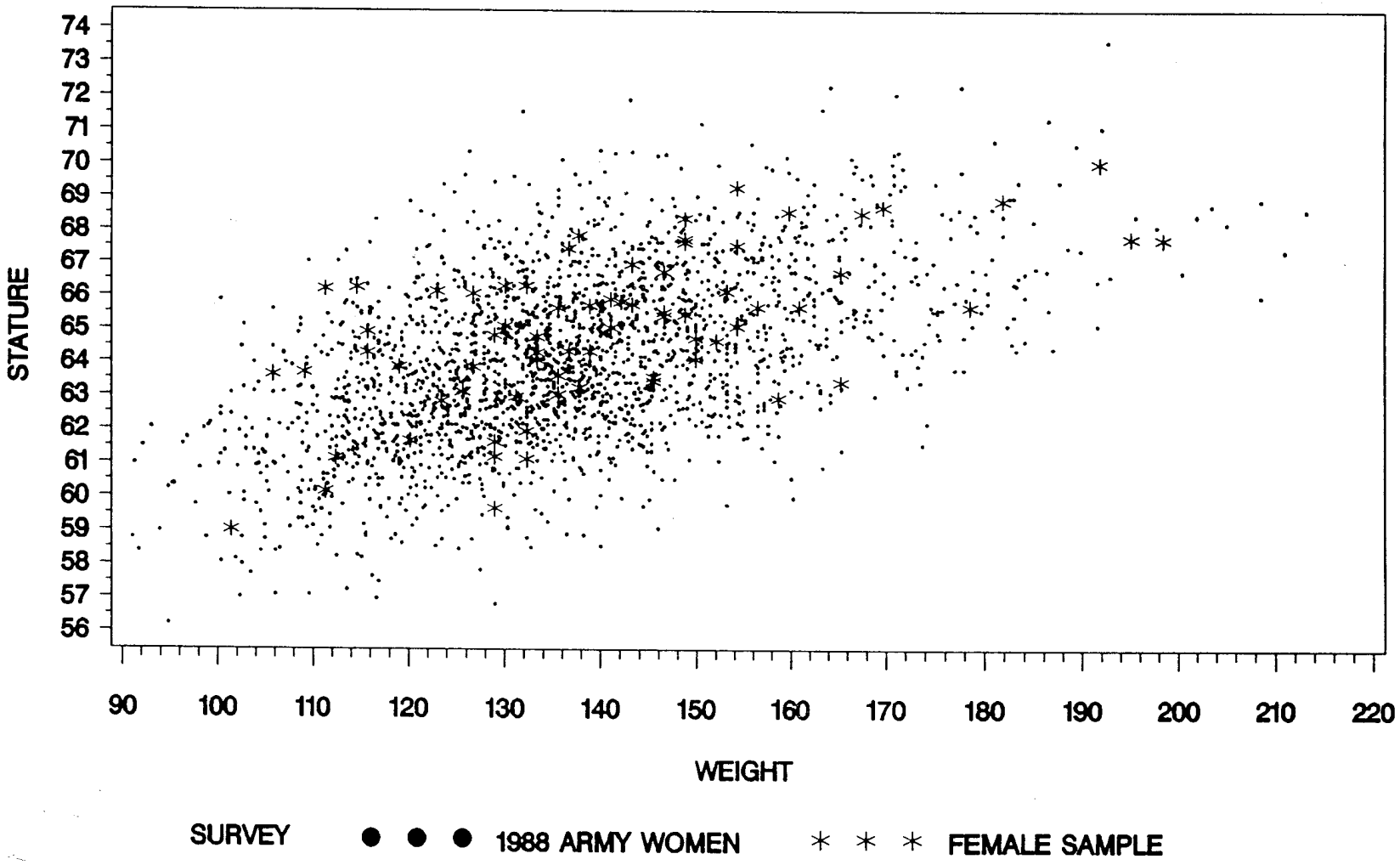

FIGURE 10. Female Subjects Compared with the 1988 U.S. Army ANSUR Females
(weight in pounds and stature in inches)

The analysis for each suit consisted of the following steps: 1) MANOVA with interpretation of the eigenvectors to identify the anthropometric variables and their combinations that reflect the variables key to determining BF size, 2) comparison of evaluator and subject overall BF ratings, 3) tabulations of garment area problems for those subjects who received a good or excellent fit, 4) tabulations of garment area problems for those subjects who received a fair or poor fit, 5) a comparison of those area ratings to determine if suits fit the same on the two groups, and 6) examination of the frequency of adjacent sizes that received overall ratings equal to or one category lower than the overall BF rating.

These procedures would indicate the type of alterations that would be required for the good and excellent ratings and what new sizes to add to accommodate the subjects who received fair or poor fit ratings. These procedures would also determine if some subjects get an equally or next BF rating in two or more sizes so that some sizes could be eliminated.

Anthropometry Key to Determining Size

MANOVAs were used to find the anthropometry which is key to determining BFNUM and BFLTH for each sex and each suit. The following anthropometric measurements were used as dependent variables in the model: weight; hip circumference, maximum; hip height; neck circumference; shoulder circumference; chest circumference; waist circumference, preferred; vertical trunk circumference (VTC); sleeve length; sleeve outseam; sleeve inseam; stature; neck height; waist height, preferred; crotch height; and biacromial breadth. The remainder of the anthropometry were omitted in order to eliminate redundancy.

For males wearing the MEAFFS, BFNUM and BFLTH are significant at the 0.01 significance level. Their interaction is not significant. Weight accounts for 91.5 percent of the variation in BFNUM. Stature accounts for 99.3 percent of the variation in BFLTH. (See Appendix B, Results 1.)

For males wearing the CD Coverall, BFNUM and BFLTH are significant at the 0.01 significance level. Their interaction is not significant. Weight and sleeve length: total account for 92.0 percent of the variation in BFNUM. Neck height accounts for 99.2 percent of the variation in BFLTH. (See Appendix B, Results 2.)

For females wearing the MEAFFS, BFNUM and BFLTH are significant at the 0.01 significance level. Their interaction is not. Crotch height contrasted with neck height account for 79.3 percent of the variation in BFNUM. Sleeve inseam contrasted neck height account for 83.1 percent of the variation in BFLTH. (See Appendix B, Results 3.)

For females wearing the CD Coverall, BFNUM and BFLTH are significant at the 0.01 significance level, but their interaction is not. Sleeve outseam and crotch height contrasted with stature account for 80.5 percent of the variation in BFNUM. Sleeve inseam and stature contrasted with neck height account for 78.0 percent of the variation in BFLTH. (See Appendix B, Results 4.)

Weight obviously figures prominently in determining number size for males wearing both the MEAFFS and the CD Coverall. The anthropometry key to determining letter size differ for the two suits worn by males. Since stature and neck height are highly correlated and since stature is a more commonly known measurement, the MANOVA for males wearing the CD Coverall was rerun without neck height to see if stature becomes more important. The results show that stature alone is by far the highest loading variable and it explains 99.25 percent of the variation in letter size. (See Appendix B, Results 5.) As such, stature and weight will be considered the keys to defining size for males wearing both suits.

Since there were only 71 female subjects, most of whom received a fair to poor fit, their results are less clear. Furthermore, practical considerations dictate that the dimensions used in the anthropometry key should be the same for both males and females. (Past studies indicate that the key dimensions for male and female are nearly similar for the same clothing item.) Stature and weight, the apparent optimal keys for males, are dimensions that are known by every member of the Air Force. Therefore, these dimensions were chosen for the anthropometry key variables, regardless of sex. Bivariate plots of stature and weight were examined to evaluate the effectiveness of the anthropometry key for both sexes.

Fit of Male Subjects in the MEAFFS

Table 9 is a bivariate frequency table of the evaluator's overall BF rating and the subjects' BF rating. It shows that 96.2 percent of the subjects were given ratings of 1 or 2 by the evaluator, while 89.5 percent of the subjects gave themselves overall fit ratings of 1 or 2.

Table 10 is a frequency table of BFNUM and BFLTH. There is a fairly good distribution of number and length sizes.

For those subjects given an overall BF rating of 1 or 2, 21.18 percent were rated as having the sleeves too long, 37.12 percent were rated as having the waist too loose, 55.89 percent were rated as having the waist too high, 56.77 percent were rated as having the hips too loose, 53.71 percent were rated as having the thighs too loose, 48.25 percent were rated as having the lower legs too loose, and 38.43 percent were rated as having the leg length too long. Collar circumference, shoulder width, chest circumference, sleeve circumference, torso length, and crotch level were rated OK for 85 percent or more of the subjects.

In order to determine if the suit fits subjects with "acceptable" overall BF ratings (1 or 2) the same as it fits subjects with "unacceptable" overall BF ratings (3 or 4), garment area ratings of both groups were compared. Garment area ratings for subjects with an overall rating of 3 or 4 show that 44.44 percent were rated as having the chest too loose, 50.0 percent were rated as having the sleeves too loose, 22.23 percent were rated as having the sleeves too short, 33.33 percent were rated as having the sleeves too long, 77.78 percent were rated as having the waist too loose, 88.89 percent were rated as having the waist too high, 83.33 percent were rated as having the hips too loose, 16.67 percent were rated as having the crotch too high, 83.33 percent were rated as having the thighs too loose, 72.22 percent were rated as having the lower legs too loose, and 44.45

TABLE 9. Bivariate Frequency of Evaluator and Male Subjects Overall Best Fit Ratings for the MEAFFS

EVALUATOR RATINGS		MALE SUBJECTS RATINGS				
		EXCELLENT	GOOD	FAIR	POOR	TOTAL
EXCELLENT	FREQUENCY	69	36	5	0	110
	PERCENT (PCT)	14.50	7.56	1.05	0.00	23.11
	ROW PCT	62.73	32.73	4.55	0.00	
	COLUMN PCT	50.00	12.50	10.20	0.00	
GOOD	FREQUENCY	68	243	37	0	348
	PERCENT (PCT)	14.29	51.05	7.77	0.00	73.11
	ROW PCT	19.54	69.83	10.63	0.00	
	COLUMN PCT	49.28	84.38	75.51	0.00	
FAIR	FREQUENCY	1	9	7	0	17
	PERCENT (PCT)	0.21	1.89	1.47	0.00	3.57
	ROW PCT	5.88	52.94	41.18	0.00	
	COLUMN PCT	0.72	3.13	14.29	0.00	
POOR	FREQUENCY	0	0	0	1	1
	PERCENT (PCT)	0.00	0.00	0.00	0.21	0.21
	ROW PCT	0.00	0.00	0.00	100.00	
	COLUMN PCT	0.00	0.00	0.00	100.00	
TOTAL	FREQUENCY	138	288	49	1	476
	PERCENT	28.99	60.50	10.29	0.21	100.00

