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SIZING EVALUATION OF NAVY WOMEN'S UNIFORMS (U)

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FOR THE COMMANDER

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Body dimensions relevant to the size and fit of Navy women's uniform clothing were measured on a representative sample of 906 Naval officers and enlisted women. Six commonly-worn items of uniform clothing were tried on each subject to find the size of best fit. Subsequent statistical analysis was undertaken to determine which body dimensions and which values of these dimensions best predicted the size of best fit. The resulting information was used to develop sizing charts for use in catalogues from which Navy women order clothing. The reliability of the charts was tested on an additional sample of 170 women. Success in predicting correct sizes from the charts varied from 87% to 49% depending on the garment. Use of the charts resulted in 90% to 100% correct predictions within one size of best fit for all garments. A number of sizing and design problems in the garments were revealed during the course of this study. These became the basis for a companion study (Robinette, et al 1990) in which new sizing programs for Navy women's clothing were developed.

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PREFACE

A number of people contributed time and attention to this research project. The authors would like to thank Paula Leuci at NCTRF for her contribution in making the extensive anthropometric measurements used as the basis for this research, and Scena Proodian (NCTRF) for her assistance. Thanks go to the hundreds of patient subjects who took part in the study and the test coordinating personnel at the various Navy bases.

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SUMMARY

The fit and sizing of six items of Navy women's clothing was evaluated with a view toward developing size prediction charts for use by women ordering uniform clothing from a catalogue. Garments included in the evaluation were the service dress blue coat, slacks, and skirt, the summer white skirt and slacks, and the short-sleeved white shirt.

Body dimensions relevant to the size and fit of uniform clothing were measured on a representative sample of 906 Navy women. All subjects tried on each of the six garments to determine the size of best fit. Various statistical procedures were then employed to determine what body dimensions, and which values of those dimensions, most reliably predicted the size of best fit for each garment. The results indicated that for all six garments, body circumference measurements were most indicative of garment size. Slacks and skirts seemed to be dependent on hip and waist measurements, and the coat on bust and hip measurements. Sizing for the shirt seemed to be best selected by bust circumference and neck circumference. Height was used to predict length for all the garments except the white shirt.

The statistical data were used to create size prediction charts which were tested on 170 new subjects. The number of correctly predicted sizes varied from garment to garment, ranging from a high of 87% for the short-sleeved white shirt to a low of 49% for the white slacks. Use of the charts resulted in 90% to 100% correct predictions within one size of best fit for all garments.

During the course of the evaluation, a number of sizing and design problems in the garments themselves became evident. The most commonly noted problem, for example, was that the bust point of the best-fit service dress blue coat was too high, causing a bunching above the bust. Fitters also found that subjects often needed larger sizes of the coat to fit their shoulders and/or arms which for a number of women, resulted in coats that were too big in the bust and hips. With regard to lower body garments, a great many women had problems with too-big waists or too-small hips. Black women had greater difficulty than did white women in obtaining a good fit, especially in lower body garments. Comparative statistical analyses revealed that there were significant body size differences between white and black women of the same height and weight, primarily in bust circumference, sleeve length dimensions, and crotch height.

In general, the design problems in the garments themselves and the proportional differences between women of different races were not remediable by merely assigning different sizes of garments. The data collected in this study became the basis for a companion study in which altogether new sizing programs for Navy women's clothing were developed. Recommendations were also made for design modifications in most garments.

SIZING EVALUATION OF NAVY WOMEN'S UNIFORMS

INTRODUCTION

This is the first of two technical reports prepared by Navy Clothing and Textile Research Facility (NCTRF) that summarize research into fit and sizing problems of six items of Navy women's clothing. The initial effort, and the one on which this report is focused, was the evaluation of the fit of the service dress blue coat, slacks, and skirt, the summer white skirt and slacks, and the short-sleeved white shirt. The object of the evaluation was to develop size prediction charts for use by women ordering uniforms from a catalog. In the second phase of the effort, Robinette et al. (in press) used data gathered in the fit evaluation to create new sizing programs for future clothing.

While uniform clothing is issued to women upon entrance into the Navy, it is often necessary for them, thereafter, to mail-order their uniforms. To save the cost of alterations and returns, it was decided to create sizing charts for inclusion in the catalogs to help women determine more accurately which sizes would best fit them. The approach in this first phase of the study was to collect a series of anthropometric (body size) measurements on a large sample of Navy women, to ask these women to don the test garments, and to have both skilled Navy evaluators and the subjects themselves determine the size(s) of best fit. The object was to devise sizing charts by determining which body sizes matched which garment sizes.

In addition to establishing anthropometric criteria for use in assigning sizes, the study served to identify basic sizing problems with the clothing itself. These problems, summarized in this report, led to the second phase of the study, which was to develop improved sizing programs for the production of new patterns

The first phase of the study, reported here, was conducted in a series of steps as follows:

- collecting demographic and anthropometric data from a large sample of Navy women;
- evaluating the fit of selected garments;
- developing size prediction charts; and
- testing the effectiveness of the charts.

Test results were quite favorable. The subjects found the charts easy to use, and as a result of using the charts, 90 to 100 percent of the subjects were assigned a size which was either the same as their best-fit size or just one size smaller or larger.

SURVEY METHODS

The NCTRF gathered demographic, size, fit, and anthropometric information on 906 Navy women at the Naval Training Center in Orlando, FL, the Navy Annex in Washington, DC, the Navy Hospital in Bethesda, MD, and Naval bases in Norfolk, VA, Cecil Field N.A.S., FL, Mayport, FL, Newport, RI, and Charleston, SC. The information sought is shown on the data collection sheet in Figure 1.

SUBJECT #: _____ DATE: _____

SS#: _____ DATA COLLECTOR: _____

DATE OF BIRTH: _____ DATA ENTERER: _____

PLACE OF BIRTH: _____ RANK/OCCUPATION: _____

W ☐ B ☐ A ☐ H ☐

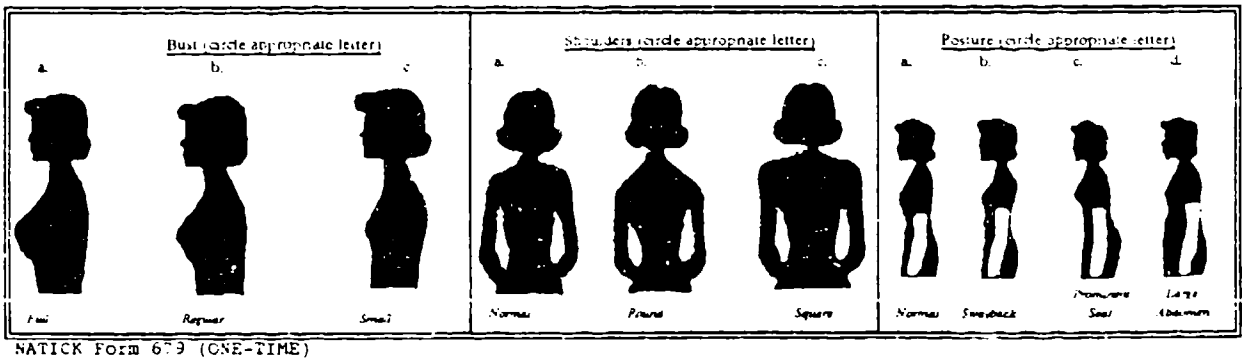
WEIGHT	_____
HEIGHT	_____
NECK CIRCUMFERENCE	_____
SHOULDER CIRCUMFERENCE	_____
CHEST CIRCUMFERENCE (at scye)	_____
BUST CIRCUMFERENCE (at bustpoint)	_____
CHEST CIRCUMFERENCE (below bust)	_____
WAIST CIRCUMFERENCE	_____
HIP CIRCUMFERENCE	_____
WAIST BACK	_____
SLEEVE INSEAM	_____
SLEEVE OUTSEAM	_____
SLEEVE LENGTH	_____
WAIST HEIGHT (outseam)	_____
CROTCH HEIGHT (inseam)	_____

ITEM	WHITE SHIRT	WHITE SKIRT	WHITE SLACKS	BLUE SKIRT	BLUE COAT	BLUE SLACKS
Navy Size						
Commercial Size						
Rating Fitter						
Rating Subject						

FIT ASSESSMENT: 1 = Excellent 2 = Good 3 = Fair 4 = Poor

Comments (Fit Subject's):

Comments (Data Collector's):



NATICK Form 679 (ONE-TIME)

Figure 1
Women's Uniform Size Evaluation Data Sheet

ANTHROPOMETRY AND DEMOGRAPHICS

Due to limited time and resources only those demographic and anthropometric variables considered most crucial to the determination of sample representativeness or clothing fit were obtained. The measurement techniques were the same as those used in other large-scale military surveys so that comparisons of Navy and other military body size data could be made. The measurements are described in the Appendix.

Demographics of the sample population were compared with the Navy population to determine the sample's representativeness. Table 1 shows race and rank comparisons. For these two demographic variables, the sample used for this study appears to provide a good representation.

TABLE 1. Demographics

RACE	Sample	Navy Population*
Whites	74%	72%
Blacks	21%	20%
Hispanics	4%	4%
Oriental	1%	1%
Other	---	2%
OFFICER/ENLISTED MIX		
Officer	11.5%	13%
Enlisted	88.5%	87%

* Based on the Fiscal Year 1987 quarterly reports.

The sample used for this evaluation was further studied by comparing it with larger military samples obtained in the 1968 Air Force and 1977 Army surveys. Table 2 shows a comparison of the three groups. Though the Navy women appear very similar to the others in linear dimensions, trunk circumference and weight values suggest that the Navy women are slightly larger. The largest difference is in weight; Navy personnel are four to nine pounds heavier.

