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Pants alteration by graphic somatometry techniques

Carol Jean Todd Pouliot

Iowa State University

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Pants alteration by graphic somatometry techniques

Carol Jean Todd Pouliot

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

Major: Textiles and Clothing

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CHAPTER 1. INTRODUCTION

The traditional method of pattern alteration uses measurements of body circumference and body length as a basis for making personal adjustments. A sewer takes body measurements and compares them with the corresponding measurements of a commercial pattern. Alterations are then made based upon the body measurements plus a prescribed amount of ease.

Alterations may include changes in both length and width so that the pattern reflects the personal body measurements. In cases where "perfect fit" is sought, the pattern is frequently constructed in some inexpensive fabric such as muslin or gingham, and additional alterations are made to fit the particular figure type and figure problems.

In general, this technique produces fairly satisfactory results for the average sewer who is working with bodice and skirt patterns. However, the alteration of pants patterns is not so easily accomplished by this measurement technique. Pants, more than other types of outerwear, need to be
altered to fit the contour of the hip and thigh areas. Crotch length and shape are also determining factors in the way that pants fit the body. Unfortunately, neither shape nor contour can be determined from traditional circumference measurements.

It is possible, however, to analyze body contour in terms of specific body types. Sheldon, a clinical psychologist interested in classifying the human body into types, observed that in most individuals, there are three types of morphological structures (Sheldon, Stevens, & Tucker, 1970). Characteristics of these types are apparent in any body region, although not uniform from region to region. This method of body typing, known as somatotyping, evaluates the human figure on the basis of skeletal structure, total physique, head and trunk proportions, and limb proportions. Although an individual fits predominantly into one of these three types, he or she will also possess characteristics of one or both of the other types.

In 1926, Sheldon developed a standardized technique for taking photographs of individuals. These photographs were then used as sources of data from which anthropometric measurements could be taken (Sheldon et al., 1970). Although Sheldon recognized that these photographs could not be used
to measure length along any curved surface because of the loss of depth perception, Sheldon et al. (1970) were convinced that there was no means, other than photography, for accurately measuring the soft parts of the body in terms of body width and thickness.

Sheldon's original subjects in his 1920's study were 4,000 college males selected from a variety of colleges in the Midwest and in the East (Sheldon, et al., 1970). As the study progressed, Sheldon became interested in looking at the female body in terms of his three body types. However, at the time of the original publication of this source, Sheldon had not collected enough standardized photographs of women to make any generalizations.

More recently, Douty (1968) modified Sheldon's method of somatotyping by developing a system called graphic somatometry in which silhouettes of subjects were projected through a gridded screen. The photographs of these projected silhouettes were then used to analyze posture, general mass, proportion, contour, and the balance and symmetry of identical body parts. Brinson (1977) used the graphic somatometry method to evaluate the above-mentioned body characteristics in terms of body angle measurements. She was able to satisfactorily fit each of her selected subjects
by using body angle measurements to alter basic bodices and skirts.

Other methods have been developed to study the shape of the human body. Philipsz (1962) devised a method in which beam calipers were used to trace an individual's silhouette onto paper. Philipsz was then able to determine and classify three types of hip silhouettes based on the information obtained from her tracings. In a follow-up study, Reed (1963) used Philipsz's method and classification system to alter skirt patterns to fit individual figure types. Although the method used by Reed produced skirts that fit well, she found that the caliper method for obtaining hip silhouettes was both cumbersome and time-consuming.

Although several studies have evaluated hip silhouette and its effect on skirt fit and alteration, little research has been found concerning the use of silhouettes in determining pattern alteration for pants or slacks. Saladino (1970) used Philipsz's three classifications of hip silhouettes in her study on alteration of commercial pants patterns. However, the study was inconclusive and, upon evaluation, Saladino found that one of her subjects needed additional alteration due to posture.
5

Goals

I believe that a pants pattern alteration method that incorporates body measurements, graphing techniques, and measurements of body angles would correct for postural defects, and would therefore produce a pattern with better fit than a pattern altered by body measurement techniques only. Therefore, this study will use graphic somatometry techniques to evaluate body shape and posture. The goal of this research is to develop a method of pattern alteration for pants that will take into consideration such factors as body mass, shape, balance, symmetry, and posture.

Objectives

The objectives of this study are as follows:

1. To use somatographs of women to quantify figural and postural variations of the waist, abdomen, hip, thigh, and crotch areas.

2. To develop a method in which crotch length and shape may be defined mathematically by using the somatograph and computer graphing techniques.

3. To determine which alterations are needed in fitting commercial pants patterns to individual figures.

4. To develop a set of instructions for altering pants by using graphic somatometry and computerized techniques to determine figural and postural variations.

5. To develop a pants alteration technique that gives a fit superior to the fit achieved by traditional pants pattern alteration techniques.
Assumptions

The assumptions in this research are:

1. The sideseam of pants can be determined as a line drawn from the midpoint of the profile waist to the ankle bone. In the somatographs, the ankle bone is in line with the plumb line of the screen.

2. The crotch depth plus ease can be determined by placing a dowel rod between the legs and as close to the torso as possible. This rod will be kept parallel to the floor.

3. The crotch point can be defined as the point that is the intersection of the midpoint of the thigh (profile view) and the dowel rod. This point will be on, in front of, or in back of the sideseam line, depending upon posture of the individual.

4. The lowest part of the torso is to the posterior side of the crotch point.

5. The length and size of the waist darts can be determined from the computerized representations of the body.

Limitations

This study is limited to those individuals participating in the pretesting and the testing of this alteration technique, and the findings cannot be generalized to other individuals.
Hypotheses

This research develops a computer assisted method of pants pattern alteration that incorporates graphic somatology and mathematical concepts. The evaluative rating scale was used to answer two questions: 1) Is the fit produced by each method of pattern alteration judged to be good or bad for each criterion? 2) Is the fit produced by one method judged to be better than the fit produced by the other method for each criterion?

The diagnostic rating scale was used to answer three questions: 1) Was a less-than-good rating assigned because of any specific criterion? 2) In which direction did the fit vary from a correct fit (i.e., tight or loose) for each specific criterion? 3) By what degree did the fit vary from a correct fit?

The overall hypothesis of this research is: There will be no significant difference between ratings of fit in pants made by the Experimental Method and by the Unit Method.

The testable sub-hypotheses are that:

1. There will be no difference between the ratings for pants altered by the Unit Method and pants altered by the Experimental Method for each evaluative criterion.
2. Body type will not interact with the method of alteration in the evaluative ratings for each criterion.

3. There will be no difference between the ratings for pants altered by the Unit Method and pants altered by the Experimental Method for each diagnostic criterion.

4. Body type will not interact with the method of alteration in the diagnostic ratings for each criterion.

One additional hypothesis that could not be statistically tested was that: There would be no single mathematical function that could describe the curvature of the crotch area for all figure types. This hypothesis was supported in the developmental stages of the study, and is expanded upon in Chapter 3.
CHAPTER 2. REVIEW OF THE LITERATURE

In reviewing the existing literature, I found little research in the areas of pants fit and alteration. Therefore, I was forced to rely heavily on commercial sewing books and instructional texts. I also referred to any materials involving the fitting and alteration of skirt patterns, in particular, that research which dealt with alteration for body shape or type.

Recent Research on Fitting Pants and Skirts

One inconclusive study on fitting pants in relation to body shape was done by Saladino (1970) at Iowa State University. Saladino used the beam caliper method devised by Philipsz (1962) to trace and classify three distinct body shapes. These classifications, based upon the back hip tracings, were the flat hip, the pear-shaped hip, and the round hip types.

Saladino (1970) selected three "mature" women with 38" hip circumference measurements, one of each hip type, to
participate in her study. Alterations to a basic pant pattern were made by a method which was a composite of directions from several commercial sewing books and instructional texts, and a pant muslin was constructed for each subject. These muslins were compared with muslins constructed from an unaltered pattern, and, of course, the altered pants produced a better fit.

It is not clear if Saladino (1970) used the traced body shapes for any purpose other than to classify and select participants for her study. Saladino (1970) did, however, report that additional alteration was needed to correct for the forward-leaning posture of one of her three subjects.

Brinson (1977) used the graphic somatometry method developed by Douty (1968) to analyze posture, general mass, proportion, contour, and the balance and symmetry of paired body parts. She then devised a method of pattern alteration for bodices and skirts which combined traditional body measurement techniques and the measurement of body angles. For the alteration of skirts, Brinson (1977) measured the abdomen-to-waist angle, the lower back to waist angle, and the side body angles from the somatographs of her participants. These angle measurements were then duplicated in the skirt pattern after circumference alterations had been made, and a satisfactory fit was obtained for all subjects.
In her recommendations, Brinson (1977) questioned whether the body angle measurements taken from the somatograph should be duplicated exactly on the pattern, or if some allowance needed to be made for ease in the garment. Brinson (1977) had speculated that when the hip circumference alteration had been completed, the waist circumference would be automatically corrected once the dart and sideseam angle measurements were corrected. Although Brinson (1977) did not find this to be true in her research, she still questioned whether such a relationship was being obscured because of her failure to understand how ease fit into the total alteration process. Brinson (1977) also questioned whether the sideseam curve should exactly duplicate the curve of the body shown by the somatograph, or if ease should somehow be added to the full hipline area at the sideseam. Although Brinson (1977) formulated these questions, no further research can be found that attempts to provide any answers.

Traditional Pattern Alteration for Pants and Skirts

The traditional methods of pattern alteration use measurements of body circumference and body length as a basis for making personal adjustments. In addition, these methods
may take into consideration such things as figure types, postural variations, figure irregularities, ease requirements, and the correct order of alteration. Regardless of which process is used or what factors are considered, the goal of all methods of pattern alteration is to produce a garment that fits the body well. Therefore, I found it necessary for the purpose of this research to define "good fit" in pants.

**Definition of good fit**

As I reviewed the literature on the fit of pants, I found two types of definitions for good fit: global definitions and itemized definitions.

**Global definition of good fit** Two authors defined good fit in pants in terms of an overall impression or evaluation. Oblander, Ekern, and Zieman (1978) described good fit as:

> A perfectly fit pair of slacks should fit without any wrinkles. The center creases should hang straight down or parallel with (sic.) the floor, and in the back, the slacks should hang straight down from the hipline to the hemline. (p. 450)

Although I agree that pants should fit without any distracting wrinkles, I believe that it is impossible for the center creases to "hang parallel with the floor." Unfortunately, there is no evidence to indicate that the authors
actually meant to write "perpendicular to the floor," which is the criterion cited by most authors. Therefore, I disregarded this definition of good fit.

Tyroler (1963) defined good fit in pants by describing what the pants pattern should look like.

A good pattern has a fairly straight up-and-down center seam in both front and back ... the center seams of pants must be straight or they will bag. There will be a tiny bit of bias to a well-constructed pattern, just enough to accommodate the human figure, but never enough to condemn you to eternal bagginess, sagginess, and miserable sitting. You should be able to sit on that seat curve without sliding off! (p. 49)

This definition, although it shows some humor, does not leave the reader with any answers to how much is a "tiny bit" of bias, or what is a "fairly straight up-and-down" center seam. For the purpose of this research, I needed a more concrete definition of good fit in pants.

**Itemized definitions** The following itemized definitions were composed from criteria listed by Erwin and Kichen (1969), "McCalls" (1968), Perry (1972), and Fitting Pants (Note 1). For ease in reading, they are presented in table form (see Table 1).

Definitions listed in Table 1 were later used in the development of the rating scale used in this study.
### TABLE 1

Compiled itemized definitions of good fit for pants

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<th>Criterion</th>
<th>Drawn</th>
<th>Modified</th>
<th>Perry</th>
<th>Sitting</th>
<th>Pants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grainlines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Horizontal grainlines at hipline should be straight and parallel to the floor</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2. Vertical grain should be perpendicular to the floor</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3. In woven fabrics, crosswise grain should slant toward CB, and lengthwise grain should angle toward outside at hips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>CF and CB seam placement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. CF and CB seams should divide the figure in half</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>5. Grainlines at CF and CB should be perpendicular to the floor</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Side seam placement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Side seams should divide the figure in half</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Side seams should be perpendicular to the floor</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8. Side seams should correspond to the slant of the leg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Waist seam placement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Waist seam should be parallel to the floor</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Waist seam should be at natural waistline (narrowest part) when standing</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Darts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Darts should end just above the fullest part of the body curve that they cover</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Darts should lie flat and form a smooth contour from base to point</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>Crotch shape</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Crotch curve should hug body contours</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Ease</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Pants should have sufficient ease for movement</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Pants should hang smoothly and be supported by figure contours</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Pants should fit smoothly across abdomen and seat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>17. Closures should be smooth and without distortion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Postural variations

Few patternmaking or sewing texts outlined postural variations as a part of the analysis of the body. However, Hillhouse and Mansfield (1948), Minott (1972), and Ingels and Yep (Note 2) all evaluated posture in an attempt to predict which alterations would be necessary. Conversely, many other texts waited until the pant muslin had been constructed before identifying fitting problems resulting from postural variations. In Table 2, I have outlined the postural variations listed by the sources named above.

Hillhouse and Mansfield (1948) defined correct posture as having the waistline and hip level parallel to the floor; where a vertical line drawn through the center of the side hip passes through the center of the waistline, knee, shoulder, ear, and anklebone.

A posture that leans back from the waist exhibits these variations: the center back of the waistline is lowered, the center front waistline is lifted, and the center front is longer from the waist to hip level than the center back. Recommended alterations for this postural variation would be to add length to the center front between the waist and hip level, and to decrease length of the center back between the waist and hip level.
TABLE 2
The body analyzed in terms of postural variation

<table>
<thead>
<tr>
<th>Variation</th>
<th>Hillhouse 5 Mansfield</th>
<th>Minott</th>
<th>Ingels &amp; Yep</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Correct</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Leans back from waist</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Leans back from hips</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Leans back from knees</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Swayback</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6. Overly erect</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Head tilts forward</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>8. Average</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Hip tilted forward</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Hip tilted backward</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[a\] These postural variations only affect the fit of bodices.

A posture that leans back from the hips also results in a lengthening of the center front and a shortening of the center back. The same alteration technique used for the posture leaning back from the waist is recommended for this postural variation.

A posture that leans back from the knees increases the length from the knee to the center front waist and decreases the length from the knee to the center back waist. As a
result, the center front is longer than the center back from the waist to the hip level. The alteration procedure used for this postural variation is the same as the two alteration procedures reported above.

The fifth postural variation, the swayback, was defined by both Hillhouse and Mansfield (1948) and Ingels and Yep (Note 2). The swayback posture is one in which the body is tilted forward from the hip to the waist and back from the waist to the shoulder. This variation shortens the space between the waist and the back hip level. The recommended alteration for this variation is to decrease the center back length between the hipline and the back waist.

Minott (1972) combined description and a quantitative approach to define her three postural variations. The average posture stands fairly straight with the seat neither held out nor tucked under. Sideseams would fall straight, and closely align with the ankle bone (This resembles the correct posture as detailed above). From a quantitative standpoint, the center front waist-to-floor measurement is equal to, or up to 1/2" longer than, the center back waist-to-floor measurement.

The hip tilted backward posture stands with the abdomen lowered and the derriere lifted up and out (This resembles
the swayback posture as detailed above). In this case, the center front waist-to-floor may measure 1/2" or more shorter than the center back waist-to-floor.

The hip tilted forward posture, as identified by both Minott (1972) and Ingels and Yep (Note 2), stands in a slouched position with a fairly flat, low seat and a high prominent roll below the front waist or prominent hip bones. For this postural variation, the center front waist-to-floor measurement may be 5/8" or more longer than the center back waist-to-floor measurement.

Definitions of these postural variations were later used when evaluating the posture of the participants in this study.

**Figure types**

Minott (1972) and Oblander et al. (1978) are the only two patternmaking texts that attempted to classify the female body into specific figure types. Minott (1972) classified the figure in two ways: symmetric/asymmetric and according to hip types.

Although Minott did not define the symmetric figures she described the asymmetric figure as one which exhibits a difference between left and right sides. This difference
may be in length, height of hip, width, or a combination of these differences (such as a high, wide hip). Specific alterations used for the asymmetric type depend upon the individual figure, and are made after the construction of the first-fit muslin.

Minott's hip types are average, heart, and diamond. Definitions for each type are very explicit; the average hip has the greatest circumference at the seat level (7" to 9" below the waist); the heart hip type has the greatest circumference 3" to 4" below the waist; the diamond hip type has the greatest hip circumference at the thigh level with the difference between waist and hip circumferences reaching 11" or more. Minott also recognized that some hip types may be classified as semi-heart; one in which the hip circumference at the seat level may be the same measurement as or up to 1" more than the 3" or 4" hip level circumference. Specific alterations for these hip types are discussed in Minott's pattern alteration text.

Oblander et al. (1978) isolated two figure variations -- the full figure and the petite figure. The full figure variation was then subdivided into the reverse figure and the queensize figure. Oblander et al. (1978) recognized that the average woman is nearly evenly proportioned from
front to back, with perhaps more weight in the derriere. Logically then, the reverse figure may be described as one with a large stomach and a flat seat. On the other hand, the queensize figure has both a large stomach and a large derriere, coupled with large thighs. The petite figure, as defined by Oblander et al. (1978) is a figure that is very small and slender. Specific alterations for these figure types are discussed in The Sew/fit Manual.