TABLE 10. Bivariate Frequency of Best Fit Length Size and Best Fit Number Size for Male Subjects in the MEAFFS

BEST FIT LENGTH SIZE		BEST FIT NUMBER SIZE									
		32	34	36	38	40	42	44	46	48	TOTAL
LONG	FREQ.	0	0	6	14	33	37	17	1	1	109
	PCT	0.00	0.00	1.26	2.94	6.93	7.77	3.57	0.21	0.21	22.90
	ROW PCT	0.00	0.00	5.50	12.84	30.28	33.94	15.60	0.92	0.92	
	COL. PCT	0.00	0.00	13.33	10.77	21.71	38.54	45.95	25.00	20.00	
REG.	FREQ.	1	2	16	71	91	43	13	3	4	244
	PCT	0.21	0.42	3.36	14.92	19.12	9.03	2.73	0.63	0.84	51.26
	ROW PCT	0.41	0.82	6.56	29.10	37.30	17.62	5.33	1.23	1.64	
	COL. PCT	100.00	33.33	35.56	54.62	59.87	44.79	35.14	75.00	80.00	
SHORT	FREQ.	0	4	23	45	28	16	7	0	0	123
	PCT	0.00	0.84	4.83	9.45	5.88	3.36	1.47	0.00	0.00	25.84
	ROW PCT	0.00	3.25	18.70	36.59	22.76	13.01	5.69	0.00	0.00	
	COL. PCT	0.00	66.67	51.11	34.62	18.42	16.67	18.92	0.00	0.00	
TOTAL	FREQ.	1	6	45	130	152	96	37	4	5	476
	PCT	0.21	1.26	9.45	27.31	31.93	20.17	7.77	0.84	1.05	100.00

percent were rated as having the leg length too long. Collar circumference, shoulder width, and torso length were rated OK for 85 percent or more of the subjects. Basically, the problems found in subjects with "acceptable" overall ratings are intensified in subjects with "unacceptable" overall ratings.

When deciding what changes need to be made to the pattern to better accommodate a given population, the importance of fit, the ease of suit alteration, and the number of subjects affected by a pattern change in each specific area are taken into consideration. Although most of the men were given a BF rating of 1 or 2, the above frequencies indicate that the suit could be made tighter in the hip and thigh area.

Fit of Male Subjects in the CWU-66/P

Table 11 is a bivariate frequency table of the evaluator's overall BF rating and the subjects' overall BF rating. It shows that 90.3 percent of the subjects were given ratings of 1 or 2 by the evaluator, while 82.8 percent of the subjects gave themselves overall fit ratings of 1 or 2.

Table 12 is a frequency table of BFNUM and BFLTH. There is a fairly good distribution of number and letter sizes.

For subjects with an overall BF rating of 1 or 2, 24.42 percent were rated as having the shoulders too tight, 16.04 percent were rated as having the sleeves too loose, 42.56 percent were rated as having the waist too loose, 54.88 percent were rated as having the waist too high, 88.37 percent were rated as having the hips too loose, 86.75 percent were rated as having the thighs too loose, 74.89 percent were rated as having the lower legs too loose, and 33.96 percent were rated as having the leg length too long. The collar circumference, chest circumference, sleeve length, torso length, and crotch level were rated OK for 75 percent or more of the subjects.

Of the few subjects with an overall rating of 3 or 4, 45.65 percent were rated as having the shoulders too tight, 23.92 percent were rated as having the chest too tight, 43.48 percent were rated as having the sleeves too loose, 21.74 percent were rated as having the sleeves too long, 21.74 percent were rated as having the sleeves too short, 67.38 percent were rated as having the waist too loose, 60.87 percent were rated as having the waist too high, 91.30 percent were rated as having the hips too loose, 17.39 percent were rated as having the crotch too high, 28.26 percent were rated as having the crotch too low, 89.13 percent were rated as having the thighs too loose, 76.08 percent were rated as having the lower legs too loose, and 50.00 percent were rated as having the leg length too long. The collar circumference and torso length were rated OK for 97 percent or more of the subjects.

Although most of the men were given a BF rating of 1 or 2, these frequencies indicate that the suit could fit tighter in the hip and thigh area.

TABLE 11. Bivariate Frequency of Evaluator and Male Subjects Overall Best Fit Ratings for the CWU-66/P

EVALUATOR RATINGS		MALE SUBJECTS RATINGS				
		EXCELLENT	GOOD	FAIR	POOR	TOTAL
EXCELLENT	FREQUENCY	33	14	2	0	49
	PERCENT (PCT)	6.93	2.94	0.42	0.00	10.29
	ROW PCT	67.35	28.57	4.08	0.00	
	COLUMN PCT	30.56	4.90	2.82	0.00	
GOOD	FREQUENCY	75	249	52	5	381
	PERCENT (PCT)	15.76	52.31	10.92	1.05	80.04
	ROW PCT	19.69	65.35	13.65	1.31	
	COLUMN PCT	69.44	87.06	73.24	45.45	
FAIR	FREQUENCY	0	23	17	5	45
	PERCENT (PCT)	0.00	4.83	3.57	1.05	9.45
	ROW PCT	0.00	51.11	37.78	1.31	
	COLUMN PCT	0.00	8.04	23.94	45.45	
POOR	FREQUENCY	0	0	0	1	1
	PERCENT (PCT)	0.00	0.00	0.00	0.21	0.21
	ROW PCT	0.00	0.00	0.00	100.00	
	COLUMN PCT	0.00	0.00	0.00	9.09	
TOTAL	FREQUENCY	108	286	71	11	476
	PERCENT	22.69	60.08	14.92	2.31	100.00

TABLE 12. Frequency of Best Fit Length Size and Best Fit Number Size for Male Subjects in the CWU-66/P

BEST FIT LENGTH SIZE		BEST FIT NUMBER SIZE									
		32	34	36	38	40	42	44	46	48	TOTAL
LONG	FREQ.	0	0	0	9	25	35	31	10	2	112
	PCT	0.00	0.00	0.00	1.89	5.25	7.35	6.51	2.10	0.42	23.53
	ROW PCT	0.00	0.00	0.00	8.04	22.32	31.25	27.68	8.93	1.79	
	COL. PCT	0.00	0.00	0.00	13.85	18.12	23.49	36.90	47.62	22.22	
REG.	FREQ.	0	2	2	28	69	89	40	9	7	246
	PCT	0.00	0.42	0.42	5.88	14.50	18.70	8.40	1.89	1.47	51.68
	ROW PCT	0.00	0.81	0.81	11.38	28.05	36.18	16.26	3.66	2.85	
	COL. PCT	0.00	100.00	25.00	43.08	50.00	59.73	47.62	42.86	77.78	
SHORT	FREQ.	0	0	6	28	44	25	13	2	0	118
	PCT	0.00	0.00	1.26	5.88	9.24	5.25	2.73	0.42	0.00	24.79
	ROW PCT	0.00	0.00	5.08	23.73	37.29	21.19	11.02	1.69	0.00	
	COL. PCT	0.00	0.00	75.00	43.08	31.88	16.78	15.48	9.52	0.00	
TOTAL	FREQ.	0	2	8	65	138	149	84	21	9	476
	PCT	0.00	0.42	1.68	13.66	28.99	31.30	17.65	4.41	1.89	100.00

Fit of Female Subjects in the MEAFFS

Table 13 is a bivariate frequency table of the evaluator's overall BF rating and the subjects' overall BF rating. It shows that the evaluator did not give a rating of 1 to any subjects. Only 29.6 percent of the subjects were given a rating of 2, and 64.8 percent were given a rating of 3. Only 15.5 percent of the subjects gave themselves a rating of 1; 56.3 percent gave themselves a rating of 2, and 22.5 percent gave themselves a rating of 3. The subjects tended to rate themselves higher than the evaluator.

Table 14 is a frequency table of BFNUM and BFLTH. There is a fairly good distribution of number sizes, while the distribution of length sizes is skewed toward size S. A bivariate plot of mean area ratings indicated by BFLTH (Figure 11) shows that a problem definitely lies in the lengths of the suit. It is recommended that size XS (extra short) be added to any sizing system intended to accommodate females.

For subjects with an overall BF rating of 1 or 2, 71.43 percent were rated as having the collar too loose, 85.72 percent were rated as having the shoulders too loose, 28.57 percent were rated as having the chest too tight, 71.43 percent were rated as having the sleeves too loose, 52.38 percent were rated as having the sleeves too long, 100.0 percent were rated as having the waist too loose, 66.67 percent were rated as having the torso too long, 19.05 percent were rated as having the crotch too low, 38.10 percent were rated as having the lower legs too loose, and 38.10 percent were rated as having the leg length too long. Waist level, hip circumference, and thigh circumference were rated OK for 85 percent or more of the subjects.

The above frequencies indicate that females need sizes that have smaller shoulders and waists with respect to the hips. Problems in length should be all but eliminated by the addition of XS sizes. Making these changes should ensure that subjects who were given an "acceptable" fit can have an even better fit.

In order to determine if these are the same changes needed by subjects with an "unacceptable" fit, garment area ratings for subjects with overall ratings of 3 or 4 were examined. They show that 86.00 percent were rated as having the collar too loose, 82.00 percent were rated as having the shoulders too loose, 36.00 percent were rated as having the chest too tight, 92.00 percent were rated as having the sleeves too loose, 76.00 percent were rated as having the sleeves too long, 94.00 percent were rated as having the waist too loose, 86.00 percent were rated as having the torso too long, 22.00 percent were rated as having the hips too tight, 48.00 percent were rated as having the crotch too low, 78.00 percent were rated as having the lower legs too loose, and 48.00 percent were rated as having the leg length too long. Again, waist level and thigh circumference were rated OK for 85 percent or more of the subjects.