Larger values for weight and other mass-related variables are often explained by age differences since aging tends to have the effect of increasing these dimensions. An age comparison of the Navy, Air Force, and Army women, shown in Table 3, indicates that the Navy sample is a somewhat older group. There are considerably fewer 20-and-under subjects in the Navy sample, and its mean age is three years older. The question is further examined later in this report in a discussion of age and size relationships, pursuant to the question of whether older women are those wearing the larger sizes.

A second type of anthropometry was the rating of subjects' bust, shoulders, and posture. (see Figure 1). The results of these assessments are shown in Table 4.

TABLE 2. Comparison of Anthropometry for Selected Dimensions for Women of the Navy, Air Force, and Army*

Dimension	NAVY 87 Mean	NAVY 87 SD	AIR FORCE '68 Mean	AIR FORCE '68 SD	ARMY '77 Mean	ARMY '77 SD
Weight	136.14	19.73	127.28	16.59	132.22	19.16
Height	64.28	2.57	63.82	2.36	64.16	2.57
Neck Circumference	13.20	0.70	13.29	0.66	12.74	0.62
Shoulder Circumference	41.50	2.47	39.53	2.02	39.52	2.15
Chest Circumference at Scye	34.76	2.26	33.17	1.95	33.68	2.05
Bust Circumference	36.54	2.74	35.33	2.24	34.73	2.53
Chest Circumference below Bust	30.94	2.21	29.26	1.92	29.46	1.98
Waist Circumference	28.07	2.65	26.46	2.16	27.96	2.72
Waist Back Length	15.84	0.93	15.95	0.37	16.08	1.04
Sleeve Inseam	17.56	1.09	17.37	0.95	17.74	1.03
Sleeve Outseam	22.41	1.22	Not Measured		21.18	1.17
Sleeve Length	31.98	1.56	31.33	1.31	Not Measured	
Waist Height	40.28	1.99	39.48	1.77	39.92	2.05
Crotch Height	29.60	1.74	29.33	1.59	30.07	1.74

* Weight in pounds; all other values in inches.

TABLE 3 Age Comparison of Navy Sample with the 1968 Air Force and 1977 Army Women

	NAVY '87		AIR FORCE '68		ARMY '77	
Mean (yrs)	25.5		23.4		23.6	
SD	5.[illegible]		6.5		5.4	
	Freq. (%)	Cum. Freq. (%)	Freq. (%)	Cum. Freq. (%)	Freq. (%)	Cum. Freq. (%)
20 and under	7.5	7.5	50.4	50.4	37.5	37.5
21 - 25	42.9	50.4	30.3	80.7	40.2	77.7
26 - 30	28.7	79.1	7.2	87.9	13.9	91.6
31 - 35	14.9	94.0	4.8	92.7	4.9	96.5
36 - 40	5.1	99.1	3.7	96.4	1.6	98.1
41 - 45	0.6	99.7	2.5	98.9	0.8	98.9
46 - 50	0.3	100.0	0.7	99.6	0.9	99.8
51 - 56	----	----	0.4	100.0	0.2	100.0

TABLE 4. Frequencies and Percentages ( ) of Body Shape Types

BUST	Full	Regular	Small	
	167 (19.3)	399 (46.1)	300 (34.6)	
SHOULDERS	Normal	Round	Square	
	501 (59.4)	64 (7.6)	279 (33.1)	
POSTURE	Normal	Swayback	Prominent Seat	Large Abdomen
	579 (70.3)	75 (9.1)	143 (17.4)	27 (3.3)

FIT

Before being measured, each subject was asked to try on her stated size and additional sizes, as needed, for each of the six garments. Size of best fit was determined by a fitter's estimation of the correct size. The quality of fit for the best size was then assessed by both subject and fitter.

Table 5 shows the size frequencies and percentages (in parentheses) of the six garments. For example, 36 women (or 4.1%) wore short-sleeved white shirt size 32 with neck size 12. The table also indicates that not all garments and sizes were recorded for every subject (frequencies of subjects wearing all clothing sizes range from 858 to 900). As expected, given normal population dispersion, the middle sizes were assigned more frequently. And, as discussed later in this report, the middle sizes are those where the greatest overlapping occurs -- that is, where different sizes were assigned to women with comparable body dimensions.

The frequency distributions and percentages (in parentheses) of the fit ratings given by fitters and subjects appear in Table 6. The short-sleeved white shirt received the highest ratings for fit. Good or excellent fit ratings were given 78% of the time by fitters; 74% of the subjects rated the fit as good or excellent. The summer white skirt and slacks received the next best scores, with 50% or more good or excellent ratings from subjects and fitters. The remaining three garments did not fare as well with less than 50% good or excellent ratings from fitters. Interestingly, the subjects more frequently gave good or excellent ratings than did the fitters. Of the six garments, the service dress blue slacks clearly were rated as the worst fitting. Only 13% of the fitters and 20% of the subjects rated the fit as good or excellent.

Comments from the fitters were also examined in an attempt to identify specific features of each garment that created fitting problems and to determine how these features related to body measurements. Very few comments were recorded for the short-sleeved white shirt except those relating to the need for additional sizes, and the desire for a more tailored look. By far the most commonly noted problem was that the bust point of the best-fit service dress blue coat was too high, causing a bunching above the bust. Table 7 shows bust circumference statistics for those subjects who were recorded as having this problem and, for comparison purposes, the bust dimensions for the service dress blue coat. Fitters also found that subjects often needed larger sizes of the dress blue coat to fit their shoulders and/or arms; this apparently resulted with great

TABLE 6. Frequencies and Percentages ( ) for Fit Ratings*

		FIT RATINGS							
		Excellent		Good		Fair		Poor	
Short-Sleeved White Shirt	Fitter	88	(9.8)	615	(68.2)	186	(20.6)	13	(1.4)
	Subject	116	(12.8)	556	(61.4)	194	(21.4)	39	(4.3)
Summer White Skirt	Fitter	75	(8.4)	438	(49.0)	320	(35.8)	61	(6.8)
	Subject	95	(10.5)	414	(45.9)	269	(29.9)	123	(13.7)
Summer White Slacks	Fitter	74	(8.3)	394	(44.0)	341	(38.1)	86	(9.6)
	Subject	95	(10.6)	361	(40.3)	282	(31.5)	158	(17.6)
Service Dress Blue Skirt	Fitter	31	(3.4)	317	(35.1)	434	(48.1)	120	(13.3)
	Subject	78	(8.6)	346	(38.4)	334	(37.0)	144	(16.0)
Service Dress Blue Coat	Fitter	64	(7.1)	336	(37.2)	387	(42.8)	117	(12.9)
	Subject	115	(12.7)	374	(41.4)	280	(31.0)	135	(14.9)
Service Dress Blue Slacks	Fitter	15	(1.7)	105	(11.7)	312	(34.9)	462	(51.7)
	Subject	27	(3.0)	154	(17.2)	248	(27.7)	467	(52.1)

* Not all subjects have complete data so totals vary.

TABLE 7. Bust Circumference Data for Subjects who Received "Bust Too Large" Comments from Fitters for the Service Dress Blue Coat*

Size	n	Mean Bust Circumference	Range	Blue Coat Bust Dimensions
6	1	32.00	---	36.00
7	8	32.25	31-34	36.50
8	9	32.94	32-35	37.00
9	2	30.75	29.5-32.0	37.50
10	9	33.61	32-35	38.00
11	9	34.16	32.5-37.5	38.50
12	29	35.00	33-39	39.00
13	14	36.07	34-49	39.75
14	19	36.00	34-38	40.50
15	8	36.88	36-39	41.25
16	24	37.60	36-40	42.00
18	21	39.05	37-42	44.00
20	12	41.04	39-44	46.00
22	8	43.31	41.5-45.0	48.00

* Dimensions in inches.

frequency in coats that were too big in the bust and sometimes, particularly in the larger sizes, too big in the hips as well. This suggests some flaw in the design dimensions of the dress blue coat that merits attention.

With regard to the lower body garments, a large number of comments concerned too-big waists or too-small hip. Apparently many subjects were given larger sizes to accommodate the hips, resulting in waists that were too big. Investigators concluded that there is a need for garments which accommodate a greater variety of body types.

The measuring/fitting team from NCTRF observed that black women had greater difficulty than did white women in obtaining a good fit, especially in lower body garments. Table 8 presents univariate summary statistics of anthropometry by race. Due to perceptions of fit differences by race a multivariate statistical comparison was done of proportional differences between the black and white racial groups.

The multivariate comparison indicated that there were significant differences between white and black women. These appear primarily to be differences in bust circumference, sleeve length dimensions and crotch height. Previous studies have shown that, on the average, black males have longer limb lengths than white males of the same height. Sleeve length and crotch height differences in these data could lead one to speculate that this phenomenon is true of black females, too. In general, any dimensional differences between groups of subjects of the same height and weight indicate the possibility of shape differences between the two groups. There were too few Asians to evaluate and, while there are enough Hispanics to make meaningful proportional comparison, there are not enough of them to occupy all the sizing categories in sufficient numbers to draw any conclusions about the effect of these differences on sizing. Furthermore, the fitters did not observe any substantial fitting problems for these groups.

The size and shape differences found will not be accommodated by merely assigning a different size. Pattern changes are called for to rectify the problem. The information gathered in this report was further examined and the resulting information regarding proportional differences was used in devising a sizing system for future clothing, which should accommodate both whites and blacks better by accommodating a greater variety of body types (Mellian et al, in press).