**Additional figure irregularities**

Although no other sources isolated specific figure types in an attempt to predict which alterations would be needed, many sources discussed figure irregularities in relation to the fit of the basic muslin. These figure irregularities were:

1. large or high hip
2. protruding hip bone
3. protruding abdomen
4. flat abdomen
5. large derriere
6. flat derriere
7. flat side hip
8. hollow pubic bone
9. bow legs
Alterations for each of these figure irregularities are completed after the construction of the first-fit muslin, and therefore are not included in this research.

**Measurement procedures**

Every patternmaking and alteration source reviewed for this research used a body measurement chart as a basis for determining necessary alterations. Table 3 is a composite of all body measurements used by Colton (1976), DuBane (1978), Iowa Home Economics Association (IHEA) (1977), Lewis (1976), "McCalls" (1968), Oblander et al. (1978), Tyroler (1963), and Ingels and Yep (Note 2). These authors only represent a portion of those references consulted; other sources simply duplicate the information reported here, and therefore were not listed in this table.

**Ease recommendations**

Ease recommendations for pants varied from author to author in both the amount and the specificity. Most sources used in this research listed a standard ease allowance for all figure types. However, Minott (1972) and Tyroler (1963) recommended specific amounts of ease for the different figure types and sizes. For ease in summary, I have listed the recommended ease allowance in table form. Table 4 lists the
### TABLE 3

**Body measurements used in altering pants patterns**

<table>
<thead>
<tr>
<th>Body Measurements</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Colton</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>X</td>
</tr>
<tr>
<td>Hip circumference</td>
<td>.</td>
</tr>
<tr>
<td>3&quot; below waist</td>
<td></td>
</tr>
<tr>
<td>7&quot; below waist</td>
<td></td>
</tr>
<tr>
<td>fullest hip</td>
<td></td>
</tr>
<tr>
<td>depth of fullest hip</td>
<td>X</td>
</tr>
<tr>
<td>Crotch depth</td>
<td>X</td>
</tr>
<tr>
<td>Crotch length</td>
<td>X</td>
</tr>
<tr>
<td>Waist to ankle</td>
<td>X</td>
</tr>
<tr>
<td>Waist to knee</td>
<td>X</td>
</tr>
<tr>
<td>Leg circumferences</td>
<td></td>
</tr>
<tr>
<td>thigh</td>
<td>X</td>
</tr>
<tr>
<td>knee</td>
<td>X</td>
</tr>
</tbody>
</table>
ease allowances recommended for all figure types by Colton (1976), DuBane (1978), IHEA (1978), Oblander et al. (1978), Palmer (1974), and Ingels and Yep (Note 2). Table 5 lists the ease allowances recommended by Minott (1972) and Tyroler (1963) for specific figure types.

These tables (3 - 5) later became the basis of the measurement chart used in this research (see Appendix C).

**Pattern selection**

Authors of the patternmaking and alteration texts disagreed about how pattern size should be determined. Colton (1976), IHEA (1977), "McCall"s (1968) Roxane (1972), and Ingels and Yep (Note 2) all agreed that a pants pattern should be selected according to the full hip measurement or the hip measurement taken at 7" below the waist.

On the other hand, DuBane (1978) and Lewis (1976) both believed that pants patterns should be selected according to the individual's waist measurement because it is easier to alter for the hips than the waist (won't have to disturb darts, pockets, or any waist details). Lewis (1976) did concede, however, that when the hips are much larger than the waist, the full hip circumference should be used in the selection of the correct pattern size.
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Colton</th>
<th>DuBane</th>
<th>IHEA</th>
<th>Oblander</th>
<th>Palmer</th>
<th>Ingels &amp; Yep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>0&quot;</td>
<td>0&quot;</td>
<td>0-1&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full hip circumference (3&quot; below waistline)</td>
<td>3/4&quot;</td>
<td>1/2&quot;</td>
<td>1-2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh circumference</td>
<td>2&quot;</td>
<td>2&quot;</td>
<td>2&quot; or more</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee circumference</td>
<td>2&quot; or more</td>
<td>2&quot; or more</td>
<td>2&quot; or more</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crotch depth</td>
<td>0-1&quot;</td>
<td>0-1&quot;</td>
<td>1/2-3&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total crotch length</td>
<td>up to 1 1/2&quot;</td>
<td>1-2&quot;</td>
<td>1-2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front crotch length</td>
<td>3/4&quot;</td>
<td>1/2&quot;</td>
<td>1/2-3&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back crotch length</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1/2-3&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Up to 3" for full figures.*
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Type</th>
<th>Size</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>Small (up to 25 3/4&quot;)</td>
<td>1/2&quot;</td>
<td>Minott Tyroler</td>
</tr>
<tr>
<td></td>
<td>Medium (26-29 3/8&quot;)</td>
<td>1/2-1&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large (over 30&quot;)</td>
<td>1-1 1/2&quot;</td>
<td></td>
</tr>
<tr>
<td>Hip circumference</td>
<td>Average small</td>
<td>1-1 1/2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average medium</td>
<td>1 1/2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average large</td>
<td>2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semi-heart small</td>
<td>1 1/2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semi-heart medium/large</td>
<td>1 1/2-2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heart small</td>
<td>1 1/2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heart medium/large</td>
<td>2&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diamond small/medium/large</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>Crotch depth</td>
<td>Small (hips below 35&quot;)</td>
<td>1/8&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium (hips 35-38&quot;)</td>
<td>3/4&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large (hips over 38&quot;)</td>
<td>1&quot;</td>
<td></td>
</tr>
</tbody>
</table>
The third school of thought is that pants patterns should be purchased two sizes smaller than the full hip circumference measurement. The reasoning behind this idea is that a pattern which is too small can more easily be made larger to look and fit better. Conversely, if the pattern was purchased according to the full hip measurement, then the leg circumference would be much too large. Then, any alteration at the sideseam would only cause diagonal wrinkles in the pant legs.

Alterations

There are typically three methods of traditional pants pattern alteration: the slash and spread/lap\(^1\), the redrawn seamline, and the pivot and shift method. Frequently, sources used a combination of the first two methods, the method used being dependent upon the type and amount of alteration needed. The three methods of alteration are defined in the following paragraphs, and sources are listed for each.

\[^1\] The folded pleat method is considered in this research to be analogous to the slash and lap method of alteration.
**Slash and spread/lap** The slash and spread/lap method of pants pattern alteration increases length or width by cutting the pattern and inserting paper. Conversely, the pattern is decreased by cutting and overlapping the pattern. This method is used by such resources as Colton (1976), DuBane (1978), IHEA (1977), "McCalls" (1968), Minott (1972), Palmer (1974), Perry (1972), Romaniuk and Knight (1974), Roxane (1972), and Ingels and Yep (Note 2).

**Redrawn seamline** The redrawn seamline method is used only occasionally, and then only when two inches or less total circumference, or one inch or less total length needed to be added to or subtracted from the pants pattern. The method consists of drawing a new seamline outside of the original seamline in order to increase, or drawing a new seamline inside of the original in order to decrease the pattern measurements. The sources consulted that use such a technique are Bishop and Arch (1966), Colton (1976), DuBane (1978), "McCalls" (1968), Moore (1971), Palmer (1974), Person (1974), Romaniuk and Knight (1974), Roxane (1972), and Ingels and Yep (Note 2). It is noteworthy, however, that many of these sources also used the slash and spread/lap method of alteration as their primary method.
The pivot and shift method of pants alteration involves redrawing seamlines after the pattern has been rotated on a construction point (i.e., a waist point), or moved up/down or in/out from the original position while keeping grain lines parallel to the original grainline position. Few sources used this method of pants pattern alteration. Those who did, included Ekern (1977) and Oblander et al. (1978).

Order of alteration

Order of the alteration process may vary slightly from method to method. However, the typical order of alteration for pants was:

1. crotch depth,
2. width alterations,
3. length alterations,
4. dart placement.

The specific order of alteration used in this research is discussed in Chapter 3.

Development and Application of Body Typing Systems

The theory of body typing is based on the assumption that it is possible to discriminate differences among human
beings (Sheldon et al., 1970). Methods of body typing have grown out of scientific research in the field of anthropometrics, which is a science and technique of measuring the anatomical and physiological features of the body. This definition includes all external measurements of body dimensions (static anthropometry), angular and linear ranges of body segments, and postural and limb forces and strengths (dynamic anthropometry) (Croney, 1971, p. 47).

Although many attempts have been made throughout history to scientifically classify the human body into types, I will discuss primarily two such attempts that are directly related to this research. A broader history of body typing may be found in Croney (1971).

Development of Somatotypes

Sheldon et al. (1970) believed that any classification of the human physique must be based on four points in order to be an adequate system. These four points are:

1. a study involving a large number of individuals,
2. a method of looking at separate components of the body as opposed to classifying the whole body as an overall type,
3. a method of dividing the body into regions for the purpose of measurement and classification, and
4. a method using comparison of both photographic records and anthropometric measurements.
In 1926, Sheldon began to develop a classification for male body types (Sheldon et al., 1970). He devised a method in which anthropometric measurements of diameters could be taken from standardized photographs of men. This pilot study lasted for ten years and involved 46,000 men. In some respects, these men were representative of the American population, although a majority were taken from academic settings.

Sheldon et al. (1970) reported in the results of this study that the use of standardized photographs for taking anthropometric measurements of diameters was the only technique that produced precise and accurate measurements of the soft parts of the body. He substantiated this claim by measuring the body itself and by taking measurements from subsequent photographs of the same individual. By using this method of measurement, Sheldon (1954) was able to devise a method of body typing based on three components -- endomorphy, mesomorphy, and ectomorphy².

Sheldon believed that any physique contained these three components in a varying ratio, and that these components could be detected in any body region. At the conclu-

² These components were coined from the terms used to describe the three initial layers in the early embryonic forms of higher life.
sion of his first study on men, Sheldon (1954) had been able to find examples of all 88 known body types (somatotypes), and from these, he standardized height-weight tables for all 88 somatotypes at all ages from 18 to 65.

Branching from his research on male figure types, Sheldon was curious to see if women exhibited the same body characteristics as men. In the most recent publication found, Sheldon et al. (1970) had not collected enough standardized photographs of women to make any generalizations. However, in his limited studies on the female body, he found that it is not unusual for females to have highly endomorphic legs and highly ectomorphic upper body segments. This is to say that women tended to be thin in the upper body regions and more fleshy in the legs.

Development of body build and posture types

Douty began her own investigation of the female body when she became dissatisfied with information that was provided by detailed body measurements. Douty (1969) recognized that these detailed measurements provided little information about the location and distribution of the body mass, nor did they take into consideration the way that the figure contour and the general body appearance are affected by posture. Therefore, Douty turned to Sheldon's work as a basis for her own research.
Douty, Moore, and Hartford (1974) recognized that Sheld- 
don's somatotypes were based on a continuous scale, when in 
fact they may not represent a continuous variable. There- 
fore, his typology would be misapplied by researchers who 
consider mesomorphy to be the median between endomorphy and 
ectomorphy. In order to avoid this type of error, Douty 
began searching for other ways to evaluate the body analyti- 
cally.

In looking at the body, Douty reasoned that

The positioning of body segments that is revealed 
in total posture is an outcome of paired muscle 
groups and their interaction with other muscle 
groups as they support the bony and fleshy struc- 
tures of the body through automatic reciprocal 
innervation. If one set of a pair is stronger or 
more tense than the other, it may dominate the 
interaction and a typical positioning of body 
framework and the body segments will result. 
(Douty, 1970-71, p.2)

With this reasoning in mind, Douty used a photographic 
method similar to Sheldon's to look at the positioning of 
the body framework and body segments. Because these photo- 
graphs were actually body silhouettes projected through a 
gridded screen, Douty called them "somatographs" (Douty, 
1968).

Much information about body alignment and distribution 
of flesh can be obtained from these somatographs. From the 
posterior somatograph, it is possible to look at
1. general mass and shape,
2. size and contour of body segments,
3. proportional relationships of body units,
4. body alignment, and
5. the condition of balance and symmetry of identical (sic.) body parts on the two sides of the balance line (Douty, 1968, p.25).

Then, from the profile view or "posture-graph," it is possible to obtain detailed information about body alignment or disposition of body segments (Douty, 1968).

In her pilot study at Auburn University, Douty obtained the somatographs of 300 women who had enrolled in freshmen textiles and clothing classes from 1963-1965. Three judges evaluated the somatographs according to body build and posture. From these evaluations, Douty developed her Body Build Scales and Posture Scale by using the mode of the evaluations as the "average," and obtaining a regular progression in both directions in terms of weight and shape. She then developed composite figures and paired them with verbal descriptions composed from the judges' observations and the literature already available on body types (Douty, 1968).

Although neither the Body Build Scale nor the Posture Scale were used to numerically rate the somatographs of par-
participants of this research. I compared the postures of the participants with the drawings of Douty's scale. It is interesting to note that Douty's postural variations from excellent posture all show some degree of a forward leaning of the body. This is in direct contrast to the postural variations defined by Hillhouse and Mansfield (1948) in which all exhibited a backward-leaning posture.

Related Mathematical Concepts

The field of mathematics can easily lend itself to the quantification of the total body structure. By representing the body as a series of known analytic functions, it is possible to obtain a good approximation of the actual body form.

There are many mathematical techniques which can be used to predict and explain body curvature. These techniques include approximation of length along a line, quadratic interpolation, and cubic spline interpolation -- all of which are discussed thoroughly in Chapter 3. However, at this writing, I have been unable to locate any research that attempts to quantify the body by using splines or any other mathematical function. Nonetheless, I believe that by using mathematical functions to look at body curvature in relation
to a balance line, it is possible to account for posture, distribution of flesh, and body asymmetry -- the three factors that are most often neglected in pattern alteration and patternmaking.
CHAPTER 3. PROCEDURES

The procedures used in this research are quite lengthy and detailed. A basic outline of the procedures is given in the following paragraphs.

A translucent gridded screen was constructed for use in the photographic process. Thirty-six female volunteers between the ages 12 and 55 were photographed in a minimum of clothing. Seven were selected according to characteristics of five body types: round, pear-shaped, average, weight in front, and weight in back. The somatographs of each individual were then analyzed, and data points that described the contours of the body were selected.

Two computer programs which used correction for distortion, approximation of length along a line, quadratic interpolation, and cubic spline interpolation were developed to correct plot full-scale representations of the body curves. The resulting plots were measured for dart size and length and crotch depth. Center front, center back, and sideseams were also developed from the visual information given by the body plots.
After the plots had been interpreted and seams had been developed, two pants patterns were altered for each of the seven models; one by the Unit Method of alteration, and one by the Experimental Method. Measurements of the completed patterns were then compared, and the first-fit muslins were constructed.

Because no complete evaluation scale for the fit of pants could be found, I developed an evaluative rating scale and a diagnostic rating scale to be used in this research. Three judges were selected and then trained by using the developed scale to rate the fit of pant muslins on two of the seven models. Evaluation of the other five models (two pant muslins per model) immediately followed the training session.

The judges' responses to the evaluative and diagnostic rating scales were transformed to normal deviates and analyzed by a three-way analysis of variance and the overall means. Scatter plots were constructed to aid in the interpretation of the means. The findings are reported in this thesis.
Construction of the Screen and Platform

A graphic screen for use in the photographic session was constructed by modifying the method developed by Helen Douty (1968) at Auburn University. The screen was constructed by first stretching an 84" x 48" piece of architect's linen across a two-inch-wide mahogany frame, and then stapling the linen into place. A plumb line, which divided the screen in half vertically, was penciled onto the screen; other vertical lines were then drawn parallel to the plumb line at one-centimeter intervals. Likewise, lines were drawn at one-centimeter intervals and perpendicular to the plumb line, beginning one centimeter from the outer edge of the frame. This procedure produced a grid pattern of one-centimeter squares.

Black pressure tape was applied to the grid in the following manner:

1. The plumb line was marked by 1/8-inch-wide black pressure tape.

2. Every tenth vertical line, i.e., every tenth centimeter, counting either direction from the plumb line, was marked with 1/16-inch-wide black pressure tape.

3. Every tenth horizontal line, i.e., every tenth centimeter, measuring up from the lower outer edge of the frame, was marked with 1/16-inch-wide black pressure tape.

4. Every remaining vertical and horizontal one-centimeter line was marked with 1/32-inch-wide tape.
A second mahogany frame, identical to the first, was matched to the framed screen. The two frames were fastened together with wood screws, and then slipped into a triangular stand. The stand held the screen rigidly in a position that was perpendicular to the floor.

A small platform consisting of a 1" x 10" x 20" board screwed onto two 2" x 2" x 10" blocks was also constructed for use in the photographic session. When the subject stood on the platform during the photographic process, she was actually one inch above the bottom of the linen screen. However, when dealing with silhouette photography, some amount of length distortion is unavoidable, and so the additional height provided by the platform allowed the ankle to show above the frame for all subjects. This extra height was important because the center of the ankle was used to align the subject with the plumb line of the screen for the profile-view photographs.

Photographic Process

The photographic procedure used the following equipment: the gridded screen and platform, a 35 mm camera with a 35 mm lens, a camera tripod, a cable release, two 3"
quartz lights with stands, and a barn door\textsuperscript{3} for use on one quartz light. Additional materials included lengths of elastic, ponytail bands, barrettes, a 1/4" dowel rod, and a tape measure marked in one-inch increments\textsuperscript{4}.