On comparison of the percentages between subjects with "acceptable" fits and those with "unacceptable" fits, it can be seen that the subjects with "unacceptable" fits have what appears to be shorter arms and crotch lengths. This data suggests that the biggest difference between subjects

TABLE 13. Bivariate Frequency of Evaluator and Female Subjects Overall Best Fit Ratings for the MEAFFS

EVALUATOR RATINGS		FEMALE SUBJECTS RATINGS				
		EXCELLENT	GOOD	FAIR	POOR	TOTAL
EXCELLENT	FREQUENCY	0	0	0	0	0
	PERCENT (PCT)	0.00	0.00	0.00	0.00	0.00
	ROW PCT	0.00	0.00	0.00	0.00	
	COLUMN PCT	0.00	0.00	0.00	0.00	
GOOD	FREQUENCY	8	11	2	0	21
	PERCENT (PCT)	11.27	15.49	2.82	0.00	29.58
	ROW PCT	38.10	52.38	9.52	0.00	
	COLUMN PCT	72.73	27.50	12.50	0.00	
FAIR	FREQUENCY	3	27	14	2	46
	PERCENT (PCT)	4.23	38.03	19.72	2.82	64.79
	ROW PCT	6.52	58.70	30.43	4.35	
	COLUMN PCT	27.27	67.50	87.50	50.00	
POOR	FREQUENCY	0	2	0	2	4
	PERCENT (PCT)	0.00	2.82	0.00	2.82	5.63
	ROW PCT	0.00	50.00	0.00	50.00	
	COLUMN PCT	0.00	5.00	0.00	50.00	
TOTAL	FREQUENCY	11	40	16	4	71
	PERCENT	15.49	56.34	22.54	5.63	100.00

TABLE 14. Frequency of Best Fit Length Size and Best Fit Number Size for Female Subjects in the MEAFFS

BEST FIT LENGTH SIZE		BEST FIT NUMBER SIZE									
		32	34	36	38	40	42	44	46	48	TOTAL
LONG	FREQ.	0	0	1	0	1	0	0	0	0	2
	PCT	0.00	0.00	1.41	0.00	1.41	0.00	0.00	0.00	0.00	2.82
	ROW PCT	0.00	0.00	50.00	0.00	50.00	0.00	0.00	0.00	0.00	
	COL. PCT	0.00	0.00	5.26	0.00	10.00	0.00	0.00	0.00	0.00	
REG.	FREQ.	2	8	5	3	3	1	1	0	0	23
	PCT	2.82	11.27	7.04	4.23	4.23	1.41	1.41	0.00	0.00	32.39
	ROW PCT	8.70	34.78	21.74	13.04	13.04	4.35	4.35	0.00	0.00	
	COL. PCT	22.22	44.44	26.32	23.08	30.00	100.00	100.00	0.00	0.00	
SHORT	FREQ.	7	10	13	10	6	0	0	0	0	46
	PCT	9.86	14.08	18.31	14.08	8.45	0.00	0.00	0.00	0.00	64.79
	ROW PCT	15.22	21.74	28.26	21.74	13.04	0.00	0.00	0.00	0.00	
	COL. PCT	77.78	55.56	68.42	76.92	60.00	0.00	0.00	0.00	0.00	
TOTAL	FREQ.	9	18	19	13	10	1	1	0	0	71
	PCT	12.68	25.35	26.76	18.31	14.08	1.41	1.41	0.00	0.00	100.00

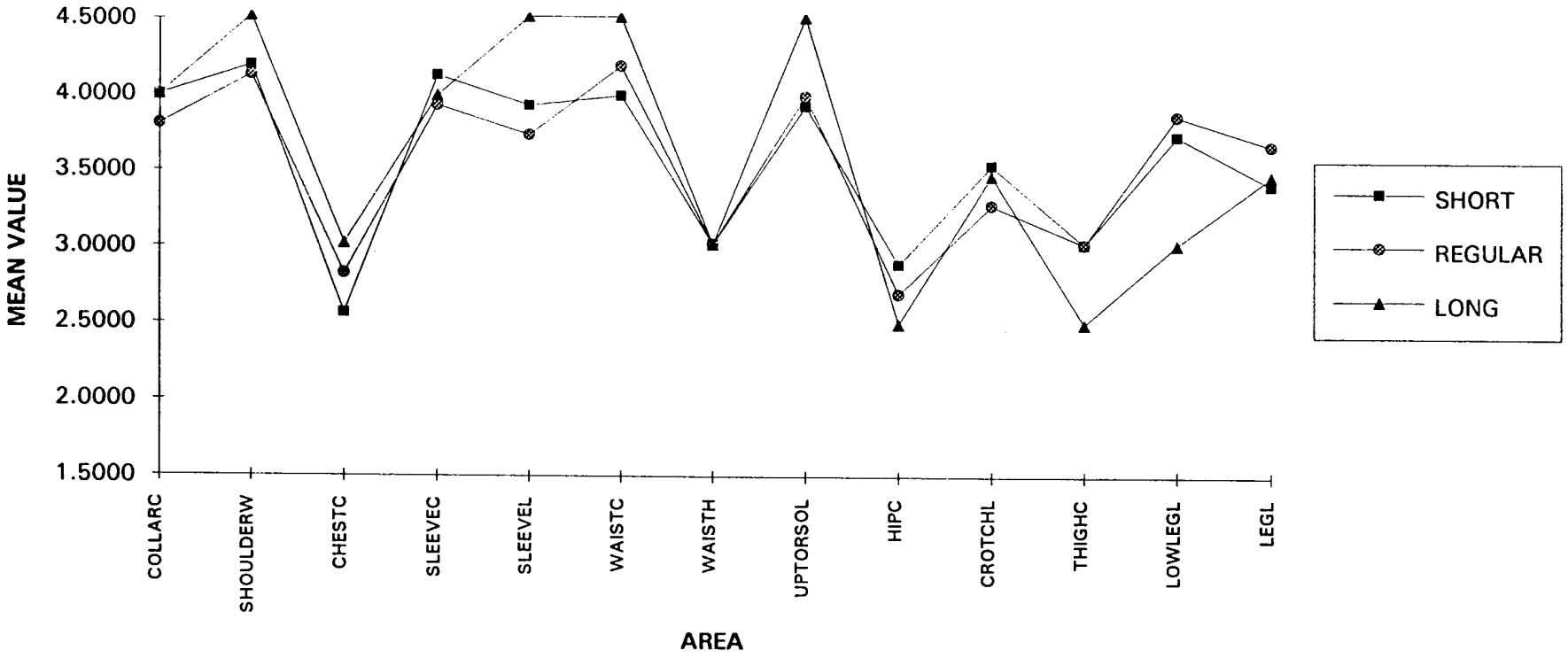

FIGURE 11. Plot of Mean Area Ratings Indicated by Length Size for Female Subjects in the MEAFFS

with "acceptable" and "unacceptable" fits is in the proportioning of their torsos. While most of the subjects with "acceptable" fits have shorter upper torso dimensions relative to their lower torso dimensions, many of the subjects with "unacceptable" fits have longer upper torso dimensions relative to their lower torso dimensions. Providing XS sizes should help eliminate some of this problem.

Fit of Female Subjects in the CWU-66/P

Table 15 is a bivariate frequency table of the evaluator's overall BF rating and the subjects' overall BF rating. It shows that the evaluator did not give a rating of 1 to any of the subjects. Only 22.5 percent of them were given a rating of 2, and 71.8 percent were given a rating of 3. Subject ratings of 1 or 2 (mostly 2) were found with 67.6 percent of the subjects, while 28.2 percent of subjects gave themselves a rating of 3. The subjects noticeably tended to rate themselves higher than the evaluator.

Table 16 is a frequency table of BFNUM and BFLTH. As with the MEAFFS, there is a good distribution of number sizes, while the distribution of length sizes is skewed toward size S. This strongly suggests that size XS (extra short) be added to the sizing system whether it is a male/female combined or separate system.

For subjects with an overall BF rating of 1 or 2, 75.00 percent were rated as having the collar too loose, 62.50 percent were rated as having the shoulders too loose, 62.50 percent were rated as having the chest too tight, 56.25 percent were rated as having the sleeves too loose, 18.75 percent were rated as having the sleeves too long, 18.75 percent were rated as having the sleeves too short, 93.75 percent were rated as having the waist too loose, 62.50 percent were rated as having the torso too long, 31.25 percent were rated as having the crotch level too low, 31.25 percent were rated as having the thighs too loose, 68.75 percent were rated as having the lower legs too loose, and 31.25 percent were rated as having the leg length too long. Waist level and hip circumference were rated OK for 85 percent or more of the subjects.

These frequencies indicate that the females need sizes that are better proportioned for them. In general, they need smaller shoulders and waists, and larger chests with respect to the hips. XS sizes should correct problems with lengths.

For subjects with an overall BF rating of 3 or 4, 76.36 percent were rated as having the collar too loose, 74.54 percent were rated as having the shoulders too loose, 50.91 percent were rated as having the chest too tight, 87.27 percent were rated as having the sleeves too loose, 54.55 percent were rated as having the sleeves too long, 92.73 percent were rated as having the waist too loose, 65.45 percent were rated as having the torso too long, 56.36 percent were rated as having the crotch level too low, 27.28 percent were rated as having the thighs too loose, 85.45 percent were rated as having the lower legs too loose, and 50.91 percent were rated as having the leg length too long. Waist level and hip circumference were rated OK for 85 percent or more of the subjects.