SIZE PREDICTION CHARTS

The complexity of determining how size should be selected becomes evident when one considers that 15 anthropometric dimensions were measured and that 6 garments were involved, 2 with multiple sizing criteria. To reduce the number of variables to be examined, a factor analysis was done. The results indicated similar findings for all six garments: measurements which indicate body circumferences were most indicative of garment size. Of the other dimensions, height was retained for all garments except the shirt to predict length. The number of anthropometric variables to be used in the sizing analysis of a specific garment was further reduced by common sense. For instance, bust circumference is obviously not needed to choose slacks size. Of the three chest circumferences (chest circumference at seye, bust circumference, and bust circumference below bust), bust circumference was selected since it is the most commonly taken measure and the person ordering clothing would be most likely to know it. Below are the anthropometric variables which were retained for examination in determining size assignments for each garment.

TABLE 8. Summary Statistics for the Anthropometry of the Navy Women's Clothing Evaluation Sample by Race*

(n=886)†

	WHITE n=662 (74%)				BLACK n=183 (21%)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Weight	136.70	19.60	87.00	210.00	136.79	19.26	94.00	189.00
Height	64.41	2.52	57.87	73.03	64.44	2.55	57.87	72.05
Neck Circumference	13.19	6.96	11.50	16.00	13.28	0.70	11.00	15.00
Shoulder Circumference	41.56	2.49	35.00	50.00	41.44	2.40	36.50	48.00
Chest Circ. at Scye	34.88	2.23	28.87	44.00	34.40	2.25	29.00	43.00
Bust Circumference	36.70	2.72	29.50	47.00	36.11	26.93	30.00	46.00
Circumference below Bust	31.17	2.14	25.75	39.00	30.23	2.10	26.00	37.00
Waist Circumference	28.10	2.63	22.00	37.00	28.04	2.64	23.00	37.00
Hip Circumference	38.94	2.66	33.00	48.00	38.99	2.78	31.38	48.00
Waist Back Length	15.89	0.91	13.00	19.00	15.79	0.99	14.00	19.50
Sleeve Inseam	17.42	0.98	14.00	20.50	18.28	1.21	15.50	21.50
Sleeve Outseam	22.28	1.13	18.00	26.00	23.11	1.28	19.00	27.00
Sleeve Length	31.89	1.48	27.50	36.00	32.56	1.61	28.50	37.50
Waist Height	40.32	1.95	34.25	47.64	40.63	2.00	35.83	46.85
Crotch Height	29.47	1.65	24.80	35.43	30.49	1.72	26.57	35.43

	ASIAN n=9 (1%)				HISPANIC n=34 (4%)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Weight	122.75	23.37	102.00	173.00	126.63	19.70	98.00	176.00
Height	61.46	2.72	58.66	66.54	62.16	2.19	58.07	66.93
Neck Circumference	12.90	0.82	12.00	14.00	12.91	0.57	12.00	14.00
Shoulder Circumference	40.42	2.42	37.00	44.50	40.93	2.30	36.00	46.00
Chest Circ. at Scye	33.49	2.26	30.00	37.00	34.41	2.11	30.50	39.00
Bust Circumference	34.78	2.44	31.50	39.50	35.98	2.68	30.50	41.50
Circumference below Bust	29.56	2.34	27.00	34.00	30.32	2.38	26.00	37.00
Waist Circumference	27.43	2.95	24.00	32.50	27.47	2.79	23.00	35.00
Hip Circumference	36.65	3.26	34.00	44.50	38.12	2.91	34.50	46.00
Waist Back Length	15.32	0.77	14.00	16.50	15.36	0.87	14.00	17.25
Sleeve Inseam	16.39	0.93	15.00	18.00	16.99	0.84	15.50	19.00
Sleeve Outseam	21.03	1.56	19.25	24.00	21.70	0.95	20.00	23.50
Sleeve Length	30.35	1.71	28.00	33.00	31.16	1.35	28.50	34.00
Waist Height	38.23	2.50	36.22	42.9	38.60	1.65	35.04	41.34
Crotch Height	27.34	1.73	25.59	30.31	28.24	1.52	24.80	31.10

* Weight in pounds; all other measurements in inches.

† Total n is 906. Race was not recorded for 18 subjects and they were not included here.

Short-Sleeved White Shirt	Summer White Skirt	Summer White Slacks
Neck Circumference	Waist Circumference	Waist Circumference
Shoulder Circumference	Hip Circumference	Hip Circumference
Bust Circumference	Height	Height
Waist Circumference		
Dress Blue Coat	**Dress Blue Skirt**	**Dress Blue Slacks**
Shoulder Circumference	Waist Circumference	Waist Circumference
Bust Circumference	Hip Circumference	Hip Circumference
Waist Circumference	Height	Height
Hip Circumference		
Height		

In seeking to determine how these body measurements predict size, a series of bivariate plots and least squares regression equations were prepared and reviewed. What quickly became apparent was the considerable overlapping of sizes, making it difficult to discern the relationship of body measurements to sizes. This was especially true for the slacks and skirts, as can be seen in Figure 2, a plot of waist circumference and hip circumference measurements and the size of best fit for the summer white skirt. To reduce the number of hidden observations (wherein only one subject appears on the plot though one or more additional subjects could have identical measurements), only subjects who received a fit rating of excellent or good from the fitter are shown in the bivariate. The overlapping of sizes is most readily apparent in the midsection of the distribution where it can be seen, for example, that size 13 was selected by women with hip circumferences ranging from 35.5" to 40.0", and that size 18 could apparently be worn by women with waist circumferences ranging from 25.5" to 35.0". One possible explanation is that there is little difference between some sizes.

This was explored by statistically comparing the means of the anthropometric dimensions for each size first in a MANOVA and then in a Duncan Multiple Range Test. What became apparent was that, at least for the skirts and slacks, and possibly for the coat, several sizes could be grouped together. Interestingly, they grouped as they often do commercially: 6, 7-8, 9-10, 11-12, 13-14, 15-16, 18, 20, 22. There appears to be no need to have both of each pair. At the same time, since they already exist, persons who are given one of an interchangeable pair of sizes, can be fitted just as well in the other. Since, for the time being, all of these sizes are in the inventory, size selection criteria were developed for each size by dividing the grouped categories into two equal parts.

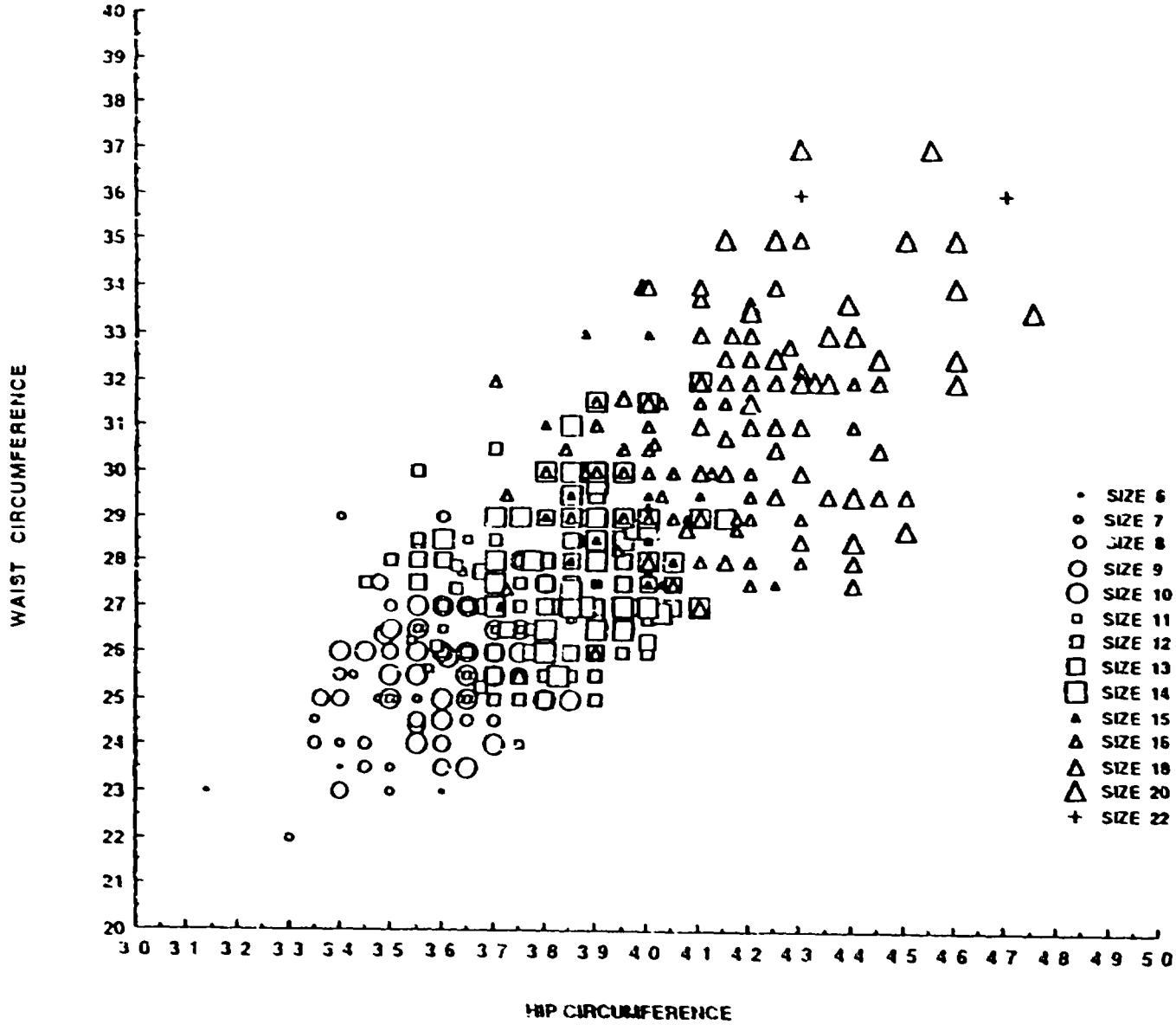


Figure 2
Size of Best Fit for the Summer White Skirt vs. Body Size.