It is commonly known that it is possible to minimize the amount of distortion of the silhouette by increasing the distance between the subject and the light source. However, the light source cannot be so far away from the subject that the silhouette of the subject will be ill-defined. The optimum distance between the subject and the light source depends upon factors such as the size of the room where photographing is being done, size and brightness of primary and secondary light sources, and the amount of natural light in the room. Brackelsberg (Note 3) found that the optimum distance between the primary light source and the screen, under conditions available at Iowa State University, was within the range of fifteen to twenty feet.

\textsuperscript{3} A barn door is an attachment that has four metal plates hinged onto a collar. The plates are painted flat black, and may be used to control the amount of light diffusion.

\textsuperscript{4} I hypothesized that an English unit tape would be easier for the photographic assistant to read than a metric tape in dim lighting conditions.
It is possible to further minimize the amount of distortion of any one body region by adjusting the height of the light. For this particular research on pants pattern alteration, the critical region of the body, i.e., the area in which we wanted the least amount of distortion, was the waist, hip and upper thigh area. Therefore, the height of the light was adjusted so that the light would be directed to the hip area on a woman of average height\textsuperscript{5}.

The photographic equipment was set up as illustrated in Figure 1. The distance from the screen to the primary light source, the height of the primary light source, the placement of the camera, and the placement of the secondary light source were constant during the photographic process. The distance from the screen to the primary light source and the height of the primary light source are critical in determining the amount of length and width distortion, so these two measurements were recorded for later use in the interactive computer program.

Each volunteer was instructed to undress so that she wore only bra and panties. An elastic was fastened around her waist so that the slight indentation created would mark

\textsuperscript{5} Average height for a woman is considered to be 5'4" according to 1971-1974 data presented in the Statistical Abstracts of the United States.
her waistline. If the subject had hair that touched her shoulders, she was instructed to pin it in some fashion so that the outline of the lower neck and the shoulder area could be seen.

Back view photographs were taken first. Each subject was instructed to step onto the platform with her back to the screen, and each was assigned a number in order to provide anonymity. The volunteer was instructed to move to the right or left until her feet were an equal distance on either side of the plumb line (see Figure 34, Appendix B). Subjects were told to stand in a natural position, inhale, exhale, and then not breathe until after the photograph was taken. I hypothesized that this type of breathing exercise would provide for the most natural silhouette. The measurement from the midpoint of the side of the body at the waist line to the surface of the screen was taken and recorded.
before the subject moved from this position. This measurement is the body to screen back view distance, and was used later in the interactive computer program.

Profile photographs were taken with the subject's left side next to the screen. The subject was positioned so that the center of her ankle was aligned with the plumb line of the graph. Her arms were placed against her sides, and care was taken so that her arm(s) or elbow(s) did not show in the silhouette. If the arm(s) or elbow(s) were visible, it would add width to the waist and/or hipline. The dowel rod was placed between the legs and as close to the torso as possible, and an assistant held the rod parallel to the floor (see Figure 34, Appendix B). The same breathing exercise was used, and the measurement from the navel to the surface of the screen was recorded.

Selection of Subjects

The seven subjects used in this research were purposely chosen from 36 volunteers that had been the first 36 respondents to a classified advertisement. Volunteers ranged in age from 12 to 55. Somatographs were taken for all 36 women, and seven individuals were selected according to five different predetermined body types. Postural variances,
i.e., the variations from perfect posture, were not considered in the selection process.

The different body types for the women used in this study had been predetermined from looking at somatographs taken for use in various courses at Iowa State University, and by comparing these somatographs to the body types discussed by Minott (1972), Oblander et al. (1978), and Saladino (1970). I found that there were predominantly five body types, discounting figure irregularities. Two of these types were determined from the back view somatograph, two were determined from the profile view somatograph, and one was determined by evaluating both back view and profile view somatographs. These five body types are round, pear-shaped, weight in front, weight in back, and average.

Round and pear-shaped refer to the shape of the hip area in the back view somatograph. A round hip type is defined as a hip shape approximating the shape of a circle (see Figure 38, Appendix B). A pear-shaped hip type is defined as a hip shape that is noticeably heavier in the lower portion of the hip and/or thigh area (see Figure 35, Appendix B).

Weight in front and weight in back refer to the distribution of weight on either side of the midpoint of the pro-
file waistline. Weight in front describes a figure in which the mass of the abdomen is proportionately larger than the mass of the derriere (see Figure 37, Appendix B). Weight in back describes just the opposite situation, in which the mass of the derriere is proportionately greater than the mass of the abdomen (see Figure 34, Appendix B).

The average figure type is determined by looking at both the back and profile view somatographs. The average figure is neither round nor pear-shaped, and is evenly proportioned from front to back (see Figure 36, Appendix B).

Any of these figure types may range from very thin to fleshy. After careful evaluation of the somatographs of the 36 women, I found that round and average hip types occurred more frequently in this sample than any of the other hip types. Therefore, the seven subjects were randomly selected, two from both the round hip type and the average hip type, and one each from the remaining three body types. One round hip type and one average hip type were used to train the judges. The remaining five (one of each body type) were used for the final judging process.
Interpretation of Somatographs

One of the objectives of this research was to quantify the body in some way so that corrective pattern alterations could be made. One way of doing this was to look at the body in terms of graphing techniques, so that the silhouette was interpreted as a series of data points on a graph. The plumb line was labeled as the y-axis, and any horizontal line could have been labeled as the x-axis. For all subjects in this study, the x-axis was determined by the major horizontal division, i.e., a ten-centimeter increment, that was closest to the dowel rod in the profile view somatograph. The x-axis was either above or below the dowel rod silhouette, but was required to be on the same horizontal line in both the back and profile view somatographs. The next step was to select data points for the front, back, lower crotch, and left and right hiplines, and record the coordinates. For each body portion, data points were selected at the intersection of graph lines when possible.

Front data

Data points corresponding to the front half of the profile body were selected first. Information for this section of the body necessarily included the crotch point, the leg
point, and the front waist point. The crotch point, for the purpose of this research, was defined as the point that is the intersection of the midpoint of the thigh (profile view) and the dowel rod. The leg point was defined as the point of the silhouette where the curve of the front thigh muscle begins and the visible part of the trunk ends. The front waist point was located at the narrowest part of the front waist, i.e., at the indentation formed by the waist elastic (see Figure 2). Any number of points between the leg point and the front waist point were used, depending upon the contour of the body. Points were selected to describe the contour of the abdomen and the indentation of the waist.

**Back data**

Data points corresponding to the back half of the profile body were selected next. Information for this section of the body necessarily included the derriere point and the back waist point. The derriere point is located by first finding the x-value where the curve of the back thigh muscle begins and the visible part of the derriere ends. Then, the intersection of that x-value with the dowel rod was found. This point of intersection was defined as the derriere.

---

6 The derriere point was located inside of the silhouette because a well-fit pant provides shaping in the lower derriere.
Figure 2: Critical data points selected from profile view somatograph

point. The back waist point was located at the narrowest part of the back waist, i.e., at the indentation formed by the waist elastic (see Figure 2). Any number of points between the derriere point and the back waist point were used, depending upon the contour of the body. Points were selected primarily to describe the contour of the derriere and the slope of the back hip, i.e., the portion of the body that is above the buttocks and below the waist point.
**Lower crotch data**

Data points used to define the lower crotch (between the legs) were the leg point, the crotch point, and the derriere point. No other data points were used because it is impossible to see the body contour in this area on the somatograph.

**Left and right hipline data**

Data points used to define the hiplines necessarily included the respective side waist point and one point with a lower y-value than the y-value of the dowel rod. The side waist point was located at the narrowest part of the side waist, i.e., at the indentation formed by the waist elastic. Side waist points did not need to have the same y-value. The lowest hip point on each side of the body necessarily had a lower y-value than the y-value of the dowel rod so that the crotch depth, as defined by the dowel rod, would be included in the plot of the hipline curve\(^7\) (see Figure 3).

Any number of points between the low hip point and the side waist point were used, depending upon the contour of the body. Points were selected primarily to describe the fullness of the hip and the indentation of the waist.

---

\(^7\) The exact location of the crotch depth is used in applying the derived seamlines to the basic pant pattern.
Figure 3: Critical data points selected from back view somatograph

After the data points had been selected and recorded, the distance between the x-axis and the lowest major screen division was determined from the somatograph. This distance was used in the interactive computer program.
Development of Computer Programs and Mathematical Concepts

I hypothesized that it is possible to combine the somatographic technique and a computer program to give a graphic representation and evaluation of the body that is more detailed and accurate than the somatograph alone.

Two computer programs were developed for this research. The first program was designed to use the information interpreted from the somatographs to 1) make corrections for light distortion, 2) approximate the shape of the lower crotch curve, and 3) calculate the length along any body contour. This program employed approximation of length along a line, quadratic interpolation, and cubic spline interpolation. Furthermore, this program was designed for use on an interactive system, so that students would be able to use the program in any future classroom participation.

The second program was a simple plotting routine which used the information calculated in the first program to give graphic representations of body segments. The plots were representations of the abdomen, the derriere, the lower crotch, the left hip, and the right hip. These representations would later be developed into seamlines.
The mathematical concepts used in the interactive program are widely used, and therefore cannot be attributed to any one source. For this reason, I consulted only one text -- Johnson and Riess (1977). Following is a brief explanation of the mathematical concepts that form the basis of the interactive program.

**Correction for distortion**

It is important to recognize that a certain amount of distortion is unavoidable when using silhouette photography. Distortion is minimal when the subject is very close to the screen; however, in order to accurately determine length measurements from the somatographs, it is necessary to make corrections on both the height and width measurements of the silhouette.

**Correction for length distortion**

The correction for distortion follows the law of sines found in basic trigonometry. When looking at a diagrammatic representation of the photographic set-up from the side view, it can easily be seen that there is a slight discrepancy between the actual height of the individual and the photographed height (see Figure 4).
Figure 4: Photographic set-up from a side view

Now, by using the symbols given in Figure 3, the law of sines can be stated as

\[
\frac{h_p - h_L}{d_L + d_B} = \frac{h_T - h_L}{d_L}
\]  

Equation (3.1) can then be solved for the true height, \( h_T \)

\[
h_T = (h_p - h_L) \left( \frac{d_L}{d_L + d_B} \right) + h_L
\]  

\( h_p = \text{Photographed height of silhouette} \)
\( h_L = \text{Height of the light source} \)
\( h_T = \text{True height of individual} \)
\( d_L = \text{Distance of the light to the body} \)
\( d_B = \text{Distance of the body to the screen} \)
Note that if
\[ d_B << d_L, \text{ then } \frac{d_L}{d_L + d_B} = 1 \quad (3.3) \]
so that
\[ h_T = (h_p - h_L) (l) + h_L \approx h_p \quad (3.4) \]

Equations (3.3) and (3.4) show that light distortion becomes zero when the distance between the body and the screen approaches zero.

**Correction for width distortion** The correction for width distortion is very similar to the correction for height distortion. When looking at a diagrammatic representation of the photographic set-up from an overhead view, it can easily be seen that there is a slight discrepancy between the actual width of the individual and the photographed width (see Figure 5).

Now, by using the symbols given in Figure 5, the law of sines can be stated as
\[ \frac{w_T}{d_L} = \frac{w_p}{d_L + d_B} \quad (3.5) \]
Equation (3.5) can then be solved for the true width, \( w_T \).
$w_p = \text{Photographed width of silhouette}$

$w_T = \text{True width of individual}$

$d_L = \text{Distance of the light to the body}$

$d_B = \text{Distance of the body to the screen}$

**Figure 5: Photographic set-up from overhead view**

$$w_T = w_p \frac{d_L}{d_L + d_B} \quad (3.6)$$

Note again that if

$$d_B \ll d_L, \text{ then } \frac{d_L}{d_L + d_B} = 1 \quad (3.7)$$

so that

$$w_T = w_p \quad (3.8)$$

It is very important that the body to screen profile distance is used when approximating the front, back, and the
lower crotch data. The body to screen back view distance must be used in approximating the hiplines.

**Quadratic interpolation**

It is impossible to see the contour of the body between the legs of any individual because of the structure of the human body. Therefore, I decided to approximate the shape by using a quadratic interpolation. It is known that a quadratic can be drawn through any three points.

For instance, suppose there are three points such as those in Figure 6, and I want to interpolate the three points by a quadratic polynomial.

![Figure 6: Quadratic polynomial data](image)
The equation for a quadratic polynomial is

\[ y = ax^2 + bx + c \quad (3.9) \]

in which there are three unknowns \((a,b,c)\). In order to solve for the three unknowns, I need three equations.

\[
y_1 = ax_1^2 + bx_1 + c \quad (3.10)
\]

\[
y_2 = ax_2^2 + bx_2 + c \quad (3.11)
\]

\[
y_3 = ax_3^2 + bx_3 + c \quad (3.12)
\]

These three equations can be represented in matrix form as

\[
A \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} \quad (3.13)
\]

where

\[
A = \begin{bmatrix} x_1^2 & x_1 & 1 \\ x_2^2 & x_2 & 1 \\ x_3^2 & x_3 & 1 \end{bmatrix} \quad (3.14)
\]

It is now possible to solve for the three unknowns \((a,b,c)\) by using Cramer's rule, and obtain
\[ a = \frac{y (x_2 - x_3) - x (y_2 - y_3) + (y x_3 - x y_3)}{\text{det}[A]} \]  

\[ b = \frac{x^2 (y_2 - y_3) - y (x^2 - x_3) + (x^2 y_3 - x y_3)}{\text{det}[A]} \]  

\[ c = \frac{x^2 (x y - x y_3) - x (x^2 y_3 - x^2 y_3) + y (x^2 x_3 - x^2 x_3)}{\text{det}[A]} \]  

\[ \text{det}[A] = x^2 (x_2 - x_3) - x (x^2 - x_3) + (x^2 x_3 - x^2 x_3) \]  

This procedure produces a smooth curve that is used in this research to approximate the shape of the lower torso (that which cannot be seen in the profile view somatograph).

**Cubic spline interpolation**

It is possible to see the contour of the abdomen, derriere, and hiplines when looking at the back view and profile view somatographs. Therefore, it is possible to plot a nearly exact representation of the body for each of these areas by using cubic spline interpolation.

For example, if there are \( n+1 \) points to be interpolated exactly for a given front seam, I could use an \( n \)th degree polynomial, such as
\[ y = a_1 x^n + a_2 x^{n-1} + \ldots + a_n x + a_{n+1} \] (3.19)

However, high degree polynomials, i.e. polynomials where \( n > 3 \), exhibit an oscillatory behavior, and produce an interpretation similar to Figure 7. This behavior is undesirable in any research that strives to exactly represent the body's contours.

![Figure 7: Oscillatory polynomial behavior](image)

Splines, however, can be used to interpolate the \( n+1 \) data points with a low-degree polynomial. Look again at the data used in Figure 7. Cubic spline interpolation uses four pieces of information to complete the equation.

\[ y = a_1 x^3 + a_2 x^2 + a_3 x + a_4 \] (3.20)
In our example, the first cubic spline interpolated the first through the fourth data points. The second cubic spline, and every spline thereafter, interpolated by using the last data point used in the preceding cubic, two additional data points, and slope information determined at the fourth point in the preceding cubic. For example, the second cubic spline used the fourth through the sixth data points, and the slope at the fourth point as determined from the first cubic spline, to interpolate the shape of the curve (see Figure 8).

This illustration shows that cubic splines can be used to interpolate \( n+1 \) data points along any visible surface, so long as \( n > 3 \). However, the degree of resemblance to the

\[ \text{---} \]

\( ^a \) It is necessary for \( n > 3 \) because we need at least four pieces of information to satisfy the conditions of a cubic polynomial.
body depends upon the number and placement of the data points used. Data points should reflect all changes in the contour of the body in order to produce the most correct representation of that body segment (see Figure 9).

Figure 9: Selection of front data points

**Length along a line**

It is important to know the crotch length measurement when altering pants patterns. Although it is simple to obtain a total crotch length measurement, it is very difficult to distinguish between the front crotch length and the back crotch length because of the difficulty encountered in locating the crotch point of the body. For the purpose of
this research, I have defined the crotch point on the profile view somatograph. Therefore, it is possible to distinguish front crotch length from back crotch length by using the mathematical concept of approximating length along a line.

Consider the line defined by the function \( y = f(x) \) (see Figure 10). In order to determine the length along the line between the limits \( x_1 \) and \( x_2 \), an infinitesimal segment of the line \( y = f(x) \) must first be described.