TABLE 15. Bivariate Frequency of Evaluator and Female Subjects Overall Best Fit Ratings for the CWU-66/P

EVALUATOR RATINGS		FEMALE SUBJECTS RATINGS				
		EXCELLENT	GOOD	FAIR	POOR	TOTAL
EXCELLENT	FREQUENCY	0	0	0	0	0
	PERCENT (PCT)	0.00	0.00	0.00	0.00	0.00
	ROW PCT	0.00	0.00	0.00	0.00	
	COLUMN PCT	0.00	0.00	0.00	0.00	
GOOD	FREQUENCY	4	10	2	0	16
	PERCENT (PCT)	5.63	14.08	2.82	0.00	22.54
	ROW PCT	25.00	62.50	12.50	0.00	
	COLUMN PCT	57.14	24.39	10.00	0.00	
FAIR	FREQUENCY	3	29	18	1	51
	PERCENT (PCT)	4.23	40.85	25.35	1.41	71.83
	ROW PCT	5.88	56.86	35.29	1.96	
	COLUMN PCT	42.86	70.73	90.00	33.33	
POOR	FREQUENCY	0	2	0	2	4
	PERCENT (PCT)	0.00	2.82	0.00	2.82	5.63
	ROW PCT	0.00	50.00	0.00	50.00	
	COLUMN PCT	0.00	4.88	0.00	66.67	
TOTAL	FREQUENCY	7	41	20	3	71
	PERCENT	9.86	57.75	28.17	4.23	100.00

TABLE 16. Frequency of Best Fit Length Size and Best Fit Number Size for Female Subjects in the CWU-66/P

BEST FIT LENGTH SIZE		BEST FIT NUMBER SIZE									
		32	34	36	38	40	42	44	46	48	TOTAL
LONG	FREQ.	0	0	1	0	1	0	0	0	0	2
	PCT	0.00	0.00	1.41	0.00	1.41	0.00	0.00	0.00	0.00	2.82
	ROW PCT	0.00	0.00	50.00	0.00	50.00	0.00	0.00	0.00	0.00	
	COL. PCT	0.00	0.00	4.35	0.00	6.25	0.00	0.00	0.00	0.00	
REG.	FREQ.	1	3	7	6	5	0	1	1	0	24
	PCT	1.41	4.23	9.86	8.45	7.04	0.00	1.41	1.41	0.00	33.80
	ROW PCT	4.17	12.50	29.17	25.00	20.83	0.00	4.17	4.17	0.00	
	COL. PCT	20.00	37.50	30.43	40.00	31.25	0.00	100.00	100.00	0.00	
SHORT	FREQ.	4	5	15	9	10	2	0	0	0	45
	PCT	5.63	7.04	21.13	12.68	14.08	2.82	0.00	0.00	0.00	63.38
	ROW PCT	8.89	11.11	33.33	20.00	22.22	4.44	0.00	0.00	0.00	
	COL. PCT	80.00	62.50	65.22	60.00	62.50	100.00	0.00	0.00	0.00	
TOTAL	FREQ.	5	8	23	15	16	2	1	1	0	71
	PCT	7.04	11.27	32.39	21.13	22.54	2.82	1.41	1.41	0.00	100.00

On comparison of the percentages between subjects with "acceptable" fits and those with "unacceptable" fits, the results are similar to those for the MEAFFS. The subjects with "unacceptable" fits have shorter arms and crotch lengths, suggesting that the biggest difference between subjects with "acceptable" and "unacceptable" fits is in the proportioning of their torsos. As with the MEAFFS, while most of the subjects with "acceptable" fit have shorter upper torso dimensions relative to their lower torso dimensions, many of the subjects with "unacceptable" fits have longer upper torso dimensions relative to their lower torso dimensions. Again, XS sizes should help eliminate some of this problem.

A bivariate plot of stature and weight indicated by BF rating (Figure 12) suggests that the suit fits better on women who were taller than 62 inches and weighed less than 148 pounds. A large group of subjects with "unacceptable" fits were less than 68 inches tall and weighed more than 148 pounds. Many of these women possibly have relatively bigger hips and smaller shoulders. If so, their area ratings would indicate that the sizing system should include sizes proportioned differently from the sizes fitting the remainder of the subjects.

A bivariate plot of mean area ratings indicated by BFLTH for the two samples mentioned above (Figures 13 and 14) indicates that the mean vectors do not appear to be very different. Therefore, it appears that the suit fits the same for all sizes of women and that the problem lies primarily in the lengths.

Adjacent Sizes

Not only were subjects rated in the size of best fit, but also in the existing sizes adjacent to the size of best fit, such as the next smaller, larger, shorter, longer. In order to determine sizes that could be eliminated, bivariate frequency tables were examined for each sex and each suit. One table consisted of the BF size and the sizes with the same overall fit rating. Another table consisted of the BF size and the sizes with the next best overall fit rating. A subject may be counted more than once within a BF size category, because he/she may have gotten an equal (or next best) fit in more than one adjacent size category. Each of these tables were then broken down by overall BF rating to ensure that a size would not be dropped if by doing so, too many subjects would be downgraded from an "acceptable" fit (1 or 2) to an "unacceptable" fit (3 or 4). This was not a problem for the most part. Bivariate frequency tables of BFNUM and BFLTH (Tables 9, 11, 13, and 15) were used to see exactly how many people actually wore each size. Since a subject could be counted more than once, these tables helped determine how many subjects got equal or next best fits in more than one size. Mainly peripheral sizes are examined, because it is easier to determine how the sizing system will be effected if they are eliminated. This information is ultimately used in developing sizing systems.

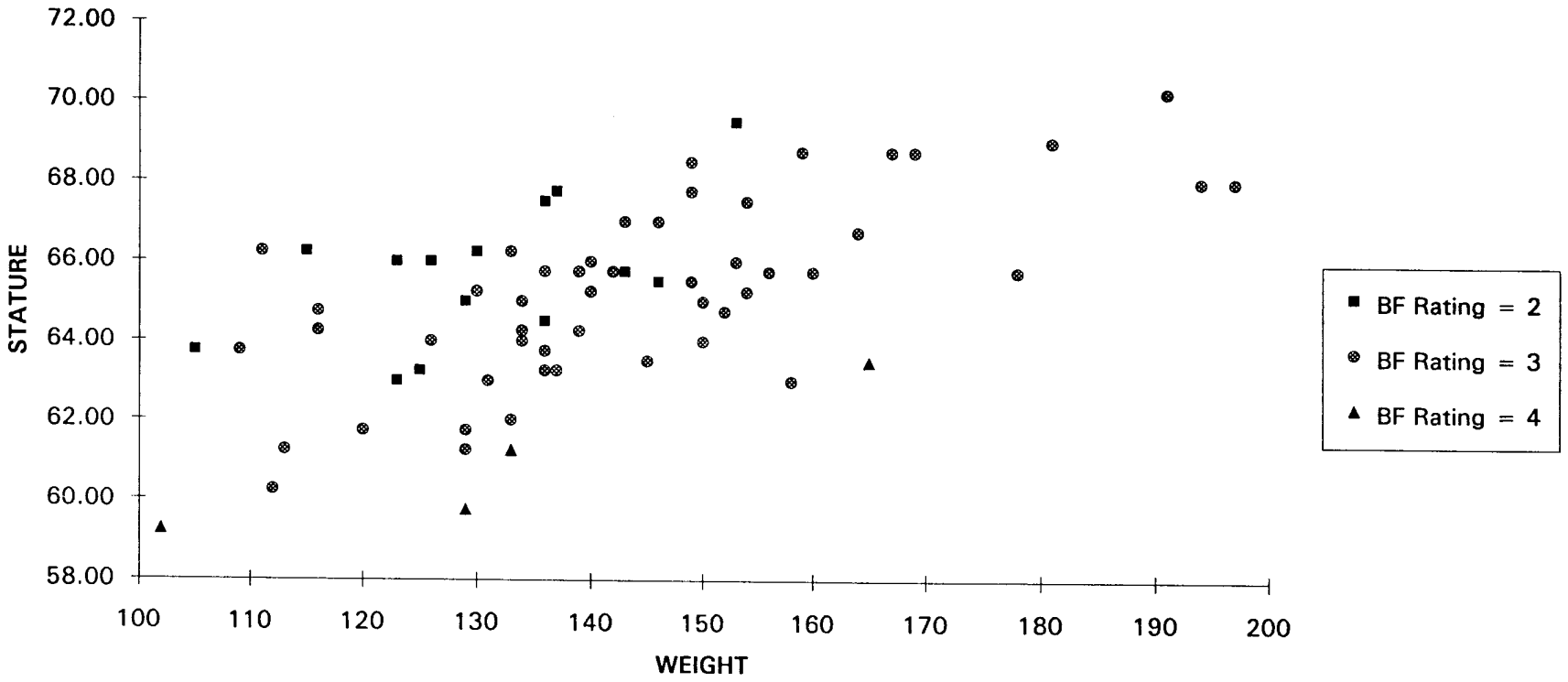

FIGURE 12. Bivariate Plot of Weight and Stature Indicated by Best Fit (BF) Ratings for Female Subjects in the CWU-66/P (weight in pounds and stature in inches)