Slacks and skirts seem to be dependent on hip and waist measurements, and the coat on bust and hip measurements. Sizing for the shirt seems to be best selected by bust circumference and neck circumference.

Because the short-sleeved white shirt showed statistical differences (at $\alpha = .01$) between each size and had no overlapping of sizes, developing the sizing system for it was much less complicated than for the coat and lower body garments. For this reason, the development of a sizing program for the short-sleeved white shirt is discussed first.

Based on bivariate plots of bust circumference and sizes, intervals for bust measurements were selected and reviewed to determine which intervals had the best prediction rate when compared with actual sizes assigned, i.e., if we use a size prediction chart based on these intervals, how well will this match the actual sizes assigned? Table 9, a comparison of the size prediction charts with the actual assigned size, shows a successful prediction rate of 63%; only 10 people (1%) are more than one size off. The intervals were varied and the comparisons were re-analyzed several times before determining that this is the highest rate that could be expected. Neck size (also used in sizing the shirt) was found to be directly related to neck circumference. Figure 3 shows the end result, plotted on a bivariate sizing table.

Like the shirt, the coat has two sizing criteria -- a numerical designation based on girth, and a length designation. Sizing criteria for coat length were established independently from girth.

The height dimension was tested on a bivariate plot of height and sleeve length. Sizing categories were created as follows:

Height (inches)	Coat Length
< 63.5	Short
$\geq 63.5, \leq 67.0$	Regular
> 67.0	Long

A comparison of these intervals with assigned sizes resulted in a 73% match.

For the remaining four garments and coat size, where interactions between two variables were found, least squares regression equations were calculated for predicting size of best fit. For the lower body garments, waist circumference and hip circumference were used as predictor variables. For the coat, bust and hip circumferences were selected as the predictor variables. This provided continuous numbers such as 6.1, 6.2, 6.3 ..... 20.1, etc. Sizes were delineated by midpoints. For example, <6.5 became Size 6, 6.5 to 7.5 became Size 7, etc. This resulted in smooth curves which separated the sizes on the two-variable charts. The curved lines formed by the predicted regressed sizes were squared off to make them more similar to commercial sizing charts and easier to use. Figures 4-8 show the size selection charts which resulted.

SHORT SLEEVED WHITE SHIRT

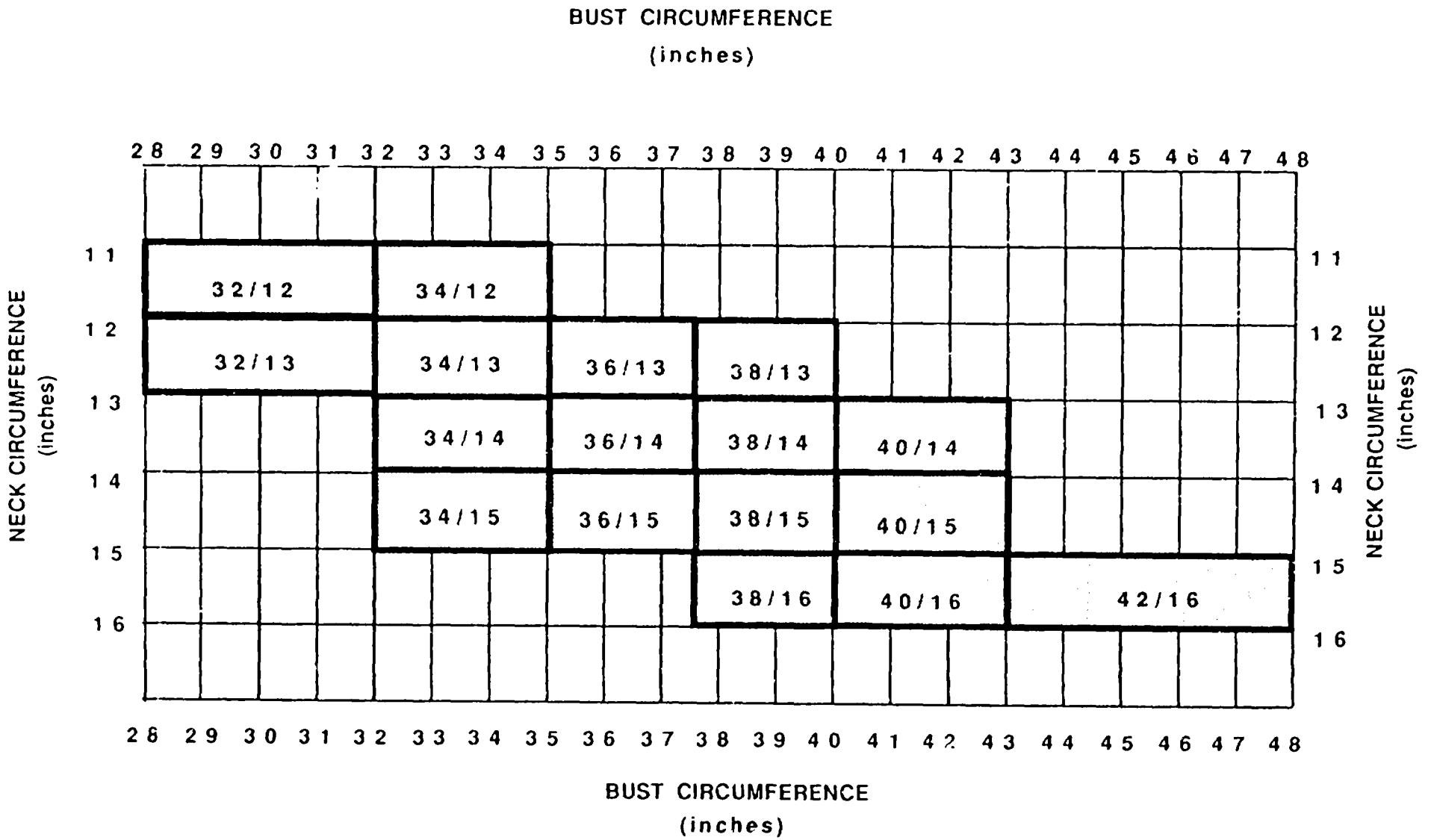


Figure 3
Size Selection Chart for the Short-Sleeved White Shirt.

SERVICE DRESS BLUE COAT

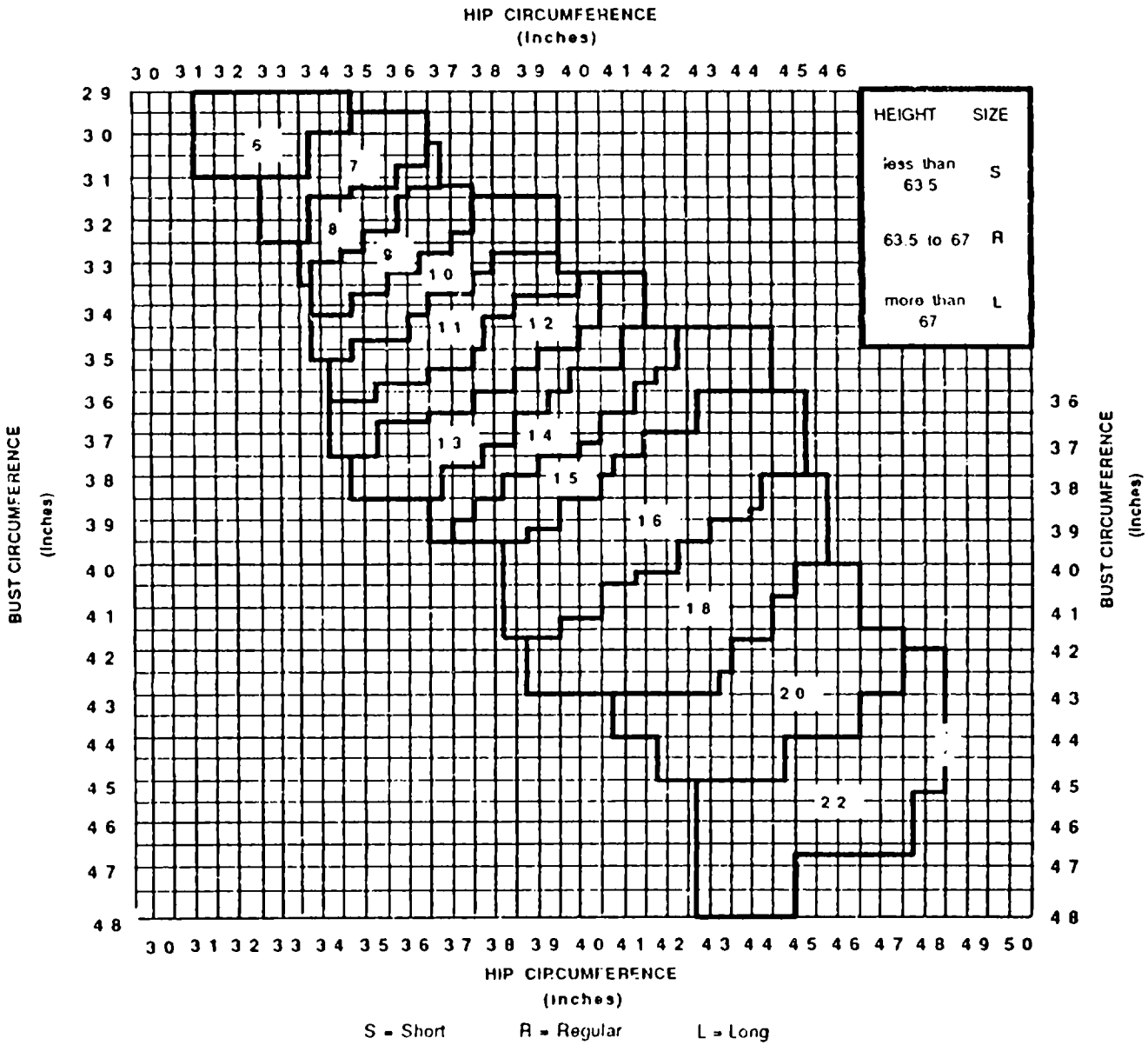


Figure 4
Size Selection Chart for the Service Dress Blue Coat.