Look at the infinitesimal line segment \( ds \) (see Figure 11). The segment \( ds \) can be written in terms of infinitesim-
mal segments along the x- and y-axes (see Figure 12). This relationship is given by Equation (3.21).

\[ ds = \sqrt{dx^2 + dy^2} \]  \hspace{1cm} (3.21)

The length along the line \( y = f(x) \) between the limits \( x_1 \) and \( x_2 \) is given by the integral shown below

\[ l = \int_{x_1}^{x_2} ds \]  \hspace{1cm} (3.22)

It is now possible to substitute Equation (3.21) into Equation (3.22) and get the relationship

\[ l = \int_{x_1}^{x_2} \sqrt{dx^2 + dy^2} \]  \hspace{1cm} (3.23)
Then, by rearranging Equation (3.23) the result is

\[ l = \int_{x_1}^{x_2} \sqrt{1 + \left( \frac{dy}{dx} \right)^2} \, dx \]  

(3.24)

Since \( y = f(x) \) defines the line, the slope of that line can be written as

\[ f'(x) = \frac{dy}{dx} \]  

(3.25)

and Equation (3.24) can finally be written as

\[ l = \int_{x_1}^{x_2} \sqrt{1 + [f'(x)]^2} \, dx \]  

(3.26)

Then, in order to calculate the length of the line between \( x_1 \) and \( x_2 \), the function

\[ \sqrt{1 + f'(x)^2} \]  

(3.27)

must be integrated with respect to \( x \) from \( x_1 \) to \( x_2 \). However, for this particular problem, the slope of the line is not known. Therefore, it must be approximated with a finite difference representation.
This approximation is necessary since \( f(x) \) is known only at a discrete number of points. If the difference representation of \( f'(x) \) given in Equation (3.28) is used, it is finally possible to write the integral equation for length along a line in a form that can be easily calculated on a computer:

\[
\ell \approx \sum_{i=0}^{n-1} \left[ 1 + \left( \frac{y_{i+1} - y_i}{\Delta x} \right)^2 \right]^{\frac{1}{2}} \Delta x
\]  

(3.29)

where \( \Delta x = x_{i+1} - x_i \) for all \( i \). Therefore, if the function \( y = f(x) \) is known at only a discrete number of points, the length along the line may be calculated by Equation (3.24).

Measurement of Subjects

The somatographic alteration technique developed in this research was used on McCall's 500 basic pant patterns. As in any alteration procedure, it was necessary to know body measurements so that the correct pattern size could be selected and altered to fit the unique measurements of any individual. Each subject was measured in her stocking feet,
and while wearing only panties on her lower torso. It was not necessary for the subjects to remove their upper body outerwear, so long as the clothing did not interfere with the subject's natural posture or the body measurement process. The measurement chart used in this study can be seen in Appendix C.

Quality of fit is partially dependent upon the accuracy of the body measurements used for the alteration. Therefore, I used elastics to mark the waistline, the 7.6 cm hip level, the 17.8 cm hip level, the fullest hip level, and the level of the fullest part of the thigh. Each elastic had Velcro tabs on the ends so that it could be adjusted for a variety of figures. All depth measurements were taken on the left side for all subjects, and then the elastics were adjusted so that they were parallel to the floor. Measurements were taken with a centimeter tape measure and recorded on the measurement chart. Circumference measurements were taken on top of the elastics; outseam length, also taken on the left side of the subject, was measured from the center of the waist elastic to the floor. At the same time, the knee level measurement was read at the center of the knee-cap. The crotch length measurement was taken from the front center of the waist elastic, between the legs, and to the back center of the waist elastic; the crotch depth was taken
while the subject was sitting erectly on a desk top. All measurements were taken twice to assure that no mistakes had been made.

Subjects used in this research ranged in size from 8 to 14. Two subjects were size 8, one subject was size 12, and four subjects were size 14.

Measurement of Body Angles

The measurement of body angles supplies information on dart length and size, and the shape of the sideseam curve. Equipment used in this procedure included a centimeter ruler and a protractor. Measurements were recorded on the chart shown in Appendix D.

**Front waist angle measurements**

The front waist angle measurements were taken by the following procedure. I began with one end of the ruler at the plotted front waist point (Y), and walked the ruler along the plotted line to a point X where the ruler began to assume a position that was perpendicular to the x-axis of the plot (see Figure 13). Point X should be just above the fullest or the roundest part of the abdomen. The length measurement from X to Y was recorded as the front waist body
length (see Appendix D). This length determined the length of all front waist darts.

The next step was to draw line XY, and a second line that passed through point X and was perpendicular to the x-axis of the plot. The waist end of this second line was labeled point Z. Angle YXZ was then measured with the protractor, and the measurement was recorded as the front waist dart body degrees. This angle measurement accounted for the sum of all front waist dart angles.

**Back waist angle measurements**

The back waist angle measurements were determined by a procedure that was very similar to the procedure used in evaluating the front waist angle measurements. I began with one end of the ruler at the plotted back waist point (M), and walked the ruler along the plotted line to a point N where the ruler began to assume a position that was perpendicular to the x-axis of the plot (see Figure 14). Point N should be just above the fullest or the roundest part of the derriere. The length measurement from M to N was recorded as the back waist dart body length. This length determined the length of the center back dart only.
Figure 13: Front waist angle measurement procedure
The next step was to draw line MN, and a second line that passed through point N and was perpendicular to the x-axis of the plot. The waist end of this second line was labeled point P. Angle MNP was then measured with the protractor, and the measurement was recorded as the back waist dart body degrees. This angle measurement accounted for the sum of all back waist dart angles.

**Sideseam angle measurements**

The sideseam angle measurements were determined by a procedure very similar to the procedure used in evaluating the front and back waist angle measurements. I began by selecting a point on the plotted line that was at the fullest or nearly the fullest part of the high hip. This point was labeled R, and the plotted waist point was labeled S (see Figure 15). Next, I measured along the plotted line from point S to point R, and recorded the measurement as the respective sideseam length.

The next step was to draw line RS, and a second line that passed through point P and was perpendicular to the x-axis of the plot. The waist end of this second line was labeled T. Angle SRT was then measured with the protractor, and the measurement was recorded as the respective sideseam body degrees. This angle measurement was later used to determine the shape of the sideseam.
Figure 14: Back waist angle measurement procedure
Figure 15: Sideseam angle measurement procedure
This procedure must be used on both the left and the right hipline plots because the two hip shapes will be treated separately in the development of the sideseams.

Interpretation of Body Plots and Development of Seams

The plotting program used the data points calculated in the interactive program to produce representations of the body's contours on a simplotter. Each resulting plot was labeled with the subject's number and an identification of the body segment being represented. The plots included representations of the front, back, back crotch, and right and left hiplines.

The next step in the procedure was to interpret these plots for information on dart length, dart size, and the shape of the corresponding seams. Seam length was determined from the output of the interactive computer program. Other materials used in the development of the seams included tissue paper, a protractor, a centimeter ruler, a standard hip curve, and the individual body measurement charts for all participating individuals.
Correction of crotch length

Before the plotted representations were developed into seams I compared the body crotch length measurement with the total crotch length measurement calculated by the interactive program. In some cases, it was found that the program indicated measurements that were longer than the body measurements. When this occurred, I evaluated the placement of the front and back waist points on the profile view somatographs.

One of the criteria for a well-fit pant is that the waistband should appear parallel to the floor. Therefore, in cases where one waist point was higher, I lowered the point so that it corresponded to the height of the other waist point. The difference was then subtracted from the calculated total crotch length and from the corresponding front or back crotch length. If there was still a difference between the calculated total crotch length and the measurement taken on the body, then front and back crotch lengths were corrected by equal amounts.

Development of front seam

The front plot is a representation of the body from the waist point to the crotch point. The shape of the plot should correspond exactly to the body from the waist point
to the leg point, and should approximate the shape of the body from the leg point to the crotch point.

For the particular plotting program used in this research, one axis of the front plot passed through the crotch point. This axis was labeled as the crotch line.

The next step was to locate the leg point on the plotted representation. This was done by first locating the leg point coordinates in the section labeled "INPUT DATA CORRECTED FOR LIGHT DISTORTION" in the interactive program. This section gives the coordinates of the data points after they have been corrected for both height and width distortion. Since the axes of the plotted graphs were labeled only at one centimeter increments from the coordinates of the crotch point, it was necessary to use a simple formula to locate the leg point on the plot.

\[
\frac{b - a}{0.127} = \text{number of squares above or below } b \tag{3.30}
\]

where

\(a\) = the \(y\)-value of the corrected leg point

\(b\) = a labeled \(y\)-value closely corresponding to point \(a\)
After the leg point was located on the plot, a line was drawn through the leg point that was parallel to the crotch line. The intersection of this line (the leg level) with the plotted line was labeled as point A (see Figure 16).

Next, I drew a line (CQ) through the crotch point (C) and perpendicular to the crotch line. Point B was located on the plotted line by dividing the distance between line CQ and the fullest part of the plotted abdomen in half. One half of the distance between the fullest part of the abdomen and the line CQ was used to locate point B because I hypothesized that the breadth of the lower crotch curve should be proportional to the thickness of the forward half of the body. A line BD was then drawn through point B and perpendicular to the crotch line.

Point E was located at the waistline by dividing the distance between line CQ and the waist point of the plot in half. Again, one-half was used because I hypothesized that the amount of bias for the front seam should be proportional to the indentation of the waist. If point E was to the left of the line BD, the distance between E and BD was measured, and E' was marked an equal distance to the right of line BD. This reflection of E' allows the bias to account for some of the fitting of the pant to the waist. The line BE' was then drawn.
Figure 16: Development of front seam
The crotch curve was perfected in the following manner. A small piece of the computer graph paper (about 2" x 2") was placed on top of the plotted line between points A and B so that both vertical and horizontal graph lines were aligned with the graph lines of the plotted paper. The simulator line was traced between A and B, and the new end points were labeled A' and B'. The traced curve was then shifted to the right and down so that A' touched the line BD and B' touched the lower plotted crotch curve. Vertical graph lines of the traced curve were necessarily aligned with the vertical graph lines of the plot. This ensured the correct orientation of the traced curve. The traced curve was then secured in place with tape, and the curve was smoothed at points A' and B'.

The front seam was finished by measuring from the crotch point, along line BE', the length of the corrected front seam measurement to the waistline point E'. The needed to be redrawn in some cases so that E intersected seamline CE' and the crotch line were then traced onto tracing paper and labeled with the subject's number and "Front Seam."
Development of back seam

The back plot is a representation of the body from the waist point to the derriere point, and the back crotch plot is a representation of the body from the derriere point to the crotch point. Before developing the back seam, it is necessary to combine these plots in order to give a clear, complete representation of the back half of the body.

The first step was to label the right end of the back crotch plot as C for the crotch point. This point corresponded exactly to the front crotch point. The left end of the back crotch plot was then labeled F, and the lower end of the back plot was labeled F' (see Figure 17). Points F and F' have identical coordinates because they both represent the derriere point. The two plots were oriented so that F laid on top of F', and both vertical and horizontal graph lines were aligned. The position of the two plots was then secured with tape.

For the particular plotting program used in this research, one axis of the back plot passed through the derriere point and the crotch point. This axis was labeled as the crotch line.

The next step was a preparation for determining the amount of bias in the back seam. A line GH was drawn tan-
Figure 17: Completion of back body plot
gent to the widest part of the derriere and perpendicular to the crotch line. The point of intersection at the derriere was labeled G, and the waist end of the line was labeled H.

At this point, it was necessary to determine which subjects exhibited a swayback posture. According to Hillhouse and Mansfield (1948), a swayback posture is one in which the midpoint of the profile waist falls forward of the shoulder and the midpoint of the fullest hip. (see Figure 18). This particular posture variation distorts the amount of bias needed for the back seam as determined in the next procedure. In this study, three out of seven subjects exhibited a swayback posture. Therefore, I developed a separate method of determining back seam bias for swayback figures.

**Back bias for average figures** Point J was located at the waistline by dividing the distance between line GH and the plotted waist point in half. One-half was used because I hypothesized that the amount of bias for the back seam should be proportional to the slope of the back above the full hipline. For all figure types, point J was located to the right of line GH (see Figure 19). However, in order to use the bias to partially fit the pant to the back waist, point J must be reflected to the left of line GH. This reflected point was labeled J'.
Figure 18: Swayback posture

Back bias for swayback figures  A line CQ was drawn through the crotch point and perpendicular to the crotch line. The measurement from line CQ to the waist point was divided in half, and reflected to the left of line GH. (see Figure 20). This reflected point was labeled J'. Again, one half the distance was used as a standard proportion.
Figure 19: Back seam for average figure
Figure 20: Back seam for swayback figures
For all figure types, the next step was to draw the back seam from J' to a point tangent to the derriere (K). The back seam was finished by measuring from the crotch point along the plotted line to point K, and along line KJ' until the length measured the same as the corrected back seam length plus 2.54 cm for ease. This is the back waistline, and should be labeled point L. I chose to put all of the ease in the pant back crotch length because I hypothesized that crotch length ease is used primarily when sitting, and so the ease should be added to the area that needs extension. Line KJ' needed to be redrawn in some cases so that L intersected with a line drawn perpendicular to the crotch line and through J'. The seamline CL and the crotch line were then traced onto tracing paper and labeled with the subject's number and "Back Seam."

Development of sidesseams

The hipline plots are representations of the body from the low hip point to the waist point, and the shapes should exactly correspond to the respective hiplines of the individual. Right and left hiplines can be determined from looking at the plots and recalling that these plots are representations of the hiplines as viewed from the back.
The first step in converting the hipline plots to the sideseams was to locate the crotch line by the following method. The coordinates of the crotch point were located by looking at the lower crotch data under the section labeled "INPUT DATA CORRECTED FOR LIGHT DISTORTION." This section gives the coordinates of the data points after they have been corrected for both height and width distortion. Then, since the axes of the plotted graph were labeled only at one centimeter increments from the coordinates of the lowest hip point, it was necessary to use a simple formula to locate the crotch point on the plot.

\[
\frac{b - a}{0.127} = \text{number of squares above or below b}
\]

(3.31)

where

\( a \) = the \( y \)-value of the corrected crotch point

\( b \) = labeled \( y \)-value closely corresponding to point \( a \)

After the crotch point was located on the plot, a line was drawn through the crotch point that was parallel to the \( x \)-axis of the plot.

Next, I determined the pattern sideseam angle by using the respective sideseam body degree measurement recorded on
the chart shown in Appendix D. The angle SRT was bisected with a line that was the same length as the recorded side-seam length, and the waist end of this line was labeled U. (see Figure 21). Ease was added to the side-seam curve by moving point U so that it was 0.6 cm further away from the plotted waist point, and by relabeling the point U'. Line U'R was the same length as line UR. The standard hip curve was then used to perfect a curve from U' to the fullest part of the hip. This perfected curve did not necessarily pass through point R, but was very close to the high hip point.

This same procedure was used to develop both sideseams, after which both sideseams and a common crotch line were traced onto a single sheet of tracing paper and labeled. However, I recognized that the crotch depth was no longer correct because the sideseams were straightened versions of the hipline curve. Therefore, the crotch depth was corrected by measuring the crotch depth on the body plot, and duplicating that measurement on the traced sideseams. In all cases, the crotch line was raised as a result.

Alteration of the Basic Pant Patterns

Two types of alteration procedures were used in this study -- the Unit Method and the Experimental Method. Later
Figure 21: Development of sideseams
in the study, the resulting fit of the two methods was evaluated by a panel of three judges and the evaluations were statistically analyzed.

First, however, the subjects' correct pattern sizes were determined by comparing individual body measurement charts to the measurement charts on the back of the pattern envelopes. It was found that two subjects were size 8, one subject was size 12, and four subjects were size 14. The procedure then began by altering pant patterns for all subjects by the Unit Method first. Pant patterns altered by the Experimental Method were done last. I hypothesized that the pattern alterations would be more accurate and consistent if all patterns altered by one method were done first, and then all patterns altered by the second method were done next.

**Unit Method alteration procedure**

The Unit Method of pattern alteration used measurements of body length and circumference to determine the placement and amount of alteration needed to accommodate an individual figure. Alterations were made by slashing and spreading to increase the pattern, or slashing and lapping to decrease the pattern. The order of alteration for pants was 1) to change crotch depth, 2) to change hip width, 3) to correct
crotch length, 4) to change waistline size, and 5) to change leg length. Corrections for high hip, hip shape, swayback, and dart size and length are made after the first fitting of the muslin and so were not a part of this study. Although the patternmaker must follow the order of alteration to some extent, it was possible to combine waist and hip circumference alterations. Following is the order of alteration used in this research.

**Crotch depth alteration**  
The subject's crotch depth measurement plus ease from the measurement chart was compared to the pant back pattern crotch depth measurement. The pattern was then either slashed and spread or slashed and lapped at the 17.8 cm hip level to reflect the needed increase or decrease (see Figure 22). The pant front was then altered by the same technique and amount used on the pant back.

**Waist and hip circumference alteration**  
The subject's waist circumference measurement plus ease and her hip circumference measurements plus ease were compared to the respective measurements on the basic pant pattern. The amount of needed alteration was then divided by four, and the alteration procedure began.
Figure 22: Alteration of the crotch depth

For all subjects, the pant front and back were slashed from the waist to the knee level, and clips were made to, but not through, the stitching line at the knee, the full hipline, the 17.8 cm hipline, and the 7.6 cm hipline (see Figure 23). Each pattern piece was then manipulated to account for one-fourth of the alteration needed. This alteration unavoidably affected the thigh circumference, however, this change was only noted and not corrected for.
Figure 23: Waist and hip circumference alteration procedure

Crotch seam length alteration  The subject's total crotch length plus ease was compared to the total crotch length of the pattern, and the amount of alteration needed was determined. Then, before beginning the alteration procedure, the individual's somatograph was evaluated. If the subject's figure was evenly proportioned from front to back, the front and back crotch lengths were altered by an equal amount. If the subject's figure was proportionately
larger in the back, two-thirds of the increase or one-third of the decrease was accounted for in the back crotch seam, and one-third of the increase or two-thirds of the decrease was accounted for in the front crotch seam. Likewise, if the subject's figure was proportionately larger in the front, two-thirds of the increase or one-third of the decrease was accounted for in the front crotch seam, and one-third of the increase or two-thirds of the decrease was accounted for in the back crotch seam.

The alteration was made by horizontally slashing from the crotch seam to, but not through the sideseam at a level just below the darts. The pattern was spread or lapped to reflect the needed increase or decrease of the total crotch length (see Figure 24).