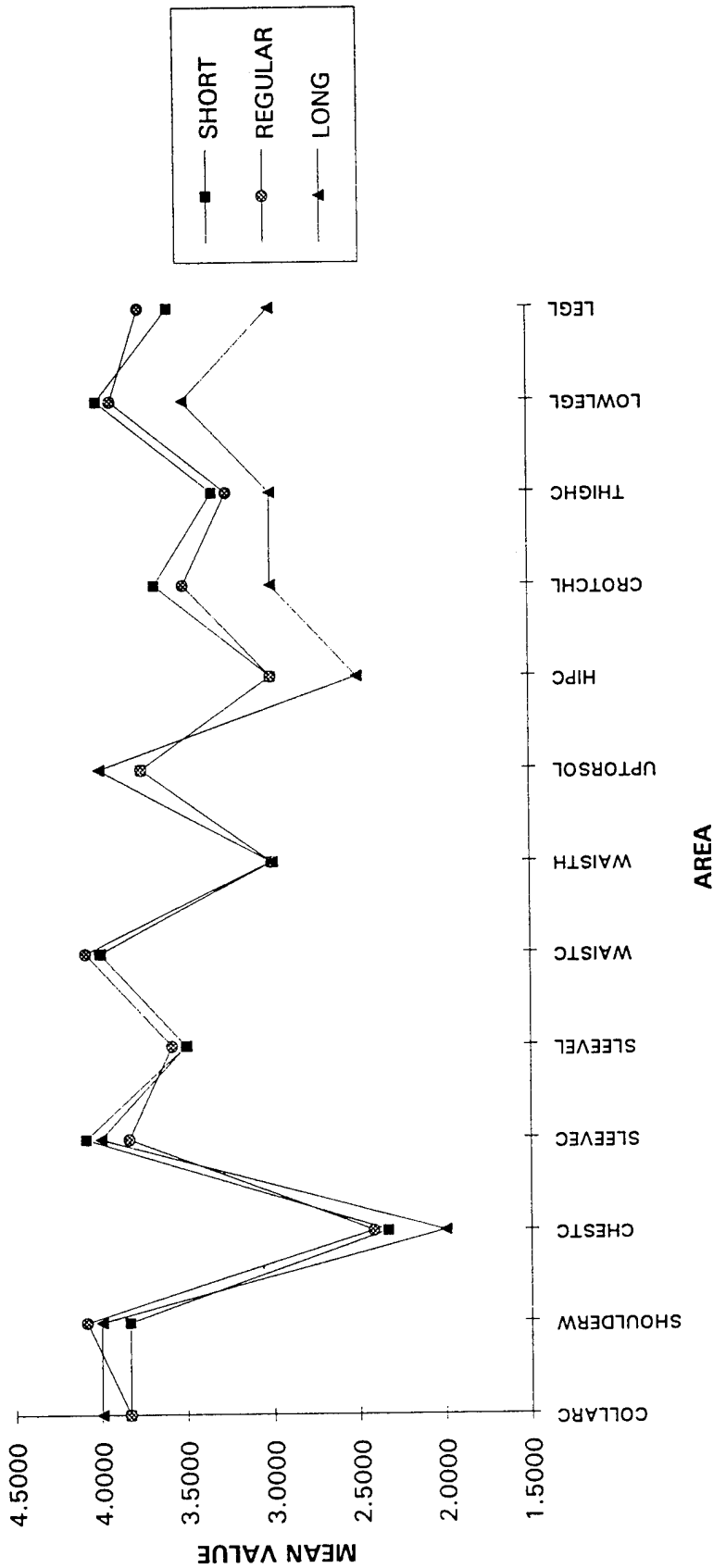

FIGURE 13. Plot of Mean Area Ratings Indicated by Length Size for Female Subjects in the CWU-66/P

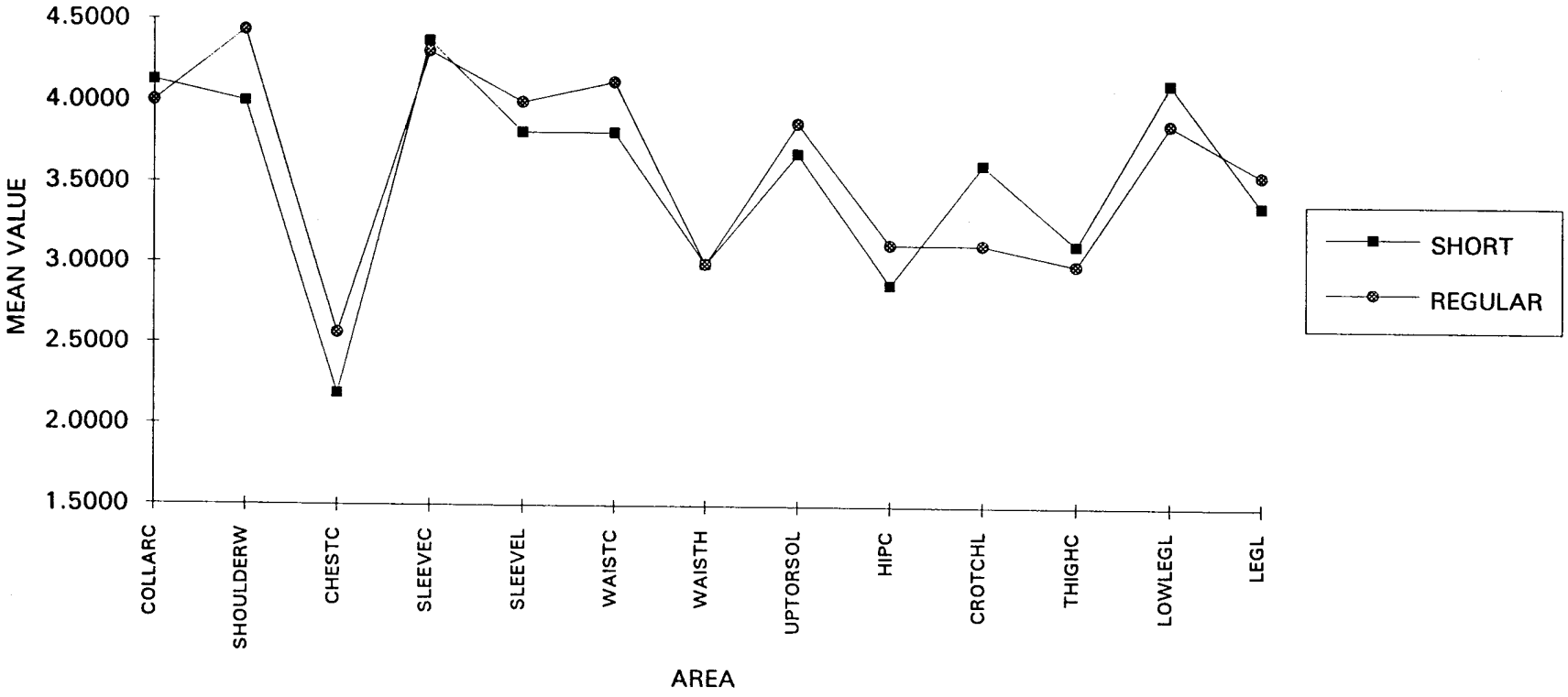

FIGURE 14. Plot of Mean Area Ratings Indicated by Length Size for Female Subjects in the CWU-66/P (Subjects >148 pounds and <68 inches)

Sizing Systems

Two possible sizing schemes were examined: a combined male/female system and a separate system for each sex.

If a unisex sizing system is developed, then XS sizes should be added to the system. Furthermore, MEAFFS sizes 32R, 46S, 48R and 48L and CD Coverall sizes 32R, 36L, and 46S can be eliminated without greatly affecting the males or females. However, if separate sizing systems based on sex are developed, then for the MEAFFS male sizing system, sizes 32S, 32R, 46S, 48R and 48L can be eliminated. For the CD Coverall male sizing system, all of size 32, 34R, 36R, and 46S can be eliminated.

The above analysis indicates that female sizes in both the MEAFFS and the CWU-66/P should include XS sizes and should be completely reproportioned. As such, it is impossible to speculate about which sizes are not needed for a female only sizing system without further fit testing after the suits have been prototyped. It is reasonable to suggest, however, that the women's sizing system should require about the same number of sizes as men.

Tariffs for a unisex sizing system for each suit are given in Tables 17 and 18.

TABLE 17. MEAFFS Tariff for a Unisex Sizing System
(All figures are in percentage, except as noted)

	BEST FIT NUMBER SIZE									
BEST FIT LENGTH SIZE	32	34	36	38	40	42	44	46	48	TOTAL
LONG	0.00	0.00	1.28	2.56	6.22	6.76	3.11	0.37	0.00	20.29
REGULAR	0.00	2.38	3.84	13.53	17.18	8.04	2.56	1.28	0.00	48.81
SHORT	1.28	2.56	6.58	10.05	6.22	2.93	1.28	0.00	0.00	30.90
TOTAL FREQ.	7	27	64	143	162	97	38	9	0	547
PERCENT	1.28	4.94	11.70	26.14	29.62	17.73	6.95	1.65	0.00	100.00

TABLE 18. CWU-66/P Tariff for a Unisex Sizing System
(All figures are in percentage, except as noted)

	BEST FIT NUMBER SIZE									
BEST FIT LENGTH SIZE	32	34	36	38	40	42	44	46	48	TOTAL
LONG	0.00	0.00	0.00	1.65	4.75	6.40	5.67	1.83	0.37	20.66
REGULAR	0.00	1.10	1.83	6.22	13.53	16.27	7.50	2.19	1.28	49.91
SHORT	0.73	0.91	3.84	6.76	9,87	4.94	2.38	0.00	0.00	29.43
TOTAL FREQ.	4	11	31	80	154	151	85	22	9	547
PERCENT	0.73	2.01	5.67	14.63	28.15	27.61	15.54	4.02	1.65	100.00

CONCLUSIONS

The results of the data analysis can be briefly summarized and applied to both the MEAFFS and the CWU-66/P. The existing sizes do not fit women well, including those sizes that fall within the body size ranges of women. Women will require some extra-short sizes and some other sizes proportioned specifically for them. The suit proportions for men are generally good and possibly a little less "room" is needed in the hip and thigh area; however, if this area is reduced the sizes will fit the women less well than they currently fit. In fact, for a unisex sizing system to fit women better, the hip and thigh areas would need to be made larger; thereby fitting men less well. This is part of the fit quality price men will pay. However, if separate sizing systems are developed, as few as eighteen sizes are needed for the men's only sizing system.

A separate sizing system is recommended for men and women. Women need to be provided with sizes that are better proportioned, but reproportioning the men's sizes to accomplish this will degrade the fit for men. Furthermore, adopting a complete women's sizing system should be easier to grade compared to a unisex system, and will make the development much less expensive.

REFERENCES

Blackwell, S.U., and K.M. Robinette (1993). Human Integration Evaluation of Three Helmet Systems, AL-TR-1993-0028, Armstrong Laboratory, Wright-Patterson AFB OH.

Gordon, C.C., B. Bradtmiller, C. Clauser, T. Churchill, J.T. McConville, I. Tebbetts, and R. Walker (1989). 1987-1988 Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics, Technical Report NATICK/TR-89-044, U.S. Army Natick Research, Development, and Engineering Center, Natick MA.

Grunhofer, H.J., and G. Kroh (1975). A Review of Anthropometric Data on German Air Force and United States Air Force Flying Personnel 1967-1968, AGARD-AG-205, Advisory Group for Aerospace Research and Development, 7 Rue Ancell 92200, Neuilly Sur Seine, France.