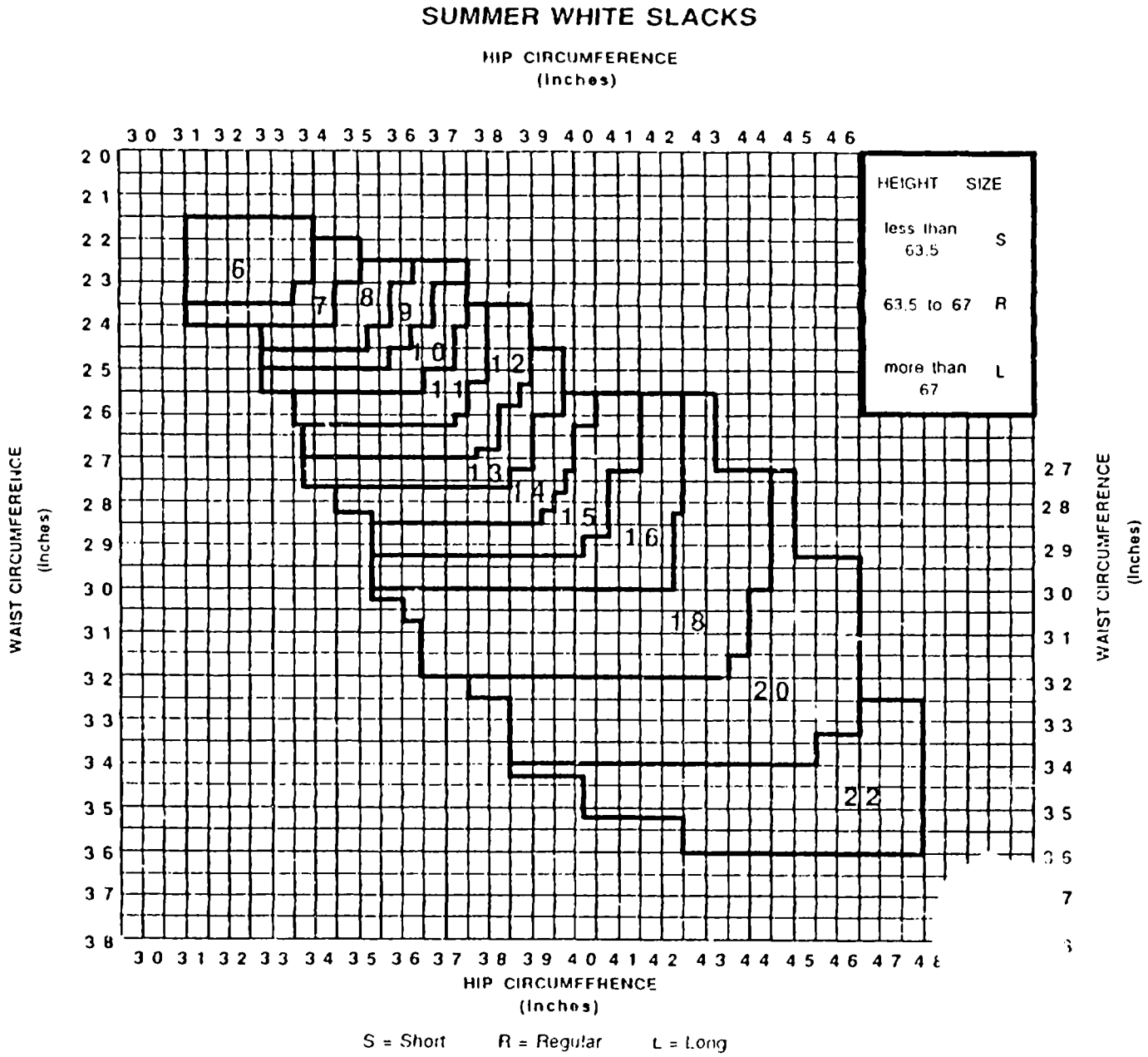


Figure 5
Size Selection Chart for the Summer White Slacks.

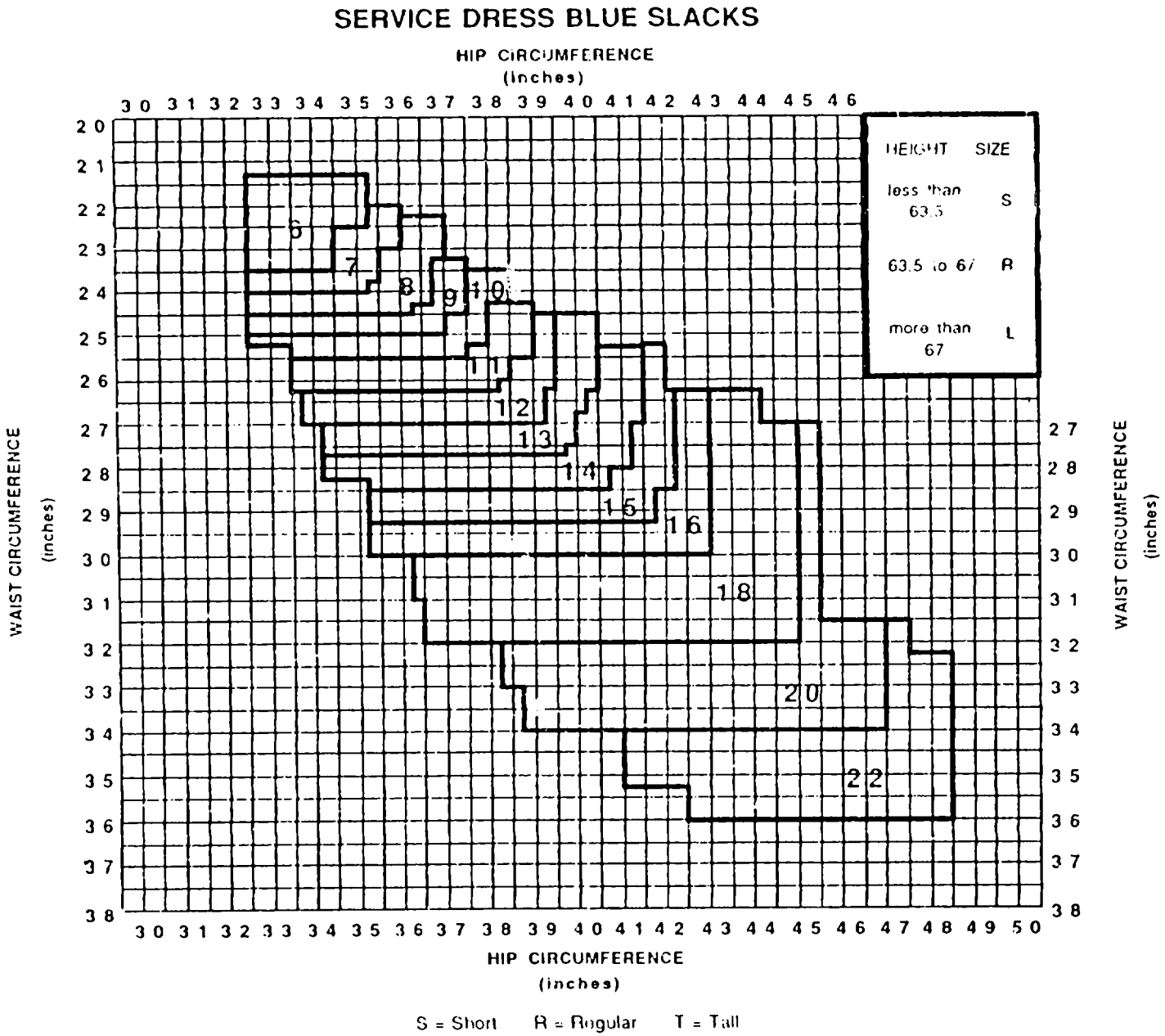


Figure 6
Size Selection Chart for the Service Dress Blue Slacks.