**Leg length alteration** The subject's outseam measurement was compared to the outseam measurement of the basic pant pattern. Because the basic pant pattern exhibited no flare, the length was increased or decreased at the hemline.

**Finishing** After all of the alterations had been made to fit the basic pant pattern to an individual figure, the pattern was perfected. First, the front crotch seam,
Figure 24: Crotch seam length alteration procedure

the back crotch seam, and the sideseams were perfected. Frequently, I noted that the 7.6 cm hip circumference measurement and the 17.8 cm hip circumference measurement were increased in the process of perfecting the sideseam curve. This increase was unavoidable if the sideseam was to exhibit a smooth curve from the fullest hip level to the waistline.

Next, all darts that had been shifted in the crotch length alteration process were straightened so that the original dart orientation was maintained.
Finally, the darts were folded toward the center and the waistline was redrawn. All pattern measurements were then compared to the needed amount determined by the body measurement chart, and any errors due to inaccurate alteration were corrected. Then critical body measurements of the altered pattern were recorded in the comparison chart shown in Appendix E.

**Experimental Method alteration procedure**

The Experimental Method of pattern alteration combined the use of body measurements and seams developed from graphic body plots to determine the placement and amount of circumference alteration, the placement and amount of crotch length alteration, the shape of the crotch seam curves and the sideseam curves, and the size and length of the waist-fitting darts for any individual figure. Once the seams had been developed, the alteration procedure was a matter of proper alignment of the developed seams and the correction of dart size and length. Dart length was corrected by relocating the dart point, and dart size was corrected by slashing and spreading to increase the dart size, or slashing and lapping to decrease dart size. The order of alteration for pants was 1) to align sideseams, 2) to align crotch seams, 3) to correct dart length and size, 4) to correct for the
forward or backward slant of the posture, and 5) to correct leg length. The fourth alteration procedure corrected for the balance of fabric from front to back of any individual pant leg. Corrections for high hip, hip shape, and swayback were built into the development of the seamlines, and so additional corrections at the first fitting should be minimal. The order of alteration described above and in the sections following must be adhered to precisely in order to produce a well-fit pant by the Experimental Method.

**Alignment of sideseams** Before aligning the traced sideseams on the basic pant pattern, it was necessary to first locate the 7.6 cm hip level (1), the 17.8 cm hip level (2), and the full hip level (3) on the traced sideseam (see Figure 25).

The traced sideseams were aligned on the pattern so that the crotch line matched the crotch line of the basic pant pattern. The traced sideseams were then shifted so that point 3 (the full hip level) was outside of the basic pattern sideseam if the hip circumference needed to be increased, and inside of the basic pattern sideseam if the hip circumference needed to be decreased. The amount of shift was equal to one-fourth of the total full hip circumference alteration. After the full hip circumference had been corrected, the traced sideseam was secured with tape.
After completion of the sideseam alignment process, I noted that for all subjects, the experimentally adapted sideseams were more curved than the McCalls 500 basic pant sideseams.

**Alignment of front and back seams** Before aligning the traced front and back crotch seams, the full hip level was drawn through point 3 and perpendicular to the grain-line. The intersection of the full hipline with the basic crotch seam was labeled point 4 (see Figure 26). The traced crotch seam was then adjusted so that the crotch line of the
traced seam matched the crotch line of the basic pant pattern, and the traced seam intersected point 4. This positioning of the crotch seam maintained the desired full hip circumference. After the crotch seams were aligned, the traced seams were secured with tape.

Figure 26: Alignment of front and back seams by the Experimental Method

I was able to detect certain trends in the amount of bias of the experimentally developed front and back seams. For all subjects, the experimentally developed front seam exhibited less bias than the McCalls 500 basic pant front.
seam. However, the back seam did not show an overall trend. Two experimental back seams had a greater bias, two showed less bias, and three had an amount of bias equal (within 0.6 cm) to the bias of the McCalls 500 basic pant pattern.

**Correction of dart length and size** Before measuring dart length, I approximated where the waistline would cross the darts. This was done by placing a ruler across the center waist point and the sideseam waist point, and marking where the ruler crossed the darts. Dart length was then measured from the point to the crossmarks and compared to the needed length determined on the body angle measurement chart. If a change in length was needed, the dart was lengthened or shortened by extending or retracting the dart point along the center of the dart. If the back dart length needed to be corrected, the long dart was adjusted to reflect the correct dart length, and the short dart was adjusted to measure 3.8 cm less than the long dart length.

After the darts had been corrected for length, the protractor was used to determine the pattern dart angle measurement, which was then recorded as the respective waist dart pattern degrees. In the case of the back dart angle measurement, the center and side darts were measured, recorded separately, and then summed. If a change in dart
size was needed, the dart was slashed along the center to the pivot point and diagonally to, but not through, the sideseam at the full hipline. If the dart size needed to be increased, the dart was spread until the angle measurement was corrected. If the dart size needed to be decreased, it was lapped until the angle measurement was correct. In the case of the two back darts, any necessary alteration was divided evenly between the two darts.

After the dart size and length had been corrected, further adjustment was made on the placement of the darts in relation to the front crotch seam. The basic front darts were 9 cm from the original front seam. In addition, the decreased amount of bias in the experimental front seam increased the distance between the center seam and the front dart. I hypothesized that a better fit would be achieved by shifting the front dart so that it remained 9 cm from the center front seam. This procedure was done across all models. Dart placement was later checked on the Unit Method patterns so that the dart placement was identical across both methods.

I also hypothesized that any single waist dart that was greater than or equal to twenty degrees would produce too large a bubble at the dart point. There was one model (G12)
in this study whose front waist dart angle measurement was greater than twenty degrees. For this particular model, I divided the front waist dart into two equal-sized darts of the same length. The center dart was located 6 cm from the center front seam; the side dart, 10.5 cm from center front. Later, the front dart of the Unit Method pattern was divided into two darts so that the dart number was identical across both methods.

**Correction for postural variation** Hillhouse and Mansfield (1948) defined correct posture in terms of two criteria: 1) waistlines and hip levels should be parallel to the floor, and 2) a line drawn through the center of the ankle and perpendicular to the floor should also pass through the ear, shoulder, center of the profile waist, center of the profile hip, and center of the profile knee.

One of the assumptions in this research was that a correctly placed sideseam for basic pants could be defined as a line drawn from the midpoint of the profile waist to the ankle bone. By definition, this line should also pass through the center of the profile hip and the center of the profile knee, and should be perpendicular, or nearly perpendicular to the floor. I hypothesized that any pant sideseam altered to meet these criteria would produce a sideseam that
was in line with the slant of the posture, and therefore would result in a pant leg with better distribution of fabric from front to back.

The alteration technique used in this research was based on information obtained from the profile view somatograph. For each subject, I determined where the midpoint of the knee was in relation to the plumb line of the somatograph. For five of the seven subjects, this point was in front of the plumb line, i.e., five of the seven subjects leaned forward from the ankles. The other two subjects had correct posture. The number of centimeters that the midpoint of the knee fell forward of the plumb line was recorded on each individual's body angle measurement chart (see Appendix D).

The first step in altering for this postural variation was to locate the knee level of the pant pattern by measuring from the waistline, along the sideseam, and to the level indicated by the individual's body measurement chart. If the midpoint of the knee was forward of the plumb line, then the back leg width needed to be decreased in order to correctly align the sideseam. This was done by slashing the pant back pattern from the hemline through the knee level, and over to the full hipline (see Figure 27). Then I lapped
the pattern the determined amount at both the kneeline and at the hemline. The upper thigh area was allowed to lap in order to accommodate the lower leg alteration.

Alternately, if the midpoint of the knee was behind the plumb line, then the front leg width would need to be decreased in order to correctly align the sideseam. This would be done by slashing the pant front pattern from the hemline through the knee level, and over to the full hipline (see Figure 28). An additional clip would need to be made at the kneeline, which would go to, but not through the sideseam. Then the front pattern would be lapped the determined amount at the kneeline and at the hemline, and the upper thigh area would be allowed to lap in order to accommodate the lower leg alteration. However, in this study, no subjects exhibited a backward slanting posture. In effect, this alteration procedure decreased the total leg circumference of the pant.

**Leg length alteration** The subjects' outseam measurements were compared to the outseam measurement of the basic pant pattern. Because the basic pant pattern exhibited no flare, the length was increased or decreased at the hemline.
Figure 27: Correction for forward-leaning posture
Figure 28: Correction for backward-leaning posture
Finishing  After all of the alterations had been made to fit the basic pant pattern to an individual figure type, the pattern was perfected. All darts were folded toward the center, and the waistlines were redrawn from the center waist point to the left and right waist points. All pattern measurements were then compared to the needed amount determined by the body measurement chart, and any errors due to inaccurate alteration were corrected. Then, critical body measurements of the altered pattern were recorded in the comparison chart shown in Appendix E.

Comparison of Altered Pattern Measurements

After both alteration methods had been completed, the resulting pattern measurements were compared in chart form with the body measurement plus ease for each subject (see Appendix E). Evaluation of these charts showed slight differences in circumference and crotch depth measurements between methods. For two of the 7 models, body measurement plus ease was approximated more closely by the Experimental Method, and for five models, the Unit Method provided a closer approximation. It is recognized, however, that a variation of less than 0.6 cm (1/4") is within an acceptable range of error.
Construction of First-fit Muslins

Basic fitting muslins were constructed for each subject from the pants patterns altered by each of the two methods. This means that each subject modeled one pant muslin constructed from the Unit Method pattern and one pant muslin constructed from the Experimental Method pattern. A single waistband pattern was drafted according to the individual's waist measurement plus 1.3 cm of ease, and a 5 cm extension was allowed.

Both pants and waistbands were cut from a medium-weight muslin, and vertical and horizontal grainlines were drawn on the fabric face of both pant front and back with a black felt marker. Vertical grainlines were drawn at the center or near the center of the leg width, and horizontal grainlines were drawn at the full hip level and perpendicular to the vertical grainline.

The pant muslins were sewn in random order, and openings were left at the center front. All pants were sewn so that the fly opening would be pinned with the right center seam on top of the left center seam. For the purpose of

9 The pant waist has 2.5 cm ease allowance, and should always be eased onto the waistband. Therefore, the amount of ease in the waistband was determined to 1.3 cm.
this study, pant hems were standardized at 5 cm, and were sewn in by hand.

Development of the Evaluation Scale

The evaluation scale developed for this research was composed of two parts: an evaluative scale and a diagnostic scale. The evaluative scale provided information on the quality of fit, and the diagnostic scale was designed to qualify the evaluative ratings, i.e., to describe why a particular evaluative rating was assigned.

First, I developed a list of criteria for good fit in pants. This list was compiled from both verbal descriptions of good fit (Erwin, 1969; "McCalls", 1968; Oblander et al., 1978; Perry, 1972; Tyroler, 1963; Fitting Pants, Note 1) and from rating scales used in previous studies on pants and skirts (Bowlby, 1973; Saladino, 1970; Vanderpoorten, 1973). Then, I listed polar adjectives which would help to diagnose problems associated with fit for any given criteria. These diagnostic polar adjectives were then coupled with the evaluative polar adjectives bad/good for each criteria. The paired comparisons were reported on a 99-point certainty scale (Warren, Klonglan, & Sabri, 1969). This evaluation scale and an accompanying cover sheet (Appendix F) were then
distributed to three members of the Textiles and Clothing staff for their comments and suggestions.

Table 6 shows the criteria for good fit, the diagnostic polar adjectives developed for the preliminary scale, and the diagnostic polar adjectives used on the final evaluation scale. Changes suggested by the three-member panel were

1. to distinguish between the upper sideseam (above the full hipline) and the lower sideseam (below the full hipline),
2. to change "shifted forward" to "forward on body,"
3. to change "shifted back" to "back on body,"
4. to change "curve too flat" to "upper curve too flat,"
5. to change "curve too sharp" to "upper curve too full,"
6. to change "curved to front" to "leans/slopes to front,"
7. to change "curved to back" to "leans/slopes to back,"
8. to add criteria for front and back crotch curve, such as "too shallow" and "too deep."

All suggested changes were incorporated into the final draft of the evaluation scale, which can be seen in Appendix G. The same cover sheet was used with the final evaluation scale.
TABLE 6
Development of judge evaluation scale for fit of pants muslins

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Diagnostic adjectives for preliminary scale</th>
<th>Changes for final evaluation scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>too tight / too loose</td>
<td>X</td>
</tr>
<tr>
<td>High hip circumference</td>
<td>too tight / too loose</td>
<td>X</td>
</tr>
<tr>
<td>Full hip circumference</td>
<td>too tight / too loose</td>
<td>X</td>
</tr>
<tr>
<td>Front waist placement</td>
<td>1&quot; too low / 1&quot; too high</td>
<td>X</td>
</tr>
<tr>
<td>Back waist placement</td>
<td>1&quot; too low / 1&quot; too high</td>
<td>X</td>
</tr>
<tr>
<td>Front waist darts</td>
<td>1&quot; too short / 1&quot; too long, too close CP, too close SS, too small / too large</td>
<td>X</td>
</tr>
<tr>
<td>Back waist darts</td>
<td>1&quot; too short / 1&quot; too long, too close CP, too close SS, too small / too large</td>
<td>X</td>
</tr>
<tr>
<td>Front crotch length</td>
<td>too short / too long</td>
<td>X</td>
</tr>
<tr>
<td>Back crotch length</td>
<td>too short / too long</td>
<td>X</td>
</tr>
<tr>
<td>Front crotch curve d</td>
<td>shallow / deep</td>
<td>X</td>
</tr>
<tr>
<td>Back crotch curve d</td>
<td>shallow / deep</td>
<td>X</td>
</tr>
<tr>
<td>Sidesseams</td>
<td>shifted forward / shifted back, curved to front / curved to back</td>
<td>X</td>
</tr>
<tr>
<td>Upper sidesseams d (above hipline)</td>
<td></td>
<td>forward on body / upper curve too flat / curve too flat to front / curved to front</td>
</tr>
<tr>
<td>Lower sidesseams d (below hipline)</td>
<td></td>
<td>upper curve too full / upper curve too flat / upper curve too flat / upper curve too full / slopes to front / slopes to back</td>
</tr>
<tr>
<td>Vertical grain</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Horizontal grain</td>
<td>angles down at SS / angles up at SS</td>
<td>X</td>
</tr>
</tbody>
</table>

a Center front seam.
b Sideseam.
c Center back seam.
d Criterion added after judgement of preliminary scale.
e Used only an evaluative scale.
Selection and Training of Judges

Three judges were selected to evaluate the first-fit pants muslins based on their experience and expertise. One judge was a draping specialist, the second was a textiles and clothing extension specialist, and the third was a pants drafting and patternmaking specialist.

The judges were trained immediately prior to the collection of the final data. I began the training session by having the judges read the cover sheet on the evaluation scale. Then, I read an explanation (see Appendix I) which clarified those criteria or diagnostic polar adjectives that I felt could be misunderstood or misinterpreted by the judges. This explanation also included criteria for perfect fit in pants. Each judge was then given a notecard on which was written the amounts of ease used in the patternmaking process for the waistband, pant waist, full hip, and total crotch length (see Table 7). Ease measurements were given to the judges in English units because I hypothesized that English units would be more meaningful to these individuals, and therefore, easier to judge in terms of pants fit.

The judges were trained by using the evaluation scale to rate two pants muslins. In both cases, the judges were
TABLE 7  
Ease allowances for first-fit muslins

<table>
<thead>
<tr>
<th>Placement</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waistband</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>Pant waist</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Full hip circumference</td>
<td>1 1/2&quot;</td>
</tr>
<tr>
<td>Total crotch length</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

unaware of the figure type or the method used. Each model was presented to all judges at the same time. The model first faced the judges, then turned her back to the judges, and then turned so the judges could view each side. After the judges had completed their standing evaluation, the model sat in a chair for any further evaluation.

The first model presented in the training process was G02A; an average figure type. This first pant muslin was constructed from the Unit Method pattern. No evaluation time limit was given to the judges for this particular model. After the judges were finished, I began asking the judges what their ratings were for each bipolar word pair. I had previously decided that if all judges' responses fell within a twenty-point range, then all judges were rating in a similar way. If, however, the ratings were not within a
twenty-point range, then I asked each judge to defend her rating for that particular diagnostic word pair. Through discussion, the judges were able to come to some kind of an agreement about the quality of fit for each of the areas. In some cases, I reread sections of the criteria for perfect fit to clarify differences in interpretation. Also at this time, judges were told to evaluate the horizontal grain bipolar adjectives based on the front view of the pants.

Areas of disagreement between judges included waist placement; crotch length; crotch curve; upper sideseam placement, curve, and slope; lower sideseam slope; and horizontal grain.

Following the discussions between judges, a second model, G19A, was presented. She represented a round hip type, and the muslin was constructed from the Experimental Method pattern. The same modeling procedure was used, and again, the judges were given an unlimited time to respond to the evaluation scale. After all judges were finished with their ratings, I again asked the judges to discuss their ratings. This time, there was minimal disagreement on the evaluations of crotch curve and length. After this period of discussion, we proceeded directly to the final judging process.
Evaluation of the First-fit Muslins

The ten pants muslins used in the final judging process were presented one at a time, and in random order. All judges were instructed to face the back of the room (where the judging took place) and to remain facing in that direction at all times so that they would not be able to preview any pant muslin before it was modeled. The judges were told that they would have ten minutes to evaluate each pant muslin.