Mellian, S.A., C. Ervin, and K.M. Robinette (1991). Sizing Evaluation of Navy Women's Uniform, AL-TR-1991-0116, Armstrong Laboratory, Wright-Patterson AFB OH.

Robinette, K.M., M.E. Gross, S.U. Blackwell, and D. Klensch (in press). An Air Force Women's Uniform Fit Assessment, AL-TR-199X-XXXX, Armstrong Laboratory, Wright-Patterson AFB OH.

Robinette, K.M., S.A. Mellian, and C.A. Ervin (1991). Development of Sizing Systems for Navy Women's Uniforms, AL-TR-1991-0117, Armstrong Laboratory, Wright-Patterson AFB OH.

Zehner, G.F., C. Ervin, K.M. Robinette, and P. Daziens (1987). Fit Evaluation of Female Body Armor, AAMRL-TR-87-046, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB OH.

APPENDIX A

Description of Anthropometric Measurements

Landmarks (marked landmarks only)

CERVICALE: The superior point of the spine of the most prominent cervical vertebra, which is usually the seventh. The subject stands erect with the head in the Frankfort plane. The spine of the seventh cervical vertebra is the most prominent vertebral spine of the back of the neck. It is best found by having the subject bend the head downwards. Stand behind the subject and palpate the most prominent spine. Have the subjects slowly return to the Frankfort plane while intermittently touching the vertebra. When the head is in place, locate the superior point of the seventh cervical vertebra and mark it with a cross.

ACROMION, right and left: The acromion landmark is the lateral point of the acromial process of the scapula. It is located by palpating the superior surface of the acromial process on the top of the shoulder, moving laterally until the lateral border is reached. Then palpate the lateral border until the lateral point is reached.

WRIST: The wrist landmarks are immediately distal to the radial and ulnar stylod processes. A mark is drawn at the base of the radial styloid process. A second mark is drawn at the base of the ulnar styloid process. A rubber band is placed around the wrist at the level of the two marks and a short line is drawn on the center of the wrist, top and bottom, at the level of the band.

DELTOID POINT, right and left: The lateral point of the right deltoid muscle, and the margin of the left deltoid muscle at the level of the right deltoid point. The subject stands erect with the head in the Frankfort plane. Stand in front of the subject and locate, by inspection, the most protruding point of the right upper armoverlying the deltoid muscle. Draw a short horizontal mark through the landmark. Use a landmark transfer rod to establish the location of the left deltoid landmark.

WAIST (OMPHALION), right and left, anterior and posterior: Level of the center of the navel. The subject stands erect with the head in the Frankfort plane. Stand in front of the subject and locate the landmark by inspection. Draw a 4 cm horizontal line across omphalion, and using a landmark transfer rod, establish the other marks on the right and left sides, and on the back at the spine of the subject. The marks are drawn at the maximum point of quiet respiration.

WAIST (PREFERRED), right and left, anterior and posterior: The level at which the subject prefers his waist; an elastic band is placed around the waist. Instruct the subject to position the elastic band where a belt is normally worn. Make certain that the elastic does not constrict the waist. A mark is drawn at the level of the elastic on the center of the abdomen, on the right and left sides, and on the back at the spine. The marks will not necessarily be horizontal.

BUTTOCK POINT, right lateral and left lateral: Points on the thigh or hip at the level of the maximum protrusion of the right buttock. The subject stands erect with the head in the Frankfort

plane. Stand at the right of the subject and sight the point of maximum protrusion of the right buttock. Set the landmark transfer rod to the height of this protrusion and mark the level on the right and left sides.

NECK, right lateral and left lateral, anterior: The subject stands erect and looking forward. Facing the subject, place a thin bolo tie as low as possible around the base of the subject's neck and slide the holder up to the base of the neck. The cord around the neck should lie in a plane perpendicular to the long axis of the neck. Draw a mark at the bottom of the cord on the anterior side of the neck in the midsagittal plane and on the right and left sides.

SUPRAPATELLA: The superior point of the patella (kneecap). The subject stands with the patella relaxed. Stand in front of the subject and grasp the sides of the patella between the thumb and third finger, using the index finger to locate the top of the patella. In trying to locate the upper border of the patella, it may help to run your thumb and third finger up and down along its upper sides. When the top of the kneecap has been located, draw a short horizontal line through the point.

TROCHANTER: A point at the center of the lateral surface of the right greater trochanter of the right femur of a sitting subject. The subject sits with the knees flexed about 90 degrees. Stand at the right of the subject. Palpate the lateral surface of the greater trochanter near the hip joint and estimate its center. Place a mark on the landmark.

LATERAL FEMORAL EPICONDYLE, sitting: Lateral point of the right femoral epicondyle (knee pivot point). The subject sits with the knees flexed about 90 degrees. Grasp the bony prominences on the bottom of the femur (femoral epicondyles) located to the right and the left of the knee. When you have located the lateral point of the lateral femoral epicondyle, mark it with a short line.

Dimensions (in measurement order)

WEIGHT: The weight of the subject is taken to the nearest half kilogram, while the subject stands erect on the platform of the scale, looking straight ahead. The weight should be equally distributed on both feet.

THIGH CIRCUMFERENCE: The circumference of the right thigh at its juncture with the buttock is measured with a tape. The measurement is made perpendicular to the long axis of the thigh. The subject stands erect on a table, looking straight ahead. The weight is distributed equally on both feet. The legs are spread apart just enough so that the thighs do not touch.

BUTTOCK CIRCUMFERENCE: The horizontal circumference of the trunk at the level of the maximum protrusion of the right buttock is measured with a tape. The subject stands erect on a table, looking straight ahead, with heels together and the weight equally distributed on both feet. Place the tape over both the buttock landmarks, making certain that the tape is horizontal.

HIP CIRCUMFERENCE: The maiximum circumference of the hips is measured with a tape. Subjects stand erect on a table, looking straight ahead, with heels together and the weight equally distributed on both feet. The arms are folded near the waist. The measurer and the recorder take this mesurement as a team, with the measurer on the subject's left side and the recorder on the subject's right. The tape is placed around the subject's torso about 2 cm above the maximum protrusion of the buttock. The measurer and the recorder use each other and a mirror in front of the subject to verify that the tape is horizontal at all times. The tape is moved inferiorly in approximately 1 cm intervals at the direction of the measurer. The measurer reads the tape noticing the increase in circumference. The tape is moved thus until the circumference no longer increases, and begins to decrease. Final adjustments of the tape is made to achieve the level of maximum circumference. Visual inspection of the subject will often suggest the approximate area where this will occur. At the level of the maximum circumference, the measurer will read the circumference from the tape. *In some subjects the maximum circumference will occur over a fairly broad area. In such cases, the level is defined as the midpoint of maximum circumference.*

HIP HEIGHT: The vertical height of the maximum circumference of the hips is measured with an anthropomter. The subject remains in the position used for Hip Circumference. The level of maximum circumference is determined as described in Hip Circumference. The height is measured by the recorder while the tape is still in place from the measurement of Hip Circumference. The height is measured to the middle of the tape.

NECK CIRCUMFERENCE: The circumference of the neck at its base is measured with a tape. The subject stands erect, looking straight ahead. Standing behind the subject, place the tape on the anterior neck mark and ask the subject to gently place an index finger on the tape while you pass the tape over the lateral neck marks, cross it back and read the value. Exert only enough tension to maintain contact with the skin.

SHOULDER CIRCUMFERENCE: The horizontal circumference of the shoulder at the level of the maximum protrusion of the right deltoid muscle is measured with a tape. Subject stands erect, looking straight ahead, with heels together and the weight equally distributed on both feet. Place the tape over the right and left deltoid marks and measure the circumference of the shoulder, making certain that the tape is horizontal. The measurement is taken at the maximum point of quiet respiration.

CHEST CIRCUMFERENCE: The maximum horizontal circumference of the chest at the fullest part of the breast is measured with a tape. The subject stands erect, looking straight ahead, with heels together and the weight equally distributed on both feet. The shoulders and upper extremities are relaxed. The measurement is taken at the maximum point of quiet respiration.

WAIST CIRCUMFERENCE (OMPHALION): The horizontal circumference of the waist at the level of the center of the navel (omphalion) is measured with a tape. The subject stands erect, looking straight ahead, with heels together and the weight equally distributed on both feet. The subject must not suck in the abdomen. Place the tape over the omphalion waist landmarks, making certain that the tape is horizontal. The measurement is made at the maximum point of quiet respiration.

WAIST CIRCUMFERENCE (PREFERRED): The circumference of the subject's preferred waist is measured with a tape. The subject stands erect, looking straight ahead, with heels together and the weight equally distributed on both feet. The subject must not suck in the abdomen. Place the tape around the subject's torso so that it lays on all the preferred waist landmarks. The tape may not be horizontal. Measure the circumference at the maximum point of quiet respiration.

WAIST BACK LENGTH (PREFERRED): The vertical surface distance from the Cervicale landmark to the level of the preferred waist landmark is measured with a tape. The subject stands erect, looking straight ahead, with heels together and the weight equally distributed on both feet. The tape may span body hollows.

CROTCH LENGTH: The distance between the waist (preferred level) on the anterior side to the same level on the back is measured with a tape passing through the crotch to the right of the genitalia. The tape is held vertically both in front and in back. The subject stands erect looking straight ahead and must not suck in the abdomen. The heels are together with the weight distributed equally on both feet. Ask the subject to spread the legs for initial placement of the tape, and then to bring the legs back together for reading the measurement. The starting point and termination is the anterior and posterior preferred waist landmarks, respectively. The measurement is taken at the maximum point of quiet respiration.

VERTICAL TRUNK CIRCUMFERENCE: The vertical circumference of the torso is measured with a tape passing between the buttocks, to the right of the genitalia, over the right bust on women or the nipple on men, and across the middle of the shoulder. The subject stands erect looking straight ahead with the arms hanging relaxed at the side. The heels are together with the weight distributed equally on both feet. Ask the subject to slightly spread the legs for initial placement of the tape. The heels are then brought back together. The measurement is taken at the maximum point of quiet respiration.