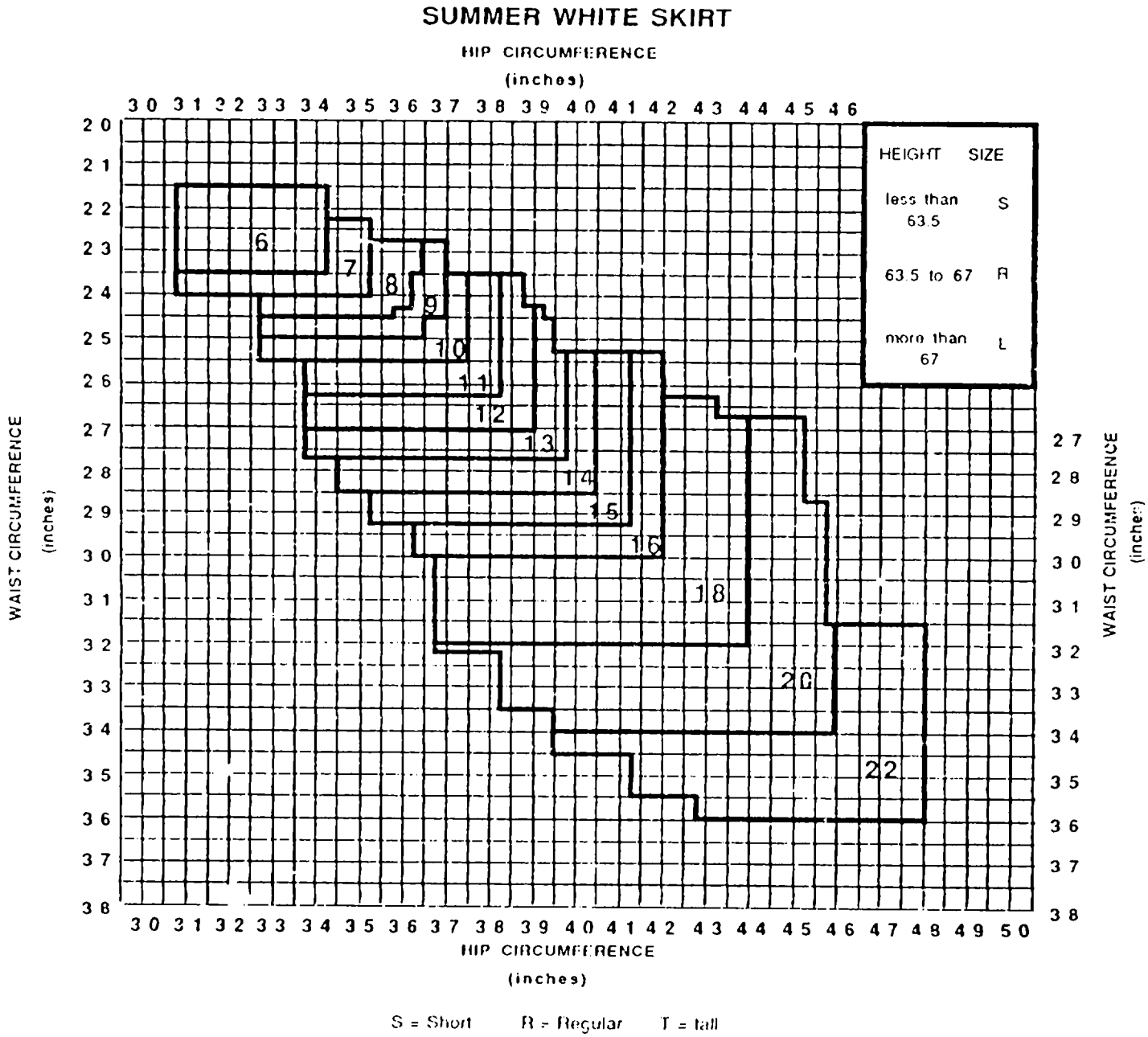


Figure 7
Size Selection Chart for the Summer White Skirt.

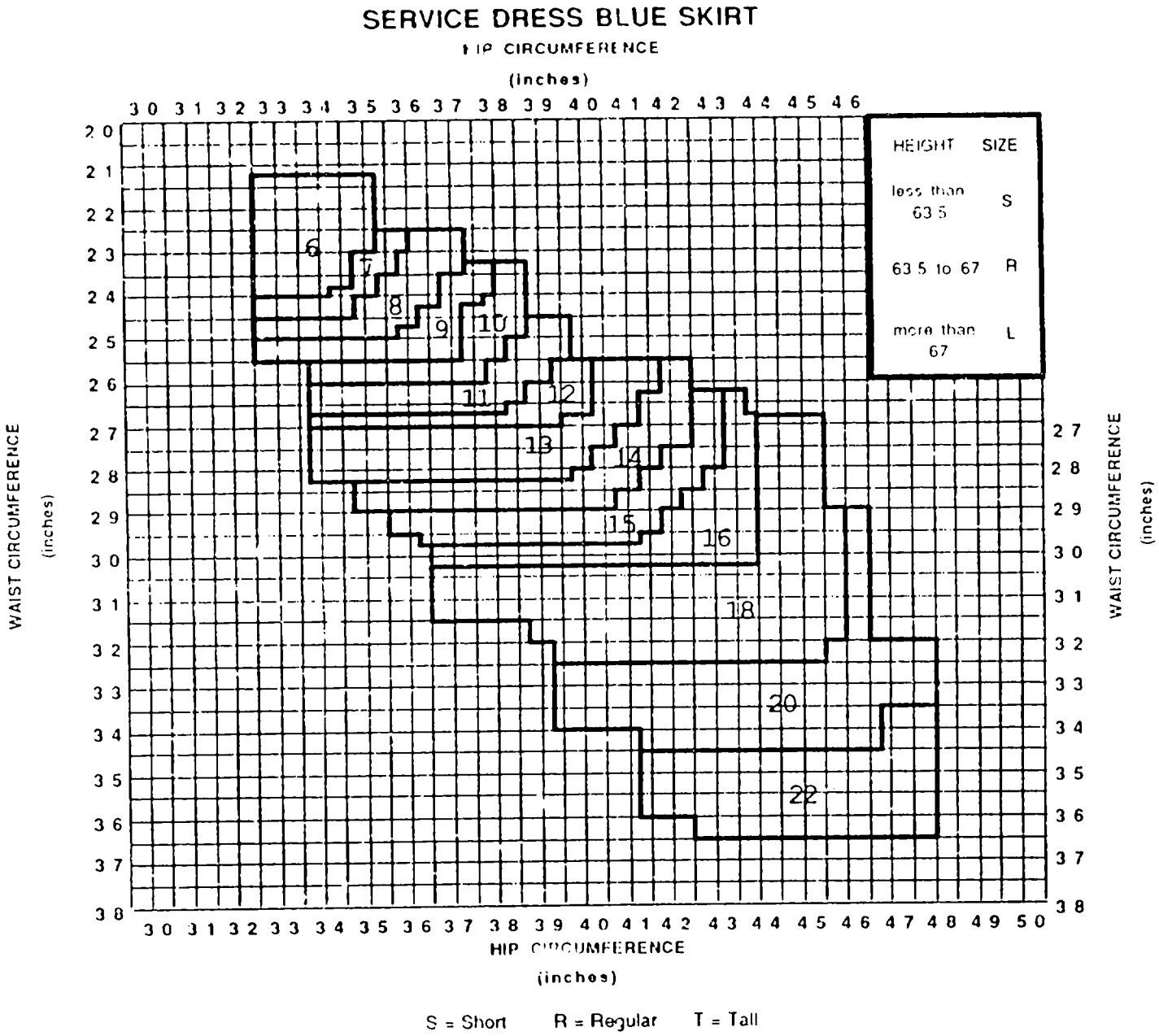


Figure 8
Size Selection Chart for the Service Dress Blue Skirt.

TABLE 9. Sizing Program Based on Bust Circumferences Compared to Assigned Sizes

WHITE SHIRT

Bust Circumference

Size	≤32	>32 ≤35	>35 ≤37.5	>37.5 ≤40	>40 ≤42.5	≥42.5
32	33	64	1			
34	8	177	52	4		
36		42	181	44	2	
38		1	50	114	21	1
40	1			31	47	1
42					6	16

Percentage Predicted Correctly = 63%

Of the six garments, the lower body garments were much more problematical, particularly with regard to waist circumference. Marked discrepancies surfaced between actual waist sizes of subjects and waist size specifications for the garments selected as best fit. In Figure 5, for example, it can be seen that subjects for whom size 6 was selected as the best fit ranged from 21 1/2" to 24 1/4" in waist circumference. The actual size 6 garment, however, is specified as having a 23 1/2" waist. In effect, many of the subjects' waists were larger than the specified sizes of the garments selected as being the best fit. The percentages listed below indicate the large number of women whose waist measurements were actually larger than the specified dimensions of the garment of best fit.

Summer White Slacks	29%
Service Dress Blue Slacks	45%
Summer White Skirt	48%
Service Dress Blue Skirt	42%

As a result, the size prediction charts were adjusted to match human and garment waist measurements. Tables 10 to 15 show percentages of the sample population assigned to each size by the prediction charts. The key dimensions of individuals who did not fall within any size, and the age distribution of the subjects assigned to each predicted size, were also examined

TABLE 10. Distribution of Subjects by Assigned Size and Age: Short-Sleeved White Shirt

Shirt Size	% Subjects Assigned	Age (in years) Mean	SD	Min	Max
32/12	2.2	27.9	5.4	21	40
32/13	2.2	24.2	3.2	19	29
34/12	5.8	24.9	3.7	19	35
34/13	20.3	26.4	4.7	19	39
34/14	6.0	25.9	4.7	20	41
34/15	0.1	23.0	..	..	..
36/13	18.9	26.1	5.0	19	42
36/14	11.8	26.3	4.4	20	40
36/15	1.2	28.5	5.3	21	39
38/13	8.9	27.0	5.9	19	44
38/14	10.9	26.8	5.3	19	48
38/15	2.0	27.7	5.9	20	40
38/16	0.0	0.0	0.0	0	0
40/14	6.9	28.0	6.0	19	48
40/15	2.0	27.8	6.0	22	43
40/16	0.2	28.5	3.5	26	31
42/16	0.4	25.8	4.6	21	31

UNASSIGNED INDIVIDUALS

Bust Circumference (inches)	Neck Circumference (inches)
42.00	12.50
43.50	14.50
44.00	14.00
44.00	14.50
44.00	14.50
45.00	14.00
45.00	14.00
46.00	14.25