Before the final judging began, I asked each model to step onto a platform in front of a mirror so that I could take pictures of how well the pant muslins fit the individual figure types. Photographing was done before the judging so that no extra wrinkles caused from sitting in the muslins would be present. The photographs of each muslin may be seen in Appendix H.

The subjects followed the same modeling procedure that was used in the training process. The judges were told the subject number and the letter "A" or "B." "A" corresponded to the first muslin presented, and "B" corresponded to the second muslin presented. Although the judges had been told that they were allowed to touch the models, no judge chose
to do so. The judges evaluated each model within the time limit, so I concluded that ten minutes was adequate time for the judging of any one individual.

After the judges' evaluation of both pairs of muslins for each individual, the subjects were asked to write down an explanation of which muslin felt better and why. These written responses provided information which would be used in the final fitting process.

Statistical Analysis of Evaluations by Judges

The evaluation scale was composed of two parts: an evaluative scale and a diagnostic scale. Each scale was based on the 99-point certainty method recommended by Warren et al. (1969) for use in social science research. Data were transformed to normal deviates by the Wolins and Dickinson method (1973), and each item was analyzed by analysis of variance and the means. However, before analysis began, it was necessary to edit some of the responses of the judges.

Certainty scale

The certainty method requires respondents to make two judgements: direction of response and certainty of that response (Warren et al., 1969). For this research, a
response of 1 to 49 on the evaluative scale indicated that the judge believed the fit to be bad; a response of 51 to 99 indicated that the fit was good. If the judge felt that the fit was neither bad nor good, or if she was uncertain about the fit, the judge was to respond with 50. Responses closer to 1 or to 99 indicated that the judge was more certain that the fit was either bad or good. Any response closer to 50 indicated that the judge was more uncertain about the fit.

Conversely, on the diagnostic scales, a response of 1 to 49 indicated that the fit was judged to be bad because the amount of ease or the length was either too little or too short; a response of 51 to 99 indicated that the fit was bad because the amount of ease or the length was either too much or too long. If the judge felt that the fit was correct, she was to respond with 50. Responses closer to 50 indicated that the judge was more certain that the fit was correct. Any response closer to 1 or to 99 indicated that the judge was more certain that the fit was bad because the ease or length was too little/too short or because it was too much/too long.

Warren et al. (1969) reported that a 99-point certainty scale is more sensitive than scales having fewer response choices. For this and other certainty scales, it is assumed
that the intervals between the response values are unequal.

Transformation of the 99-point certainty scale to normal deviates "spreads out" the ends of the original scale and "pushes together" the middle values. This action assumes that there is a greater difference between two closely corresponding values at the extreme ends than between two values near the middle of the scale. For example, a response of 99 was transformed to +2.33, a rating of 95 to +1.62, a rating of 50 to 0.00, a rating of 1 to -2.33, etc. (Wolins & Dickinson, 1973). Therefore, higher weightings were assigned to scores at the extreme ends of the scales because the judges were more certain of their scores; lower weightings were assigned to scores near the middle of the scale because judges were less certain about their responses (Warren et al., 1969).

**Editing of judges' responses**

After looking at all judge responses for all models, I found that three different kinds of problems existed for responses of two of the three judges. These problems included missing data and the listing of a numerical range instead of a single numerical response. These problems were dealt with in the following way.
Editing of missing data  

Missing data were modified in one of two ways. If data were on an evaluative scale and all responses to the diagnostic scales of that criterion were 50, (a rating indicating correct or perfect) then a rating of 99 was assigned to the evaluative scale (indicating good). This was the case for two of the five missing data. If, on the other hand, the response to any of the diagnostic scales was not 50, or if any diagnostic response was missing, the missing data were assigned the score which was the median of the other two judges' responses for that model on that specific scale. By using the median of the other two judges' responses, the mean of the responses would not be affected.

Editing of five-point ranges  

One of the three judges responded with a five-point range for two evaluative scales and three diagnostic scales. In each case, she wrote a response on the scale itself, and circled both the written and printed response (e.g., 60 65). For each of these cases, the hand-written response was used. This modification resulted in using the higher of the two scores on three responses, and the lower score on two responses.

Editing of drawn arrows  

The same judge who used the five point ranges also used an arrow drawn to indicate a leaning toward a higher or lower response. Nine times out
of ten, this arrow was accompanied by the circling of a response on the scale, and the tenth time, the arrow was placed near a printed scale response. Five times out of ten, this occurred on the evaluative scales, and five times on the diagnostic scales. For all ten deviations, I ignored the arrow and used the circled response or the response closest to the origin of the arrow.

**Analysis of variance**

A three-way analysis of variance was used to analyze the 35 adjective pairs for the three main effects and three two-way interactions. The main effects in this study were judge, treatment, and model; the interactions were judge by treatment, judge by model, and treatment by model. The error term computed in this analysis was the three-way interaction judge by treatment by model.

The means of the main effects and the interactions were computed for each item. These means were later used to determine which method of alteration was rated more favorably for each of the 35 items.
Two types of scatter plots were constructed to demonstrate the treatment by model interaction for each of the 35 word pairs. The first type of scatter plot described the responses to the evaluative scales; the second type described the responses to the diagnostic scales. An interpretation of each of the significant scatter plots will be discussed as a part of the findings of this research.
CHAPTER 4. FINDINGS AND DISCUSSION

The data were analyzed by analysis of variance and by examining means. Scatter plots of the treatment by model interactions were drawn. The findings are reported and discussed in the following sections.

Evaluations by Judges

Responses to evaluative scales

Hypothesis 1 stated that there would be no difference between the evaluative ratings given to pants produced by each method of alteration. This was tested by a three-way analysis of variance of the judges' responses to the evaluative criteria and by examining treatment means. The design of this analysis is described in Chapter 3.

Analysis of variance

No pattern of significant and non-significant F-values could be detected in the analysis of variance of the evaluative criteria. As an example, Table 8 lists the complete analysis of variance for the evaluative scale ratings of the back crotch length. Degrees
of freedom used in testing the $F$-values are listed in the table.

TABLE 8
Analysis of variance for evaluative criterion, back crotch length

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom (df)</th>
<th>Mean square</th>
<th>$F$</th>
<th>Tabular df used</th>
<th>Tabular $F$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judge</td>
<td>2</td>
<td>0.23</td>
<td>1.36</td>
<td>2 / 8</td>
<td>8.65</td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>2.46</td>
<td>14.30**</td>
<td>1 / 8</td>
<td>11.26</td>
</tr>
<tr>
<td>Model</td>
<td>4</td>
<td>0.54</td>
<td>3.12</td>
<td>4 / 8</td>
<td>7.01</td>
</tr>
<tr>
<td>Judge by Treatment</td>
<td>2</td>
<td>0.07</td>
<td>0.41</td>
<td>2 / 8</td>
<td>8.65</td>
</tr>
<tr>
<td>Judge by Model</td>
<td>8</td>
<td>0.15</td>
<td>0.87</td>
<td>8 / 8</td>
<td>6.03</td>
</tr>
<tr>
<td>Treatment by Model</td>
<td>4</td>
<td>1.32</td>
<td>7.68**</td>
<td>4 / 8</td>
<td>7.01</td>
</tr>
<tr>
<td>Error (JxTxM)</td>
<td>8</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$Tabular $F$-values at the .01 level from Snedecor and Cochran, 1967, p. 560.

$F$-values and their significance for each of the evaluative criteria are summarized in Table 9. Mean squares can be approximated by multiplying the $F$-values in Table 9 by
the error mean square in Table 8 in order to provide complete data for each of the evaluative criteria.

Hypothesis 1 was tested by the treatment main effect. A significant F-value indicated that the judges' responses as a group to the evaluative criterion differed for the two methods of alteration, independent of the model. F-values ranged from 0.00 to 40.19, but were significant for only two of the 15 evaluative criteria: the back crotch length and the horizontal grain. Therefore, Hypothesis 1 was not rejected for 13 evaluative criteria with non-significant F-values. However, Hypothesis 1 was rejected for the two criteria with significant F-values. Further interpretation will be included in the discussion of the means of the two treatments.

Hypothesis 2, which stated that model would not interact with treatment, was tested by the treatment by model interaction. F-values ranged from 0.76 to 7.68, and were significant for five of the 15 evaluative criteria: waist circumference, front waist placement, back waist placement, back crotch length, and horizontal grain. Significance indicated that the judges believed that the Unit Method produced a better fit for some models, and the Experimental Method produced a better fit for some models. However, this
<table>
<thead>
<tr>
<th>Criterion</th>
<th>Judge</th>
<th>Treatment</th>
<th>Model</th>
<th>Judge by Treatment</th>
<th>Judge by Model</th>
<th>Treatment by Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>4.98*</td>
<td>0.41</td>
<td>2.65</td>
<td>1.90</td>
<td>3.42*</td>
<td>7.81**</td>
</tr>
<tr>
<td>High hip circumference</td>
<td>6.43*</td>
<td>2.01</td>
<td>1.26</td>
<td>3.60</td>
<td>2.47</td>
<td>3.16</td>
</tr>
<tr>
<td>Full hip circumference</td>
<td>1.40</td>
<td>0.41</td>
<td>2.46</td>
<td>0.97</td>
<td>0.57</td>
<td>1.36</td>
</tr>
<tr>
<td>Front waist placement</td>
<td>0.29</td>
<td>0.00</td>
<td>11.98**</td>
<td>0.19</td>
<td>0.45</td>
<td>5.19*</td>
</tr>
<tr>
<td>Back waist placement</td>
<td>0.07</td>
<td>4.79</td>
<td>2.61</td>
<td>0.12</td>
<td>1.01</td>
<td>7.17**</td>
</tr>
<tr>
<td>Front waist darts</td>
<td>3.17</td>
<td>1.87</td>
<td>0.81</td>
<td>5.63*</td>
<td>1.00</td>
<td>0.76</td>
</tr>
<tr>
<td>Back waist darts</td>
<td>3.64</td>
<td>0.00</td>
<td>0.34</td>
<td>0.00</td>
<td>0.67</td>
<td>0.81</td>
</tr>
<tr>
<td>Front crotch length</td>
<td>2.56</td>
<td>0.18</td>
<td>2.60</td>
<td>1.06</td>
<td>0.79</td>
<td>1.24</td>
</tr>
<tr>
<td>Back crotch length</td>
<td>1.36</td>
<td>14.30**</td>
<td>3.12</td>
<td>0.41</td>
<td>0.87</td>
<td>7.68**</td>
</tr>
<tr>
<td>Front crotch curve</td>
<td>5.46*</td>
<td>1.25</td>
<td>2.37</td>
<td>2.72</td>
<td>1.00</td>
<td>0.94</td>
</tr>
<tr>
<td>Back crotch curve</td>
<td>3.03</td>
<td>0.66</td>
<td>3.79*</td>
<td>0.28</td>
<td>0.76</td>
<td>2.80</td>
</tr>
<tr>
<td>Upper sideseseam</td>
<td>0.18</td>
<td>0.45</td>
<td>0.97</td>
<td>1.00</td>
<td>3.12</td>
<td>3.14</td>
</tr>
<tr>
<td>Lower sideseseam</td>
<td>1.51</td>
<td>2.13</td>
<td>9.21**</td>
<td>13.90**</td>
<td>2.76</td>
<td>1.16</td>
</tr>
<tr>
<td>Vertical grain</td>
<td>2.57</td>
<td>0.62</td>
<td>1.62</td>
<td>1.90</td>
<td>1.19</td>
<td>1.90</td>
</tr>
<tr>
<td>Horizontal grain</td>
<td>2.02</td>
<td>40.19**</td>
<td>18.61**</td>
<td>0.52</td>
<td>1.56</td>
<td>7.23**</td>
</tr>
</tbody>
</table>

* p < .05  
** p < .01

Tabular F-values\(^a\) p < .05  4.46  5.32  3.84  4.46  3.44  3.84
   p < .01  8.65 11.26  7.01  8.65  6.03  7.01

\(^a\) Tabular F-values from Snedecor and Cochran, 1967, p. 560.
interaction is only important in the interpretation of the main effects. In cases where a significant treatment by model interaction was coupled with a significant treatment main effect, the interaction detracted from the validity of the treatment difference. Therefore, the overall means of the interaction were examined before any statements of preference were made. The implication of the treatment by model interaction will be discussed later in this chapter.

F-values for judge were significant for three of the 15 evaluative criteria: waist circumference, high hip circumference, and front crotch curve. This indicated that for these criteria the judges' use of the scale differed, independent of the model and treatment. This result suggested that the judges needed further training in the evaluation of these criteria.

The model main effect had significant F-values for four of the 15 evaluative criteria. Significance indicated that the judges viewed the models as being different from one another, independent of the treatment used. This is not surprising since each model was purposely selected to represent one of five different body types.

F-values for the judge by treatment interaction were significant for two of the 15 evaluative criteria: front
waist darts and lower sideseam. Significance indicated that the judges disagreed on which treatment produced the best fit across all models. This disagreement is not desirable because it indicates that all judges are not using the same guidelines for correct fit on these two criteria. F-values for the other 13 criteria were all very low, which indicated that most of the time, the judges' responses were approximately the same.

There was only one significant F-value for the judge by model interaction: waist circumference. This significance indicated that the judges were responding differently to the fit of the two treatments because of the difference in models. Significant F-values for the judge and model main effects and the judge by treatment and judge by model interactions were not important to the evaluation of the two methods of alteration for this study, other than to account for their share of the total variance. Therefore, only the treatment main effect and the treatment by model interactions will be discussed in the following sections.

Means Treatment main effect was analyzed further by looking at the means of the significant criteria in light of the means for treatment by model interaction. Table 10 gives the treatment means for the evaluative criteria. It
is important to note that the best possible rating on the evaluative scale was 99, which was transformed to +2.33.

TABLE 10
Treatment means for evaluative criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Unit Method</th>
<th>Experimental Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>1.80</td>
<td>1.71</td>
</tr>
<tr>
<td>High hip circumference</td>
<td>1.66</td>
<td>1.44</td>
</tr>
<tr>
<td>Full hip circumference</td>
<td>1.75</td>
<td>1.59</td>
</tr>
<tr>
<td>Front waist placement</td>
<td>1.64</td>
<td>1.64</td>
</tr>
<tr>
<td>Back waist placement</td>
<td>2.10</td>
<td>1.71</td>
</tr>
<tr>
<td>Front waist darts</td>
<td>1.86</td>
<td>1.60</td>
</tr>
<tr>
<td>Back waist darts</td>
<td>1.74</td>
<td>1.74</td>
</tr>
<tr>
<td>Front crotch length</td>
<td>1.47</td>
<td>1.57</td>
</tr>
<tr>
<td>Back crotch length **</td>
<td>0.90</td>
<td>1.47</td>
</tr>
<tr>
<td>Front crotch curve</td>
<td>1.50</td>
<td>1.70</td>
</tr>
<tr>
<td>Back crotch curve</td>
<td>1.33</td>
<td>1.21</td>
</tr>
<tr>
<td>Upper sideseam</td>
<td>1.31</td>
<td>1.23</td>
</tr>
<tr>
<td>Lower sideseam</td>
<td>1.72</td>
<td>1.55</td>
</tr>
<tr>
<td>Vertical grain</td>
<td>1.51</td>
<td>1.68</td>
</tr>
<tr>
<td>Horizontal grain **</td>
<td>1.37</td>
<td>1.97</td>
</tr>
</tbody>
</table>

** p < .01

In looking at the treatment means for the back crotch length and the horizontal grain, it can be seen that the
Experimental Method had a higher mean for both criteria, although both methods were rated as good. This indicates that the Experimental Method produced a significantly better fit than the Unit Method of alteration on these criteria. Because there was a significant treatment by model interaction it was necessary to examine the means for the interaction before stating a preference for method. Table 11 shows the treatment by model interaction terms for each of the evaluative criteria. For the back crotch length criterion, the means for Models 8 and 9 are very close for the two methods. However, the means for the other three models show that the Experimental Method was preferred by a very large margin for Models 12 and 32, and that the Unit Method was preferred by a slim margin for Model 27. Therefore, there was no overall preference for treatment.

Conversely, the means for the horizontal grain show that the two methods provided equally good fit for Model 8, but that the Experimental Method was strongly preferred for three of the other four models. Therefore, the Experimental Method provided an equal or better fit for all models than the Unit Method.