SLEEVE LENGTH: The surface distance, following the arm, from the Cervicale landmark to the Wrist landmark. The subject stands erect, looking straight ahead. The upper arm is relaxed at the side, but the arm is bent 90 degrees at the elbow, and the palm faces the torso. Measure with a tape from the Cervicale across the shoulder, bending over Acromion, following down the upper arm, bending around the elbow, to the mark on the ulnar side of the wrist. It is preferred to continue holding the zero end of the tape on Cervicale throughout the measurement, but this may not be possible. When this is impossible, verify the zero on Cervicale, and ask the recorder to hold the tape on Acromion while you measure the rest of the arm.

SLEEVE OUTSEAM: The straight-line distance between the acromion landmark on the tip of the right shoulder and the mark on the center of the right wrist is measured with a tape. The subject stands erect with both arms straight at the sides and the palms facing the thighs.

SLEEVE INSEAM: The straight-line distance between the axilla and the wrist is measured with a tape modified to include an axilla form. The subject stands erect with heels together, looking straight ahead. The arm is straight (not hyperextended) at the elbow. Measure from the highest point in the axilla to the center wrist landmark on the palm side of the hand. The axilla form

should be placed firmly in the axilla, but not so much as to cause discomfort. Note that the subjects will often tend to raise the shoulder; this must be avoided. The tape will not necessarily follow the contour of the arm.

STATURE: The vertical distance from a standing surface to the top of the head is measured with an anthropometer. The subject stands erect with the head in the Frankfort plane. The heels are together with the weight distributed equally on both feet. The shoulders and upper extremities are relaxed. The measurement is taken at the maximum point of quiet respiration.

CERVICALE HEIGHT: The vertical distance between a standing surface and the cervicale landmark on the spine at the base of the neck is measured with an anthropometer. The subject stands erect with the head in the Frankfort plane. The heels are together with the weight distributed equally on both feet. The shoulders and upper extremities are relaxed. The measurement is taken at the maximum point of quiet respiration.

ACROMION HEIGHT: The vertical distance between a standing surface and the acromion landmark on the tip of the right shoulder is measured with an anthropometer. The subject stands erect with the head in the Frankfort plane. The heels are together with the weight distributed equally on both feet. The shoulders and upper extremities are relaxed. The measurement is made at the point of quiet respiration.

NECK HEIGHT: The vertical distance between a standing surface and the neck landmark on the anterior surface of the neck is measured with an anthropometer. The subject stands erect with the head in the Frankfort plane. The heels are together with the weight distributed equally on both feet. The shoulders and upper extremities are relaxed. The measurement is made at the point of quiet respiration.

WAIST HEIGHT (OMPHALION): The vertical distance between a standing surface and the center of the navel (omphalion) is measured with an anthropometer. The subject stands erect, looking straight ahead. The heels are together with the weight distributed equally on both feet. The shoulders, upper extremities, and abdomen are relaxed. The measurement is made at the point of quiet respiration.

WAIST HEIGHT (PREFERRED): The vertical height of the subject's preferred waist is measured with an anthropometer. The subject stands erect with heels together, looking straight ahead and must be cautioned against sucking in the abdomen. The height is measured at the anterior preferred waist landmark.

CROTCH HEIGHT: The vertical distance between the standing surface and the crotch is measured with an anthropometer. Position the blade of the anthropometer so that the blunt end is facing the subject. Ask the subject to spread the legs, place the anthropometer to the right of the genitalia and then pull the anthropometer blade up until it is in firm contact with the crotch. Then have the subject stand erect, looking straight ahead, with heels together and the weight distributed equally on both feet. Ask the subject to adjust the blade. Then exert additional upward pressure on the slide of the anthropometer to achieve firm and uniform placement. Read the instrument

while it is still in place. The computer will add 1 cm to account for the width of the anthropometer blade.

BIACROMIAL BREADTH: The distance between the right and left acromion landmarks at the tips of the shoulders is measured with a beam caliper. The subject stands erect, looking straight ahead, with the shoulders and arms hanging relaxed at the side. The measurement is taken at the maximum point of quiet respiration.

SITTING HEIGHT: The vertical distance between a sitting surface and the top of the head is measured with an anthropometer. The subject sits erect with the head in the Frankfort plane. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The thighs are parallel and the knees are flexed 90 degrees with the feet in line with the thighs. The measurement is made at the maximum point of quiet respiration.

EYE HEIGHT, SITTING: The vertical distance between a sitting surface and the ectocanthus landmark on the outer corner of the right eye is measured with an anthropometer. The subject sits erect with the head in the Frankfort plane. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The thighs are parallel and the knees are flexed 90 degrees with the feet in line with the thighs. The measurement is made at the maximum point of quiet respiration.

KNEE HEIGHT, SITTING: The vertical distance between a footrest surface and the suprapatella landmark at the top of the right knee (located and drawn while the subject stands) is measured with an anthropometer. The subject sits with the thighs parallel, the knees flexed 90 degrees, and the feet in line with the thighs.

BUTTOCK-KNEE LENGTH (ANSUR): The horizontal distance between a buttock plate placed at the most posterior point on either buttock and the anterior point of the right knee is measured with an anthropometer. The subject sits erect. The thighs are parallel and the knees flexed 90 degrees with the feet in line with the thighs.

BUTTOCK-KNEE LENGTH (AF): The horizontal distance between the posterior point of the buttock and the anterior point of the knee is measured with a beam caliper. The subjects sit erect. The thighs are parallel and the knees flexed 90 degrees with the feet in line with the thighs. The beam of the caliper is parallel to the long axis of the femur.

BIDELTOID BREADTH: The maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles is measured with a beam caliper. The subject sits erect, looking straight ahead. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. Keeping the beam of the caliper horizontal, brush the blades up and down against the sides of the upper arm to assure a maximum breadth. The measurement is made at the maximum point of quiet respiration.

APPENDIX B

Results of MANOVA Procedures

RESULTS 1: Number of observations used in this analysis = 469

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

First Eigenvalue: 2.95028794 Percent: 91.49
First Eigenvector:

0.00080600 (Weight)	-0.00007460 (Hip Circ, Max)
0.00003357 (Hip Height)	-0.00037349 (Neck Circ)
0.00006352 (Shoulder Circ)	0.00008447 (Chest Circ)
0.00017183 (Waist Circ, Prefer)	0.00020926 (Vertical Trunk Circ)
0.00008393 (Sleeve Length, Total)	0.00044570 (Sleeve Outseam)
-0.00027809 (Sleeve Inseam)	0.00031286 (Stature)
-0.00019433 (Neck Height)	0.00028310 (Waist Ht, Prefer)
0.00026886 (Crotch Height)	0.00027815 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFNUM Effect

H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.19397825	6.24037	128	3127.91	0.0001
Pillai's Trace	1.00521628	3.94303	128	3512	0.0001

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 2.32515540 Percent: 99.34
First Eigenvector:

0.00014140 (Weight)	0.00016942 (Hip Circ, Max)
0.00001903 (Hip Height)	-0.00027283 (Neck Circ)
-0.00008542 (Shoulder Circ)	0.00030344 (Chest Circ)
-0.00001118 (Waist Circ, Prefer)	0.00031721 (Vertical Trunck Circ)
-0.00023298 (Sleeve Length, Total)	0.00054852 (Sleeve Outseam)
0.00008776 (Sleeve Inseam)	0.00073635 (Stature)
0.00030999 (Neck Height)	0.00026849 (Waist Ht, Prefer)
0.00011441 (Crotch Height)	0.00056881 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFLTH Effect

H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.29619356	22.6108	32	864	0.0001
Pillai's Trace	0.71437254	15.0376	32	866	0.0001

NOTE: F Statistic for Wilks' Lambda is exact.

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 0.10136957 Percent: 24.01
First Eigenvector:

-0.00005974 (Weight)	-0.00014223 (Hip Circ, Max)
0.00031324 (Hip Height)	0.00143479 (Neck Circ)
0.00025250 (Shoulder Circ)	-0.00077071 (Chest Circ)
0.00029954 (Waist Circ, Prefer)	0.00044967 (Vertical Trunk Circ)
0.00080823 (Sleeve Length, Total)	0.00087618 (Sleeve Outseam)
-0.00139970 (Sleeve Inseam)	-0.00112664 (Stature)
-0.00101646 (Neck Height)	0.00063838 (Waist Ht, Prefer)
0.00091632 (Crotch Height)	-0.00144686 (Biacromial Breadth)

MANOVA Test Criteria and F Approx. for the Hypothesis of No Overall BFNUM*BFLTH Effect

H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.66409002	1.03348	176	3964.32	0.3681
Pillai's Trace	0.39744782	1.03555	176	4862	0.3605

RESULTS 2: Number of observations used in this analysis = 469

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

First Eigenvalue: 2.70843283 Percent: 92.01
First Eigenvector:

0.00076435 (Weight)	-0.00009463 (Hip Circ, Max)
0.00006567 (Hip Height)	-0.00021911 (Neck Circ)
0.00025217 (Shoulder Circ)	0.00000332 (Chest Circ)
0.00003078 (Waist Circ, Prefer)	0.00025452 (Vertical Trunk Circ)
0.00051361 (Sleeve Length, Total)	0.00005900 (Sleeve Outseam)
-0.00036758 (Sleeve Inseam)	-0.00019922 (Stature)
0.00037938 (Neck Height)	0.00016741 (Waist Height, Prefer)
0.00017243 (Crotch Height)	-0.00005816 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFNUM Effect

H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.21479715	6.75179	112	2815.59	0.0001
Pillai's Trace	0.95034594	4.32	112	3080	0.0001

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 1.52355420 Percent: 99.21
First Eigenvector:

0.00025289 (Weight)	0.00008607 (Hip Circ, Max)
0.00015793 (Hip Height)	-0.00010655 (Neck Circ)
0.00001781 (Shoulder Circ)	0.00014744 (Chest Circ)
-0.00008350 (Waist Circ, Prefer)	0.00028549 (Vertical Trunk Circ)
-0.00010153 (Sleeve Length, Total)	0.00034311 (Sleeve Outseam)
0.00029506 (Sleeve Inseam)	-0.00007335 (Stature)
0.00103102 (Neck Height)	0.00022748 (Waist Height, Prefer)
0.00001444 (Crotch Height)	0.00041338 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFLTH Effect

H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.39154073	16.2242	32	868	0.0001
Pillai's Trace	0.61565925	12.0911	32	870	0.0001

NOTE: F Statistic for Wilks' Lambda is exact.