TABLE 11. Distribution of Subjects by Assigned Size and Age: Service Dress Blue Coat

Blue Coat Size	% Subjects Assigned	Age (in years) Mean	SD	Min	Max
6	0.6	23.8	3.3	20	27
7	0.6	26.0	1.6	24	28
8	2.0	26.2	4.1	21	38
9	5.8	25.0	4.5	19	40
10	7.6	25.6	4.4	20	38
11	9.8	26.4	4.5	19	36
12	10.3	25.3	4.4	19	42
13	13.9	26.8	5.1	19	41
14	12.4	26.3	4.8	19	42
15	10.9	26.8	5.3	19	39
16	14.4	27.1	5.8	19	48
18	8.3	28.5	5.9	19	48
20	2.6	27.5	4.9	21	35
22	0.9	29.5	8.6	21	49

UNASSIGNED INDIVIDUALS

Bust Circumference (inches)	Hip Circumference (inches)
32.00	40.50
34.00	42.00
35.00	33.00
37.00	34.00
40.00	36.00

TABLE 12. Distribution of Subjects by Assigned Size and Age: Service Dress Blue Slacks

Blue Slacks Size	% Subjects Assigned	Age (in years) Mean	SD	Min	Max
6	0.6	23.3	1.7	21	25
7	0.8	23.6	2.8	20	29
8	3.4	26.1	5.7	20	40
9	1.9	25.5	3.2	20	31
10	6.4	25.2	4.5	19	38
11	12.5	25.9	4.3	19	37
12	5.9	25.6	4.7	19	41
13	12.9	26.2	4.8	19	42
14	11.4	26.8	5.0	19	42
15	12.9	26.5	5.1	19	40
16	3.6	27.5	6.1	20	39
18	17.7	26.7	5.3	19	44
20	7.1	29.3	6.1	21	48
22	3.0	29.0	7.0	21	49

UNASSIGNED INDIVIDUALS

Waist Circumference (inches)	Hip Circumference (inches)
23.00	31.38
24.00	40.50
26.00	42.00
27.00	34.00
30.00	35.50
32.00	37.00
32.00	38.00
34.00	39.87
34.00	40.00
37.00	43.00
37.00	45.50
37.00	48.00

TABLE 13. Distribution of Subjects by Assigned Size and Age: Summer White Slacks

White Slacks Size	% Subjects Assigned	Age (in years) Mean	SD	Min	Max
6	0.3	24.0	3.0	21	27
7	0.7	23.2	1.9	20	25
8	1.8	25.6	5.2	20	38
9	2.2	25.5	3.9	20	35
10	5.9	24.9	4.4	19	40
11	10.7	25.1	4.4	19	38
12	6.6	26.0	4.3	20	37
13	13.3	25.2	5.0	19	42
14	8.6	26.4	4.9	19	42
15	14.1	26.3	4.9	19	40
16	7.8	26.9	5.8	19	40
18	8.2	26.9	5.2	19	39
20	16.8	27.7	5.8	19	48
22	3.3	28.9	6.7	21	49

UNASSIGNED INDIVIDUALS

Waist Circumference (inches)	Hip Circumference (inches)
24.00	40.50
29.00	34.00
32.00	37.00
37.00	43.00
37.00	45.50
37.00	48.00

TABLE 14. Distribution of Subjects by Assigned Size and Age: Service Dress Blue Skirt

Blue Skirt Size	% Subjects Assigned	Age (in years) Mean	SD	Min	Max
6	1.0	23.8	2.7	20	29
7	1.4	24.8	4.2	21	33
8	3.5	26.2	5.4	20	40
9	6.2	25.0	4.3	19	38
10	3.9	25.7	4.3	20	36
11	2.9	25.6	4.2	19	37
12	3.3	26.9	5.3	19	41
13	20.1	26.3	4.8	19	42
14	8.1	26.5	4.9	19	40
15	10.9	27.2	5.4	19	40
16	9.8	26.9	5.4	19	44
18	11.6	26.9	5.3	19	40
20	5.7	30.1	6.4	21	48
22	1.5	28.1	8.2	21	49

UNASSIGNED INDIVIDUALS

Waist Circumference (inches)	Hip Circumference (inches)
23.00	31.38
24.00	40.50
29.00	34.00
30.00	35.50
32.00	37.00
32.00	38.00
33.00	38.50
33.00	38.50
37.00	43.00
37.00	45.50
37.00	48.00

TABLE 15. Distribution of Subjects by Assigned Size and Age: Summer White Skirt

White Skirt Size	% Subjects Assigned	Age (in years) Mean	SD	Min	Max
6	0.7	24.0	2.2	21	27
7	0.8	23.6	2.8	20	29
8	3.0	25.5	5.0	20	38
9	1.8	27.6	5.1	20	40
10	5.8	24.8	4.3	19	38
11	12.9	25.9	4.3	19	37
12	3.7	24.4	3.4	20	34
13	14.8	26.4	5.0	19	42
14	10.2	27.0	5.0	19	42
15	13.0	26.2	4.8	19	38
16	3.5	28.5	6.3	20	40
18	17.9	26.6	5.4	19	44
20	8.3	29.1	5.9	19	48
22	3.5	28.7	6.6	21	49

UNASSIGNED INDIVIDUALS

Waist Circumference (inches)	Hip Circumference (inches)
23.00	37.00
24.00	40.50
25.00	39.50
26.00	42.00
29.00	34.00
30.00	35.50
37.00	43.00
37.00	45.50
37.00	48.00

Given the large number of subjects (n = 906), there were very few individuals who did not fall within one of the chart categories. With regard to the short-sleeved white shirt, seven out of the eight subjects who did not, would be accommodated by the addition of one more size: 42/15. Three women had 37" waists which is above the largest chart category for all of the lower body garments. (The largest waist in Navy specifications is 36 1/2".) The remaining unassigned subjects do not cluster in any one area of the sizing charts; many of them are right on a borderline and could probably be fitted by a nearby size.

Age distribution was examined to determine if size and age were related in this sample. It seems clear from examination of the tables that, except for the short-sleeved white shirt, there is a steady increase in the mean age of subjects as the sizes go from small to large. This bears out earlier research which suggests that, for the most part, size tariffing will be affected by the age of the population, i.e., the more older individuals in a population, the more larger sizes will be required.

EVALUATION OF SIZING CHARTS

The modified charts for the lower body garments and the original charts for the upper body garments were tested in the field by the NCTRF to ascertain how accurately they determine the size of best fit. This was done by using the charts to select a subject's size, evaluating how well that size fit, and determining if a larger or smaller size was needed.

One hundred seventy new subjects were recruited to participate in the sizing chart evaluation. Comparison with the larger initial fit test group (n = 906) indicates differences of less than 1/2 inch on all measured dimensions. Age and race distributions found in both groups were also comparable. Table 16 shows summary statistics for anthropometric variables and racial distribution of the subset used in this evaluation. Several dimensions not included in the original fit evaluation were added. These are: crotch length, arm circumference, scye circumference and upper thigh circumference. These dimensions were added because a number of fitters and subjects noted tightness in these areas. Measurement descriptions for these are included in the Appendix.

Tables 17 through 22 show comparisons of chart-assigned sizes with size of best fit for the six garments. Sizes (based on neck, bust, waist, or hip dimensions) were treated separately from garment length designations (short, regular, long). The percentages of subjects whose predicted size was also the size of best fit ranged from 49 percent (summer white slacks) to 87 percent (summer short-sleeved white shirt). When the percentage of women whose size of best fit was within one size of the chart-indicated size is added to the percentage of those who obtained the best fit with the chart size, the percentages increase, ranging from 100 percent for the summer short-sleeved white shirt to 90 percent for the service dress blue skirt.

Garment length was assigned by subject stature (short = less than 63.5 inches; regular = 63.5 to 67 inches; long = over 67 inches). A comparison of height-assigned lengths to length of best fit shows that, while height may be a good indicator for skirt and coat length (85% - 70%), its ability to predict slack length is not as accurate (54% for both types of slacks).

TABLE 16. Evaluation of Navy Women's Clothing Measurements
(Second Data Set)

UNIVARIATE STATISTICS
(Weight in pounds; all other values in inches)
n = 170

Dimension	Mean	SD	Min	Max
Weight	137.7	21.9	95.0	202.0
Height	64.5	2.7	58.3	71.7
Neck Circumference	13.0	0.7	11.5	15.0
Shoulder Circumference	41.4	2.6	35.7	48.5
Bust Circumference at Scye	34.7	2.5	30.0	43.0
Bust Circumference at Bustpoint	36.3	3.0	30.0	46.0
Bust Circumference below Bustpoint	30.8	2.3	26.0	38.5
Waist Circumference	28.2	2.9	23.0	37.0
Hip Circumference	38.9	3.1	31.0	47.5
Waist Back Length	15.9	1.0	12.0	19.0
Sleeve Inseam	17.1	1.3	14.0	20.5
Sleeve Outseam	22.0	1.4	18.5	25.5
Sleeve Length	31.6	1.6	28.0	36.5
Waist Height	40.1	2.1	35.8	46.1
Crotch Height	29.7	1.8	24.4	34.6
Crotch Length	27.6	1.9	23.0	33.0
Arc Circumference	11.3	1.2	8.8	14.5
Scye Circumference	16.5	1.7	13.3	21.0
Upper Thigh Circumference	23.4	2.3	18.5	29.5

Racial Composition*

White	124
Black	39
Asian	4
Hispanic	2

* Data missing for one subject.