The construction of a scatter plot provided another way to look at this information. Figures 29 and 30 show the
TABLE 11
Means for treatment by model interaction, evaluative criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Method</th>
<th>8</th>
<th>9</th>
<th>12</th>
<th>27</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference**</td>
<td>Unit</td>
<td>1.63</td>
<td>2.33</td>
<td>2.10</td>
<td>1.38</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>2.33</td>
<td>0.98</td>
<td>1.75</td>
<td>1.40</td>
<td>2.10</td>
</tr>
<tr>
<td>High hip circumference</td>
<td>Unit</td>
<td>1.98</td>
<td>1.20</td>
<td>2.10</td>
<td>1.98</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.47</td>
<td>1.60</td>
<td>1.40</td>
<td>1.17</td>
<td>1.55</td>
</tr>
<tr>
<td>Full hip circumference</td>
<td>Unit</td>
<td>1.48</td>
<td>1.98</td>
<td>2.33</td>
<td>2.33</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.33</td>
<td>1.48</td>
<td>1.75</td>
<td>1.83</td>
<td>1.55</td>
</tr>
<tr>
<td>Front waist placement*</td>
<td>Unit</td>
<td>2.33</td>
<td>2.33</td>
<td>2.10</td>
<td>-0.43</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.88</td>
<td>1.89</td>
<td>2.33</td>
<td>0.99</td>
<td>2.10</td>
</tr>
<tr>
<td>Back waist placement**</td>
<td>Unit</td>
<td>2.33</td>
<td>2.33</td>
<td>2.10</td>
<td>2.33</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.43</td>
<td>1.63</td>
<td>2.33</td>
<td>1.83</td>
<td>2.33</td>
</tr>
<tr>
<td>Front waist darts</td>
<td>Unit</td>
<td>1.63</td>
<td>2.33</td>
<td>1.98</td>
<td>1.38</td>
<td>1.98</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.67</td>
<td>1.50</td>
<td>1.67</td>
<td>1.48</td>
<td>1.67</td>
</tr>
<tr>
<td>Back waist darts</td>
<td>Unit</td>
<td>1.98</td>
<td>1.40</td>
<td>1.98</td>
<td>1.90</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.46</td>
<td>1.63</td>
<td>1.87</td>
<td>1.63</td>
<td>2.10</td>
</tr>
<tr>
<td>Front crotch length</td>
<td>Unit</td>
<td>1.55</td>
<td>1.90</td>
<td>1.83</td>
<td>0.45</td>
<td>1.63</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.12</td>
<td>1.48</td>
<td>2.10</td>
<td>1.38</td>
<td>1.75</td>
</tr>
<tr>
<td>Back crotch length **</td>
<td>Unit</td>
<td>0.97</td>
<td>0.79</td>
<td>0.37</td>
<td>1.38</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.88</td>
<td>0.85</td>
<td>2.33</td>
<td>1.17</td>
<td>2.10</td>
</tr>
<tr>
<td>Front crotch curve</td>
<td>Unit</td>
<td>1.26</td>
<td>1.48</td>
<td>1.64</td>
<td>1.60</td>
<td>1.52</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.26</td>
<td>1.48</td>
<td>2.10</td>
<td>2.33</td>
<td>1.32</td>
</tr>
</tbody>
</table>

*Negative means indicate a bad fit; positive means indicate a good fit.*

* p < .05 Treatment significance.
** p < .01 Treatment significance.
Table 11 (cont.)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Method</th>
<th>8</th>
<th>9</th>
<th>12</th>
<th>27</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back crotch curve</td>
<td>Unit</td>
<td>1.32</td>
<td>1.15</td>
<td>1.44</td>
<td>1.40</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.32</td>
<td>1.17</td>
<td>1.87</td>
<td>1.38</td>
<td>1.32</td>
</tr>
<tr>
<td>Upper sideseam</td>
<td>Unit</td>
<td>1.48</td>
<td>0.99</td>
<td>1.08</td>
<td>1.26</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.91</td>
<td>1.75</td>
<td>1.87</td>
<td>2.10</td>
<td>1.13</td>
</tr>
<tr>
<td>Lower sideseam</td>
<td>Unit</td>
<td>1.50</td>
<td>1.98</td>
<td>1.83</td>
<td>1.98</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.91</td>
<td>1.75</td>
<td>1.87</td>
<td>2.10</td>
<td>1.13</td>
</tr>
<tr>
<td>Vertical grain</td>
<td>Unit</td>
<td>1.48</td>
<td>1.48</td>
<td>0.85</td>
<td>1.63</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>1.15</td>
<td>1.75</td>
<td>2.10</td>
<td>1.29</td>
<td>2.10</td>
</tr>
<tr>
<td>Horizontal grain **</td>
<td>Unit</td>
<td>2.10</td>
<td>1.13</td>
<td>0.69</td>
<td>1.05</td>
<td>1.87</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>2.10</td>
<td>2.33</td>
<td>1.87</td>
<td>1.20</td>
<td>2.33</td>
</tr>
</tbody>
</table>

Plots of the means for the back crotch length and the horizontal grain. The judges' responses to the Unit Method are plotted on the y-axis; the Experimental Method, on the x-axis. Diagonals are drawn to bisect the quadrant of the graph in order to define which models were fitted more nearly by each alteration method. Those points above the diagonal favored the Unit Method; those below, the Experimental Method. Scatter plots for all treatment by model interactions are located in Appendix J.
Figure 29: Means for treatment by model, back crotch length

Figure 30: Means for treatment by model, horizontal grain
Responses to diagnostic scales

The diagnostic scales were analyzed in the same way as the evaluative scales and, therefore, significant F-values have the same meanings as explained in the previous section. Again, only treatment main effect and treatment by model interaction will be discussed.

Analysis of variance No pattern of significant and non-significant F-values could be detected in the analysis of variance of the diagnostic criteria. Table 12 lists the complete analysis of variance for the diagnostic scale ratings of front crotch length. Degrees of freedom used in testing the F-values are listed in the table.

F-values and their significance for each of the diagnostic criteria are summarized in Table 13. Mean squares can be approximated by multiplying the F-values in Table 13 by the error mean square in Table 12.

Hypothesis 3, which stated that there was no difference between treatments, was tested by the treatment main effect. F-values ranged from 0.03 to 22.52, and were significant for seven of the 20 diagnostic criteria. Therefore, Hypothesis 3 was rejected for these seven criteria. The hypothesis was not rejected for the 13 diagnostic criteria with non-significant F-values for the treatment main effect. Further
TABLE 12

Analysis of variance for diagnostic criterion, front crotch length

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom (df)</th>
<th>Mean Square</th>
<th>F</th>
<th>Tabular df used</th>
<th>Tabular ( F )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judge</td>
<td>2</td>
<td>0.27</td>
<td>8.59**</td>
<td>2 / 8</td>
<td>8.65</td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>0.04</td>
<td>1.36</td>
<td>1 / 8</td>
<td>11.26</td>
</tr>
<tr>
<td>Model</td>
<td>4</td>
<td>0.30</td>
<td>9.36**</td>
<td>4 / 8</td>
<td>7.01</td>
</tr>
<tr>
<td>Judge by Treatment</td>
<td>2</td>
<td>0.05</td>
<td>1.66</td>
<td>2 / 8</td>
<td>8.65</td>
</tr>
<tr>
<td>Judge by Model</td>
<td>8</td>
<td>0.09</td>
<td>2.86</td>
<td>8 / 8</td>
<td>6.03</td>
</tr>
<tr>
<td>Treatment by Model</td>
<td>4</td>
<td>0.07</td>
<td>2.18</td>
<td>4 / 8</td>
<td>7.01</td>
</tr>
<tr>
<td>Error (JxTxM)</td>
<td>8</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ a \] Tabular \( F \)-values at the .01 level from Snedecor and Cochran, 1967, p. 560.

Interpretation will be included in the discussion of the means.

Hypothesis 4, which stated that model would not interact with treatment, was tested by the treatment by model interaction. \( F \)-values ranged from 0.52 to 9.13, and were significant for six of the 20 diagnostic criteria. In cases
### Table 13

*F*-values for main effects and interactions of diagnostic criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Judge</th>
<th>Treatment</th>
<th>Model</th>
<th>Judge by Treatment</th>
<th>Judge by Model</th>
<th>Treatment by Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference tight/loose</td>
<td>3.64</td>
<td>0.67</td>
<td>5.07*</td>
<td>0.39</td>
<td>0.65</td>
<td>2.58</td>
</tr>
<tr>
<td>High hip circumference tight/loose</td>
<td>1.54</td>
<td>1.84</td>
<td>3.05</td>
<td>0.22</td>
<td>0.33</td>
<td>2.24</td>
</tr>
<tr>
<td>Full hip circumference tight/loose</td>
<td>2.96</td>
<td>0.05</td>
<td>8.79**</td>
<td>1.45</td>
<td>1.50</td>
<td>6.37**</td>
</tr>
<tr>
<td>Front waist placement low/high</td>
<td>1.23</td>
<td>7.67*</td>
<td>8.96**</td>
<td>0.77</td>
<td>0.98</td>
<td>2.38</td>
</tr>
<tr>
<td>Back waist placement low/high</td>
<td>0.49</td>
<td>21.99**</td>
<td>13.05**</td>
<td>3.82</td>
<td>1.83</td>
<td>8.66**</td>
</tr>
<tr>
<td>Front waist darts short/long</td>
<td>4.43*</td>
<td>12.37**</td>
<td>1.37</td>
<td>3.45</td>
<td>1.37</td>
<td>0.62</td>
</tr>
<tr>
<td>CB**/SS</td>
<td>3.10</td>
<td>1.78</td>
<td>3.75*</td>
<td>0.44</td>
<td>4.74*</td>
<td>0.67</td>
</tr>
<tr>
<td>small/large</td>
<td>8.45**</td>
<td>7.82*</td>
<td>2.61</td>
<td>0.31</td>
<td>2.10</td>
<td>0.59</td>
</tr>
<tr>
<td>Back waist darts short/long</td>
<td>1.26</td>
<td>0.30</td>
<td>0.55</td>
<td>0.15</td>
<td>0.49</td>
<td>0.77</td>
</tr>
<tr>
<td>CB**/SS</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>small/large</td>
<td>3.06</td>
<td>0.03</td>
<td>1.05</td>
<td>0.19</td>
<td>0.77</td>
<td>0.52</td>
</tr>
<tr>
<td>Front crotch length short/long</td>
<td>8.59**</td>
<td>1.36</td>
<td>9.36**</td>
<td>1.66</td>
<td>2.86</td>
<td>2.18</td>
</tr>
<tr>
<td>Back crotch length short/long</td>
<td>2.46</td>
<td>21.26**</td>
<td>23.22**</td>
<td>5.18*</td>
<td>2.20</td>
<td>9.13**</td>
</tr>
<tr>
<td>Front crotch curve shallow/deep</td>
<td>2.88</td>
<td>0.43</td>
<td>4.38*</td>
<td>2.72</td>
<td>4.44*</td>
<td>1.65</td>
</tr>
<tr>
<td>Back crotch curve shallow/deep</td>
<td>16.42**</td>
<td>8.45*</td>
<td>0.96</td>
<td>1.46</td>
<td>2.52</td>
<td>0.75</td>
</tr>
<tr>
<td>Upper sideseam forward/back</td>
<td>0.18</td>
<td>2.96</td>
<td>1.76</td>
<td>1.14</td>
<td>0.94</td>
<td>1.46</td>
</tr>
<tr>
<td>curve flat/full</td>
<td>0.47</td>
<td>1.48</td>
<td>2.83</td>
<td>0.61</td>
<td>1.15</td>
<td>1.27</td>
</tr>
<tr>
<td>slope forward/back</td>
<td>5.41*</td>
<td>1.82</td>
<td>1.15</td>
<td>0.70</td>
<td>2.54</td>
<td>7.75**</td>
</tr>
<tr>
<td>Lower sideseam slope forward/back</td>
<td>0.02</td>
<td>0.45</td>
<td>4.49*</td>
<td>1.01</td>
<td>0.43</td>
<td>4.17*</td>
</tr>
<tr>
<td>Horizontal grain angle down/up</td>
<td>1.14</td>
<td>22.52**</td>
<td>1.82**</td>
<td>1.43</td>
<td>0.69</td>
<td>8.96**</td>
</tr>
</tbody>
</table>

* * *

* Judge by Treatment * * *

* Judge by * Model * * *

* Treatment by Model * * *

* Judge * Treatment * * *

* Tabular * F*-values * * *

* P < .05 4.46 5.32 3.84 4.46 3.44 3.84

* P < .01 8.65 11.26 7.01 8.65 6.03 7.01


---

* Judge * Treatment * * *

* Judge * Model * * *

* Treatment * by * Model * * *

* Judge * by * Treatment * * *

* Judge * by * Hodel * * *

* Treatment * by * Model * * *

---

* Tabular * F*-values * * *

* P < .05 4.46 5.32 3.84 4.46 3.44 3.84

* P < .01 8.65 11.26 7.01 8.65 6.03 7.01

where a significant treatment by model interaction is coupled with a significant treatment main effect, the interaction detracted from the validity of the treatment difference. The meaning of the significant interaction was determined by inspecting the means, and will be discussed later in this chapter.

**Means**

Treatment main effect was analyzed by looking at the means of the significant criteria in light of the means for treatment by model interaction. Table 14 gives the treatment means for the diagnostic criteria. It is important to note that the best possible rating on the diagnostic scale was 50, which was transformed to 0.00.

In looking at the treatment means for the front waist placement, it can be seen that the Experimental Method has a mean closer to 0.00, although the placement was considered to be slightly too low. Conversely, the Unit Method front waist placement was rated as too high. The significant treatment mean indicated that the Experimental Method produced a significantly better fit across all models.

Front waist dart length was the second significant treatment main effect. Based on the treatment means in Table 14, the Unit Method was preferred over the Experimental Method. This preference was puzzling because a close
TABLE 14
Treatment means for diagnostic criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Unit Method</th>
<th>Experimental Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference tight/loose</td>
<td>0.05*</td>
<td>0.01</td>
</tr>
<tr>
<td>High hip circumference tight/loose</td>
<td>-0.12</td>
<td>-0.04</td>
</tr>
<tr>
<td>Full hip circumference tight/loose</td>
<td>-0.07</td>
<td>-0.08</td>
</tr>
<tr>
<td>Front waist placement low/high *</td>
<td>0.28</td>
<td>-0.03</td>
</tr>
<tr>
<td>Back waist placement low/high **</td>
<td>0.06</td>
<td>-0.17</td>
</tr>
<tr>
<td>Front waist darts short/long **</td>
<td>0.02</td>
<td>-0.07</td>
</tr>
<tr>
<td>CPb/SSd</td>
<td>-0.03</td>
<td>-0.01</td>
</tr>
<tr>
<td>small/large *</td>
<td>0.07</td>
<td>-0.02</td>
</tr>
<tr>
<td>Back waist darts short/long</td>
<td>-0.09</td>
<td>-0.05</td>
</tr>
<tr>
<td>CBC/SS</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>small/large</td>
<td>-0.03</td>
<td>-0.02</td>
</tr>
<tr>
<td>Front crotch length short/long</td>
<td>0.23</td>
<td>0.15</td>
</tr>
<tr>
<td>Back crotch length short/long **</td>
<td>0.21</td>
<td>0.00</td>
</tr>
</tbody>
</table>

* Negative values indicate a response for the left adjective; positive values, the right adjective.

b Center front.
c Center back.
d Side seam.

* p < .05
** p < .01
Table 14 (cont.)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Unit Method</th>
<th>Experimental Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front crotch curve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>shallow/deep *</td>
<td>0.01</td>
<td>0.14</td>
</tr>
<tr>
<td>Back crotch curve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>shallow/deep *</td>
<td>-0.14</td>
<td>0.04</td>
</tr>
<tr>
<td>Upper side seam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forward/back curve flat/full</td>
<td>-0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>slope forward/back</td>
<td>0.17</td>
<td>0.23</td>
</tr>
<tr>
<td>Lower side seam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slope forward/back</td>
<td>0.07</td>
<td>0.10</td>
</tr>
<tr>
<td>Horizontal grain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>angle down/up</td>
<td>0.19</td>
<td>0.03</td>
</tr>
</tbody>
</table>

examination of the muslins showed that in all cases, the Unit Method dart extended beyond the fullest part of the abdomen, which was described as poor fit in the directions read aloud to the judges. Table 13 indicated that there was a significant judge difference, so I examined the judge by treatment interaction for more information (see Table 15).

One judge preferred the Unit Method, but the other two judges rated the treatments equally. A significant F-value for treatment resulted because Judge 3 rated the Experimental Method dart as too short and the Unit Method dart as equally too long. Therefore, no statement about preference
TABLE 15
Means for treatment by judge, front dart length

<table>
<thead>
<tr>
<th>Judge</th>
<th>Unit Method</th>
<th>Experimental Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>-0.15</td>
</tr>
<tr>
<td>2</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>0.05</td>
<td>-0.05</td>
</tr>
</tbody>
</table>

is possible on this criterion, because it would be based on the rating of only one judge.

Front waist dart size was the third significant treatment main effect. According to the means in Table 14, the Experimental Method was judged to produce a better-sized dart. Examination of the means also showed that the darts produced by the Experimental Method were considered to be slightly too small; darts produced by the Unit Method were too large. However, this significant treatment mean indicated that the Experimental Method was preferred for determining dart size.

The fourth significant treatment mean was on the back crotch curve criterion. The means in Table 14 clearly show that the Experimental Method produced a better back crotch curve than the Unit Method. Overall, the judges rated the
Experimental Method curve as slightly too deep and the Unit Method curve as too shallow. The means in Table 14 indicated that the Experimental Method produced the better back crotch curve.

The means for back waist placement indicated that the Unit Method produced the better fit, although the placement was again considered to be too high. As with the front waist, the Experimental Method placement was considered to be slightly too low. However, for this and the following criteria, a significant treatment by model interaction detracted from the treatment significance, and so the means of the interaction were examined (see Table 16).