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 0.10268136 Percent: 28.10
First Eigenvector:

-0.00122130 (Weight)	0.00038832 (Hip Circ, Max)
-0.00044983 (Hip Height)	0.00054519 (Neck Circ)
-0.00041134 (Shoulder Circ)	0.00062487 (Chest Circ)
0.00048520 (Waist Circ, Prefer)	0.00025137 (Vertical Trunk Circ)
-0.00002751 (Sleeve Length, Total)	0.00035797 (Sleeeve Outseam)
-0.00092180 (Sleeve Inseam)	0.00208259 (Stature)
-0.00204897 (Neck Height)	-0.00013145 (Waist Height, Prefer)
-0.00001564 (Crotch Height)	0.00128095 (Biacromial Breadth)

MANOVA Test Criteria and F Approx. for the Hypothesis of No Overall BFNUM*BFLTH Effect

H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.70119786	0.98823	160	3725.35	0.5273
Pillai's Trace	0.3449687	0.98926	160	4430	0.5237

RESULTS 3: Number of observations used in this analysis = 71

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

First Eigenvalue: 6.28624981 Percent: 79.33
First Eigenvector:

0.00307247 (Weight)	0.00236676 (Hip Circ, Max)
0.00200350 (Hip Height)	0.00115178 (Neck Circ)
0.00075161 (Shoulder Circ)	-0.00122818 (Chest Circ)
0.00007601 (Waist Circ, Prefer)	0.00203882 (Vertical Trunk Circ)
-0.00243118 (Sleeve Length, Total)	0.00042254 (Sleeve Outseam)
0.00216079 (Sleeve Inseam)	0.00276744 (Stature)
-0.00677642 (Neck Height)	-0.00139006 (Waist Height, Prefer)
0.00506420 (Crotch Height)	-0.00095941 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFNUM Effect

H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.03651251	2.0236	96	244.772	0.0001
Pillai's Trace	1.9599713	1.42509	96	282	0.0138

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 1.98444066 Percent: 83.11
First Eigenvector:

0.00485151 (Weight)	-0.00138788 (Hip Circ, Max)
0.00398800 (Hip Height)	-0.00151972 (Neck Circ)
0.00016076 (Shoulder Circ)	-0.00183818 (Chest Circ)
0.00016722 (Waist Circ, Prefer)	0.00051663 (Vertical Trunk Circ)
-0.00379716 (Sleeve Length, Total)	-0.00425515 (Sleeve Outseam)
0.00714899 (Sleeve Inseam)	0.00469413 (Stature)
-0.00612260 (Neck Height)	-0.00023753 (Waist Height, Prefer)
0.00038461 (Crotch Height)	0.00340687 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFLTH Effect

H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.23876342	2.74712	32	84	0.0001
Pillai's Trace	0.95235357	2.44305	32	86	0.0006

NOTE: F Statistic for Wilks' Lambda is exact.

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 0.93660162 Percent: 48.01
First Eigenvector:

-0.00492823 (Weight)	0.00476468 (Hip Circ, Max)
-0.00101538 (Hip Height)	0.00370366 (Neck Circ)
0.00045254 (Shoulder Circ)	-0.00017694 (Chest Circ)
0.00310667 (Waist Circ, Prefer)	0.00057605 (Vertical Trunk Circ)
0.00019053 (Sleeve Length, Total)	-0.00683196 (Sleeve Outseam)
0.00204467 (Sleeve Inseam)	-0.00002432 (Stature)
0.00090001 (Neck Height)	0.00282210 (Waist Height, Prefer)
0.00263802 (Crotch Height)	-0.00144841 (Biacromial Breadth)

MANOVA Test Criteria and F Approx. for the Hypothesis of No Overall BFNUM*BFLTH Effect

H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.21679469	0.96492	80	206.51	0.5649
Pillai's Trace	1.23563879	0.94371	80	230	0.6118

RESULTS 4: Number of observations used in this analysis = 71

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

First Eigenvalue: 9.22700916 Percent: 80.50
First Eigenvector:

0.00264048 (Weight)	0.00214692 (Hip Circ, Max)
-0.00232038 (Hip Height)	0.00148779 (Neck Circ)
0.00235908 (Shoulder Circ)	-0.00171900 (Chest Circ)
0.00203701 (Waist Circ, Prefer)	0.00161336 (Vertical Trunk Circ)
-0.00201076 (Sleeve Length, Total)	0.00508919 (Sleeve Outseam)
-0.00102885 (Sleeve Inseam)	-0.00411947 (Stature)
0.00055733 (Neck Height)	0.00165554 (Waist Height, Prefer)
0.00473749 (Crotch Height)	-0.00263676 (Biacromial Breadth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFNUM Effect

H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.01787749	2.11801	112	274.73	0.0001
Pillai's Trace	2.25721052	1.39803	112	329	0.0124

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 2.26350397 Percent: 77.97
First Eigenvector:

0.00331981 (Weight)	0.00016945 (Hip Circ, Max)
0.00140219 (Hip Height)	-0.00189115 (Neck Circ)
0.00179015 (Shoulder Circ)	-0.00142301 (Chest Circ)
0.00082400 (Waist Circ, Prefer)	-0.00001900 (Vertical Trunk Circ)
-0.00282365 (Sleeve Length, Total)	-0.00067813 (Sleeve Outseam)
0.00653016 (Sleeve Inseam)	0.00447281 (Stature)
-0.00438835 (Neck Height)	-0.00106183 (Waist Height, Prefer)
0.00097589 (Crotch Height)	0.00056630 (Biacromial Braedth)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFLTH Effect

H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.18688407	3.36508	32	82	0.0001
Pillai's Trace	1.08368397	3.10446	32	84	0.0001

NOTE: F Statistic for Wilks' Lambda is exact.

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 1.14599336 Percent: 47.97
First Eigenvector:

-0.00276387 (Weight)	0.00197063 (Hip Circ, Max)
0.00200956 (Hip Height)	-0.00387723 (Neck Circ)
0.00335103 (Shoulder Circ)	0.00087139 (Chest Circ)
0.00028283 (Waist Circ, Prefer)	-0.00157023 (Vertical Trunk Circ)
-0.00138455 (Sleeve Length, Total)	-0.00508992 (Sleeve Outseam)
0.01011065 (Sleeve Inseam)	0.00586175 (Stature)
-0.00079223 (Neck Height)	-0.00669941 (Waist Height, Prefer)
-0.00059443 (Crotch Height)	-0.00642640 (Biacromial Breadth)

MANOVA Test Criteria and F Approx. for the Hypothesis of No Overall BFNUM*BFLTH Effect

H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.16155806	1.16061	80	201.696	0.2030
Pillai's Trace	1.44686939	1.14528	80	225	0.2199

RESULTS 5: Number of observations used in this analysis = 469

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

First Eigenvalue: 2.69741620 Percent: 92.18
First Eigenvector:

0.00077765 (Weight)
0.00009804 (Hip Height)
0.00026563 (Shoulder Circ)
0.00003017 (Waist Circ, Prefer)
0.00050853 (Sleeve Length, Total)
-0.00036234 (Sleeve Inseam)
0.00018826 (Waist Height, Prefer)
-0.00008970 (Biacromial Breadth)
-0.00010659 (Hip Circ, Max)
-0.00026236 (Neck Circ)
-0.00000042 (Chest Circ)
0.00027794 (Vertical Trunk Circ)
0.00005584 (Sleeve Outseam)
0.00005297 (Stature)
0.00022685 (Crotch Height)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFNUM Effect

H = Type IV SS&CP Matrix for BFNUM and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.21680183	7.17773	105	2793.66	0.0001
Pillai's Trace	0.94341905	4.57957	105	3087	0.0001

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 1.47769967 Percent: 99.25
First Eigenvector:

0.00028830 (Weight)
0.00024848 (Hip Height)
0.00005403 (Shoulder Circ)
-0.00008607 (Waist Circ, Prefer)
-0.00012012 (Sleeve Length, Total)
0.00031538 (Sleeve Inseam)
0.00028618 (Waist Height, Prefer)
0.00033358 (Biacromial Breadth)
0.00005517 (Hip Circ, Max)
-0.00022584 (Neck Circ)
0.00013942 (Chest Circ)
0.00035320 (Vertical Trunk Circ)
0.00033989 (Sleeve Outseam)
0.00062062 (Stature)
0.00016577 (Crotch Height)

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall BFLTH Effect

H = Type IV SS&CP Matrix for BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.39914292	16.9022	30	870	0.0001
Pillai's Trace	0.60744355	12.6791	30	872	0.0001

NOTE: F Statistic for Wilks' Lambda is exact.

First Eigenvalue and Eigenvector of: E Inverse * H, where
H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

First Eigenvalue: 0.09381226 Percent: 28.10
First Eigenvector:

-0.00139621 (Weight)
-0.00080061 (Hip Height)
-0.00054472 (Shoulder Circ)
0.00053441 (Waist Circ, Prefer)
0.00004264 (Sleeve Length, Total)
-0.00063388 (Sleeve Inseam)
-0.00016665 (Waist Height, Prefer)
0.00151950 (Biacromial Breadth)
0.00052242 (Hip Circ, Max)
0.00085461 (Neck Circ)
0.00073847 (Chest Circ)
0.00008493 (Vertical Trunk Circ)
0.00022336 (Sleeve Outseam)
0.00080645 (Stature)
-0.00038983 (Crotch Height)

MANOVA Test Criteria and F Approx. for the Hypothesis of No Overall BFNUM*BFLTH Effect

H = Type IV SS&CP Matrix for BFNUM*BFLTH and E = Error SS&CP Matrix

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.72266498	0.96523	150	3665.49	0.6035
Pillai's Trace	0.3161155	0.96625	150	4440	0.6003

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