TABLE 17. Chart-Assigned Size vs. Size of Best Fit:
Short-Sleeved White Shirt

Chart Shirt Size

Size of Best Fit	32	34	36	38	40	42
32	13	2				
34		49	6			
36		2	31	1		
38			4	37		
40				6	13	
42					1	4

Percentage predicted correctly = 87%

Chart Neck Size

Size of Best Fit	12	13	14	15	16
12	6	3			
13	7	65	10		
14		9	49	1	
15			5	8	
16			1		2

Percentage predicted correctly = 78%

TABLE 18. Chart-Assigned Size vs. Size of Best Fit:
Summer White Skirt

Chart Skirt Size

Size of Best Fit	6	7	8	9	10	11	12	13	14	15	16	18	20	22
6	1													
7	1	7	1											
8			1											
9			1	1	1	1								
10			1	3	9	3								
11					3	8		3						
12						1	9	4						
13							1	9			1			
14								2	11	2	1			
15									7	12	3			
16										1	7	9		
18										1	3	16	10	
20													7	4
22														3

Percentage predicted correctly = 60%
Percentage within one size of correct prediction = 36%

Chart Length Size

Size of Best Fit	S	R	L
S	50	3	
R	9	69	2
L		10	24
XS	2		

Percentage predicted correctly = 85%

TABLE 19. Chart-Assigned Size vs. Size of Best Fit:
Summer White Slacks

Chart Slack Size

Size of Best Fit	6	7	8	9	10	11	12	13	14	15	16	18	20	22
6		2												
7	1	3	1											
8		1	2											
9			1	2		1								
10				4	5									
11					2	9		1						
12					2	5	7	3						
13							2	10						
14								2	4	2	1			
15							1	1	9	8	2			
16								1	1	7	10	4		
18										1	7	10	3	
20											3	7	10	2
22												1	4	3

Percentage predicted correctly = 49%
Percentage within one size of correct prediction = 42%

Chart Length Size

Size of Best Fit	S	R	L
S	14	2	
R	43	53	3
L	2	26	24
XS	2		

Percentage predicted correctly = 54%

TABLE 20. Chart-Assigned Size vs. Size of Best Fit:
Service Dress Blue Coat
Chart Coat Size

Size of Best Fit	6	7	8	9	10	11	12	13	14	15	16	18	20	22
6		3	1											
7	1	1	3		1									
8		1	1	7	1									
9				6		4								
10				1	9									
11					2	10	1							
12					1	5	11	1						
13						1	2	10	3					
14									9	3				
15								1	4	5	1			
16										4	24			
18							1			2	9	9	2	
20												2	2	
22													2	2

Percentage predicted correctly = 58%
Percentage within one size of correct prediction = 34%

Chart Length Size

Size of Best Fit	S	R	L
S	49	29	
R	5	51	8
L		1	19
XS	7	1	

Percentage predicted correctly = 70%

TABLE 21. Chart-Assigned Size vs. Size of Best Fit:
Service Dress Blue Skirt

Chart Skirt Size

Size of Best Fit	6	7	8	9	10	11	12	13	14	15	16	18	20	22
6	6													
7	2	2												
8		1	7											
9			1	10	7	3								
10					1	3	2							
11						5	3	2						
12							8	5						
13						1	1	9	1					
14								7	9	3	3			
15								4	4	4	1			
16										2	13	5		
18											2	20	5	
20												1	2	2
22														3

Percentage predicted correctly = 58%
Percentage within one size of correct prediction = 32%

Chart Length Size

Size of Best Fit	S	R	L
S	41	4	
R	19	56	3
L		22	24
XS	1		

Percentage predicted correctly = 71%

TABLE 22. Chart-Assigned Size vs. Size of Best Fit:
Service Dress Blue Slacks

Chart Slack Size

Size of Best Fit	6	7	8	9	10	11	12	13	14	15	16	18	20	22
6	2	2												
7	1	3	1											
8			2											
9			3	3	2	1								
10				1	5	5								
11				1	2	10		1						
12							15	4						
13								8	2	1	1			
14								2	15	2				
15									1	9	5			
16									1	1	6	10		
18										1	4	16	8	
20												1	5	2
22													1	3

Percentage predicted correctly = 60%
Percentage within one size of correct prediction = 36%

Chart Length Size

Size of Best Fit	S	R	L
S	18	2	
R	39	51	3
L	3	29	23
XS	1		

Percentage predicted correctly = 54%

Also of interest was the percentage of agreement among sizes of the lower body garments, i.e., the number of subjects who wore the same size for all four garments, the number who wore two or three different sizes, and the number who wore a different size for each item. Table 23 shows the frequencies and percentages of number of sizes worn, organized by size of best fit for the service dress blue skirt. For this analysis the original larger sample was used. The table indicates that over half (56%) wore two different sizes, 24% wore three different sizes, 16% were the same size for all four garments, and 4% wore a different size for each piece.

RECOMMENDATIONS

A number of sizing and design problems in the garments themselves were revealed during the course of the study. Because the sizing system described in this report was developed for already existing clothing, it was not feasible to incorporate all of the desirable changes. Rather, the information garnered here will be used in the development of new sizing systems for new clothing being developed by the NCTRF. Recommended objectives for follow-up research include:

- Further exploration of differences between black and white body proportions, and creation of a sizing system more accommodating for both.
- Development of one sizing system for all lower body garments and one sizing system for all upper body garments.
- Development of a sizing system which is more similar to commercial systems.
- Greater selection of sizes to accommodate a greater variety of body types.
- Design changes which would include larger arm holes and shoulder region, and a relocated bustpoint in the dress blue coat.
- Larger thigh circumferences.

TABLE 23. Variety of Sizes Worn by Frequency and Percent ( )

Frequencies

Blue Skirt Size	One Size Worn		Two Sizes Worn		Three Sizes Worn		Four Sizes Worn		Totals
6	5	(21%)	15	(62%)	3	(13%)	1	(4%)	24
7	3	(12%)	19	(76%)	2	(8%)	1	(4%)	25
8	12	(21%)	31	(53%)	14	(24%)	1	(2%)	58
9	4	(7%)	32	(55%)	17	(29%)	5	(9%)	58
10	14	(15%)	45	(48%)	30	(32%)	5	(5%)	94
11	6	(11%)	28	(51%)	20	(36%)	1	(2%)	55
12	21	(18%)	57	(49%)	29	(25%)	9	(8%)	116
13	7	(10%)	42	(60%)	15	(21%)	6	(9%)	70
14	9	(8%)	59	(49%)	46	(39%)	5	(4%)	119
15	4	(6%)	48	(74%)	13	(20%)	0		65
16	26	(28%)	57	(61%)	11	(12%)	0		94
18	19	(30%)	36	(57%)	8	(13%)	0		63
20	7	(18%)	30	(77%)	2	(5%)	0		39
22	4	(67%)	2	(33%)	0		0		6
	141	(16%)	501	(56%)	210	(24%)	34	(4%)	886

REFERENCE

Robinette, Kathleen M., Sirvart A. Mellian, and Cay A. Ervin, 1990, Development of Sizing Systems for Navy Women's Uniforms, Technical Report NCTRF/TR No. 183, Navy Clothing and Textile Research Facility, Natick, Massachusetts. (In press.)

APPENDIX

MEASUREMENT DESCRIPTIONS

Weight	Weight to the nearest 0.25 pound of a subject standing on the center of a balance scale platform.
Height	The vertical distance from the floor to the top of the head.
Neck Circumference	The circumference of the base of the neck (this circumference is not in a plane perpendicular to the axis of the neck).
Shoulder Circumference	The horizontal circumference of the shoulders measured at the level of the greatest lateral protrusion of the deltoid muscles.
Chest Circumference at Scye	The horizontal circumference of the trunk measured with the tape high in the armpits.
Bust Circumference	The horizontal circumference of the trunk measured with the tape passing over the bra points.
Chest Circumference below Bust	The horizontal circumference of the trunk measured at a level just below the cups of the bra.
Waist Circumference	The horizontal circumference of the waist at the "natural" waist level.
Hip Circumference	The maximum circumference of the hips at the level of the maximum posterior protrusion of the buttocks.
Waist Back Length	The surface distance from the waist to cervicale.
Sleeve Inseam	The distance from the anterior edge of the armpit to the little finger side of the wrist measured with the arm slightly abducted, the palm held forward, and the tape tense.
Sleeve Outseam	The distance from acromiale to the thumb side of the wrist measured with the arm slightly abducted, the palm held forward, and the tape tense.

APPENDIX

MEASUREMENT DESCRIPTIONS (Cont'd.)

Sleeve Outseam	The distance from acromiale to the thumb side of the wrist measured with the arm slightly abducted, the palm held forward, and the tape tense.
Sleeve Length	A tape with its zero point on the midline of the spine is passed horizontally around the right shoulder and over the tip of the elbow to the wrist landmark. The measurement is made while the subject holds her arms up in a horizontal position parallel to the standing surface and joins them by bringing the fists together at the metacarpophalangeal and proximal interphalangeal knuckles. The forearms and fists are in a straight line.
Waist Height (outseam)	The vertical distance from the floor to the natural waist level.
Crotch Height (inseam)	The vertical distance from the floor to the midpoint of the crotch.
Upper Thigh Circumference	The circumference of the leg in a plane perpendicular to its axis measured at the level of the lowest point of the gluteal furrow.
Scye Circumference	The circumference of the scye measured with the tape passing through the armpit and over acromion.
Crotch Length	The surface distance measured from the waist front at the level of the natural waist through the crotch to the waist back at the same level.
Forearm Circumference	The maximum circumference of the lower arm as measured in a plane perpendicular to its long axis. The elbow is flexed 90 degrees, the upper arm is horizontal, and the fist is tightly clenched.

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