Table 16 shows that the Unit Method gave a better placement for Model 8; the Experimental Method gave a better fit for Model 32; and there was little difference in the means for the other three models. Therefore, it is not possible to conclude that the Unit Method is the preferred method across all models. A scatter plot was constructed to aid in the interpretation of the interaction (see Figure 31). Responses to the Unit Method were plotted on the y-axis; the Experimental Method, on the x-axis. However, because a perfect rating for this type of scale was transformed to 0.00, those data points closer to the y-axis than
TABLE 16

Means for treatment by model interaction, diagnostic criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Method</th>
<th>8</th>
<th>9</th>
<th>12</th>
<th>27</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist circumference</td>
<td>Unit</td>
<td>0.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00</td>
<td>-0.04</td>
<td>-0.13</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.00</td>
<td>0.26</td>
<td>-0.08</td>
<td>-0.17</td>
<td>0.04</td>
</tr>
<tr>
<td>High hip circumference</td>
<td>Unit</td>
<td>0.00</td>
<td>-0.17</td>
<td>-0.04</td>
<td>-0.08</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.17</td>
<td>0.08</td>
<td>-0.13</td>
<td>-0.25</td>
<td>-0.08</td>
</tr>
<tr>
<td>Full hip circumference</td>
<td>Unit</td>
<td>0.08</td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.54</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>-0.21</td>
<td>0.08</td>
<td>-0.08</td>
<td>-0.08</td>
<td>-0.13</td>
</tr>
<tr>
<td>Front waist placement</td>
<td>Unit</td>
<td>0.00</td>
<td>0.00</td>
<td>0.04</td>
<td>1.30</td>
<td>0.08</td>
</tr>
<tr>
<td>low/high&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Experimental</td>
<td>-0.34</td>
<td>-0.08</td>
<td>0.00</td>
<td>0.30</td>
<td>-0.04</td>
</tr>
<tr>
<td>Back waist placement</td>
<td>Unit</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.32</td>
</tr>
<tr>
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<sup>a</sup> Negative values indicate a response for the left adjective; positive values, the right adjective.
<sup>b</sup> Center front.
<sup>c</sup> Sideseam.
<sup>*</sup> p < .05 Treatment significance.
<sup>**</sup> p < .01 Treatment significance.
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*d Center back.*
Table 16 (cont.)

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the x-axis indicated responses favoring the Experimental Method. Conversely, those points closer to the x-axis indicated a better fit achieved by the Unit Method. Scatter plots for all diagnostic treatment by model interactions are located in Appendix K.

The sixth significant F-value was the back crotch length criterion. On first examination, the means indicated that the Experimental Method produced a better fit than the Unit Method.

A scatter plot was constructed to show treatment preferences for each model (see Figure 32). Data points closer to the y-axis favored the Experimental Method and data points closer to the x-axis favored the Unit Method.
Figure 31: Means for treatment by model, back waist placement

Figure 32: Means for treatment by model, back crotch length
An examination of the scatter plot showed that the Experimental Method was preferred for Models 9, 12, and 32. However, the lengths produced by the Unit Method were preferred for Models 8 and 27. Therefore, it is not possible to conclude that the Experimental Method produced a better crotch length across all models.

The final significant treatment F-value was the horizontal grain criterion. Again the means indicated that the Experimental Method was preferred.

Treatment by model means in Table 16 were examined to reveal that the Experimental Method produced a horizontal grainline equally level to the Unit Method for Model 8, and surpassed the Unit Method ratings for Models 9, 12, 27, and 32. Although a scatter plot was not necessary to interpret the means, one was constructed for completeness (see Figure 33). As can be seen from the examination of the means and the scatter plot, the Experimental Method was preferred in its levelness of the horizontal grain.
Figure 33: Means for treatment by model, horizontal grain

Evaluations by Models

After each subject had modeled both pant muslins, she was asked to write a short descriptive evaluation of the fit of her two pant muslins. The description was to tell which pant she preferred and why.

Four of the five models preferred the fit produced by the Experimental Method, primarily because of the smoothness of fit across the hips and in the crotch area. One model preferred the fit produced by the Unit Method because it felt "less loose" through the crotch seam. Specific obser-
vations by the models were then compared to the judges' responses in Tables 11 and 16 to determine if the judges were able to see the problems in fit that were discussed by the models.

**Evaluation by Model 8**

Model 8 noted that the crotch seam on the Unit Method pant almost ripped when she sat down, and that the waist dipped in the back. This indicated that the total crotch length was too short or the distribution of the back crotch length (i.e., length at the waist versus at the crotch point) was incorrect. I concluded that the distribution was the problem because the total crotch lengths of the two pants patterns were identical. Examination of the two pants patterns showed that the length of the back crotch point was 3 cm longer on the Experimental pant.

The judges' responses were then examined to determine if the judges observed this crotch problem. The evaluative mean in Table 11 indicated a slight preference for the Unit Method back crotch length and a marked preference for the Unit Method curve. Likewise, the Unit Method was judged to give the better back crotch length on the diagnostic criteria in Table 16. However, the *experimentally* produced back crotch curve was preferred according to Table 16. This dis-
crepancy in preference according to the diagnostic and evaluative scales is confusing, and can only be explained as a judge inconsistency.

Model 8 also noted that the pants produced by the Experimental Method felt low on the waist. According to the means listed in Table 16, the judges concurred with this complaint.

**Evaluation by Model 9**

Model 9 noted that the Unit Method pant fit too snugly, but did not give any specific area of the body where this occurred. Other comments were also very general, and so no comparison to the judges' responses could be made.

**Evaluation by Model 12**

Model 12 reported that the waistbands on both pants were tight, although the Unit Method pant was tighter. However, below the waist, the Unit Method pant seemed too large. Table 16 shows that the judges agreed that both waist circumferences were tight. However, the judges believed that the waist circumference produced by the Unit Method was less tight than the waist circumference produced by the Experimental Method. This same preference for the Unit Method pant was apparent in Table 11.
In order to determine which pattern was more nearly correct for waist circumference of the model, I consulted her pattern measurement chart, and found that the Unit Method pattern was actually .9 cm larger than the model's waist circumference plus ease; the Experimental Method pattern, 1.3 cm smaller than the model's waist circumference plus ease. Therefore, the Experimental Method pattern allowed only .5 cm ease in the waist and the Unit Method pattern allowed 3.4 cm ease. However, the two pants were sewn onto identical waistbands. Logically, the waistbands (and therefore the waist circumference according to the judges' instructions) should have felt equally tight, and the Unit Method pant should have felt larger below the waistband.

**Evaluation by Model 27**

Model 27's only specific complaint was that the waist of the Unit Method pant was too high on her body. Table 11 indicated that the judges preferred the front waist placement given by the Experimental Method and the back waist placement given by the Unit Method. The means in Table 16 show that the judges agreed with the model that the front waist placement of the Unit Method pant was much higher than the front waist placement of the Experimental Method pant.
However, the judges felt that the back waist placement of the Unit Method pant was correct and the placement of the Experimental Method pant was very slightly high. The rating of correct given in Table 16 for the Unit Method placement contrasts with the negative rating assigned in Table 11, which again points to judge inconsistency.

Because the model and the judges differed in their evaluations of the back waist placement, I compared the length of the back crotch seams in the following manner. Back waist placement is affected by the length of the back seam above the crotch curve. Therefore, I aligned the two patterns so that their crotch lines were even, and then measured the difference between the two back waist points. I found that the Unit Method pattern extended 2.5 cm beyond the back waist point of the Experimental Method pattern, and therefore should have been rated as higher on the body. Again, this disagreement between the judge responses and the physical measurements of the pattern suggests that the judges need to be trained more thoroughly.

**Evaluation by Model 32**

Model 32 preferred the fit of the Unit Method pant because it felt "less loose" through the crotch and "more snug" through the hips. Looseness in the crotch would be
caused by excessive total crotch length or incorrect distribution of the crotch length (i.e., length at the waist versus at the crotch point). Because total crotch length of the two patterns was identical, I believed that there was too much length at the crotch points. Snugness in the hips would be a direct result of incorrect hip circumference.

According to the means presented in Table 11, the judges preferred the crotch lengths given by the Experimental Method, and also the high and full hip circumferences given by the Experimental Method. Examination of the means in Table 16, however, showed that the judges believed that the front crotch length of the Unit Method pant was more nearly correct than the front crotch length of the Experimental Method pant. Because, the difference in means between the two methods on the front crotch length was very small, I could not conclude that the judges were being inconsistent. Table 16 also showed that the judges preferred the back crotch length and the high and full hip circumferences of the Experimental Method pant. This preference for the Experimental Method pant showed that the judges' evaluations were inconsistent with the evaluation given by the model. Therefore, I consulted the two pant patterns and the pattern measurement comparison chart.
Careful comparison of the lengths of the front and back crotch points showed that the Experimental Method pattern was 4.8 cm longer in the back and 1.1 cm longer in the front. This measurement explains the fullness in the crotch that the model felt. However, the means indicated that the judges believed that this fullness was necessary in order to achieve a correct fit.

Examination of the pattern measurement comparison chart showed that the 7.6 cm circumference was more nearly approximated by the Experimental Method pattern, and the 17.8 cm and full hip circumferences were more nearly approximated by the Unit Method pattern. However, the Experimental Method pant should have felt tighter in the full hip because it was actually 1.7 cm less than the body measurement plus ease, whereas the Unit Method pant had a hip circumference .3 cm larger than the body measurement plus ease.

Summary

Hypothesis 1, which stated that there would be no difference between the evaluative ratings given to pants produced by each method of alteration, was rejected for two of the 15 criteria with significant treatment $F$-values: the back crotch length and the horizontal grain. However,
before any interpretations could be made, it was necessary to look at the outcome of Hypothesis 2.

Hypothesis 2 stated that model would not interact with treatment. F-values were significant for five of the 15 evaluative criteria: waist circumference, front waist placement, back waist placement, back crotch length, and horizontal grain. Significant interaction was important only when it overlapped with significant treatment main effect, at which time the interaction affected the acceptance or rejection of Hypothesis 1.

Examination of the treatment by model means showed that Hypothesis 1 was not rejected for the back crotch length criterion because the preference for treatment was dependent upon model. However, Hypothesis 1 was rejected for the horizontal grain criterion. This means that there was no overall preference for either method for the back crotch length; the Unit Method was preferred for one model, the Experimental Method was preferred for two models, and both methods provided equally good fit for two models. The Experimental Method, however, was preferred on the horizontal grain criterion.

The same interdependent relationship existed between Hypothesis 3 and 4. Hypothesis 3, which stated that there
was no difference between the diagnostic ratings given to pants produced by each method of alteration, was rejected for seven of the 20 diagnostic criteria: front waist placement, back waist placement, front waist dart length, front waist dart size, back crotch length, back crotch curve, and horizontal grain angle. However, Hypothesis 4, which stated that model would not interact with treatment, was significant for six of the diagnostic criteria: full hip circumference, back waist placement, back crotch length, upper side-seam slope, lower side-seam slope, and horizontal grain angle.

Examination of the treatment by model means showed that Hypothesis 3 was not rejected for the back waist placement, the front dart length, or the back crotch length. This means that there was a clear preference for the Experimental Method in the front waist placement, front waist dart size, back crotch curve, and the horizontal grain criteria. No overall preference of method was given for the back waist placement, the front dart length, or the back crotch length.

The models' comparisons of the fit achieved by each method focused primarily on the fit of the crotch, the waist circumference, and the hip circumference. Four of the five models preferred the fit of the pant constructed from
the Experimental Method pattern; one (Model 32) preferred the fit of the pant constructed from the Unit Method pattern.

It should be noted that some of the significant $F$-values could be a result of chance, since only five models (one of each body type) were used in this study.
CHAPTER 5. RECOMMENDATIONS

The Experimental Method developed in this research used information obtained from mathematically analyzing the body in order to alter basic pant patterns to fit five specific body types. The fit produced by the Experimental Method was then statistically compared to the fit produced by the Unit Method of alteration, and the results were discussed in the preceding chapter.

Recommendations based upon these findings fall into three major categories: recommendations for changes in the evaluation procedure, recommendations for changes in the alteration procedure, and recommendations for further study. Each category will be discussed in the following sections.

Recommendations for Changes in the Evaluation Procedure

Observation of the judge training session and the analysis of the judges' evaluations pointed toward two problems in the evaluation procedure: difficulty with the scale and difficulty with the criteria for good fit. Following are suggestions for possible solutions to these problems.
Recommendations for rating scale

All three judges expressed difficulty in understanding the midpoint of the evaluative scale. The descriptor used was "neither bad nor good." The judges all believed that no such point exists in the evaluation of the fit of a garment, that fit is always either bad or good in varying degrees.

Because of the difficulty in comprehending the descriptor, I recommend that the midpoint of the scale should be defined as "unsure," meaning that the judge is unsure whether the fit is bad or good. Therefore, the closer the rating is to the endpoints of the scale, the more sure that respondent is that the fit is either bad or good; the closer the rating is to 50, the more unsure the respondent is that the fit is either bad or good.

A second problem with the scale was detected in the analysis of the data. Missing data (failure to respond to a scale) was encountered four times in the analysis. One possible reason for this oversight was that the criteria were listed in pair form (i.e., front crotch length, back crotch length) instead of in units (i.e., all front criteria first, all back criteria second).

The recommended solution to this problem is to rearrange the criteria so that all front ratings would be listed
first, all back ratings would be listed second, and all side ratings would be listed third. This order would avoid constant turning of pages, and should decrease the possibility of response failure.

**Recommendations for criteria of good fit**

Analysis of the judges' responses showed that the judges did not follow the criteria for good fit read aloud in the initial instructions to the judges for at least one criterion: front dart length. This suggests that a more effective means of describing good fit is needed.

I hypothesize that the best solution would be to construct a basic pant muslin that incorporates all the criteria for good fit for a sportswear form. This muslin would then be put on the form, and used to illustrate each criterion discussed in the initial instructions to the judges. The muslin example would be left within sight during the evaluation process so that the judges could refer to it throughout the evaluation. This does not, however, guarantee that the judges will make use of the aid.

One alternative solution considered was to give the judges separate sheets of written and/or drawn examples of good and bad fit. However, the amount of paper involved
would be cumbersome, and I believe that the judges would not bother searching for any of the criteria.

A second alternative, similar to the first, would be to incorporate drawings of good and bad fit in the margins of the scale. Therefore the visuals would be adjacent to the criteria, and the judges would be more likely to use the aids. However, the main drawback in this solution is that drawings alone are an inadequate way to describe the fit of the garment on a three-dimensional body. A three-dimensional example of standard fit would have more visual meaning for the judges, and therefore, I believe that the muslin example offers the best solution.

Recommendations for Changes in the Alteration Procedure

Recommendations for changes in the alteration procedure are based on my evaluation of the muslins. Each model was asked to return at a date following the evaluation for a final fitting of her Experimental Method pant muslin. Three specific alterations were needed across all models: an increase in the circumference ease, an increase in the length of the back darts, and a repositioning of the front crotch curve.
Recommendations for circumference ease

The hip circumference ease used in this research was 3.8 cm. This resulted in a pant muslin that fit very snugly through the full hip, upper hip, and the waist. Because in the Experimental Method the ease in the upper hip and the waist is a result of the ease used in the full hip, I recommend that 5 cm of ease be used in the full hip area. This will provide more room for expansion of the hips and the abdomen when the model is seated.

Recommendations for back dart length

Back dart length was calculated as 3.8 cm above the fullest part of the derriere. This resulted in a dart that was approximately 1.3 - 1.8 cm too short. Therefore, I recommend that the back dart length should extend to within 1.8 cm of the fullest part of the derriere.

Recommendations for front crotch curve

For all models, there was excess fabric in the front crotch area. This fabric produced a vertical fold in the front crotch, and was not detected by any of the judges. The judges' failure to notice this problem was probably because no judge approached or touched any of the models.
In the final fitting process, I found that the crotch curve calculated by the computer program could be used if it was repositioned so that the curve was deeper. This was accomplished by pivoting the front crotch curve at the full hipline so that the center front seam was on straight grain. This repositioning removes the excess fabric in the front crotch area, and also decreases the thigh circumference of the pant (because the crotch point is shifted toward the center of the leg). However, this also destroys the fitting bias that had been incorporated into the front seam. More work must be done with larger numbers of models before determining whether repositioning of the curve provides an adequate solution. I suspect, however, that additional work in the development of the front crotch is necessary.

Recommendations for Further Study

Although several attempts have been made to quantify the body for the purpose of pattern alteration, this pilot study is the first attempt to analyze the body mathematically with the aid of somatographs and computer facilities. The fit of the pants produced by the Experimental Method was evaluated as equal to or better than the fit produced by the Unit Method by the three judges. Therefore, I strongly
believe that further work with the Experimental Method of alteration is necessary and desirable.

The Experimental Method used in this study could be further developed to construct complete sets of basic patterns for any individual figure. However, before this goal is reached, I recommend that the following studies be completed:

1. Use the existing Experimental Method of alteration for pants on a larger sample of women. For this study, the researcher should do all of the computing and pattern alteration so that he/she can maintain control over the alteration procedure. Therefore, he/she can evaluate the fit and make any necessary modifications in the method.

2. Devise a set of directions for the Experimental Method that could be used in a classroom situation. The interactive program used in this research was designed to be used in a classroom, so the directions would need to focus specifically on teaching the process of measuring body angles, developing seam lines, and altering the basic pant pattern.

3. Develop a computer program that constructs the actual seam lines of the pant pattern on a flatbed plotter. This program would need to include information on the characteristics of basic pant patterns for each of the standard sizes.

4. Adapt the Experimental Method so that it could be used for the alteration of basic bodices for any individual figure. The computer programs used in this research are designed so that they could be used to approximate the seamlines of a basic bodice. Only the alteration procedure would need to be developed.

5. Use the Experimental Method of alteration to alter pant and shirt patterns for men. The method of alteration should be similar to the techniques used on women, however, differences in body structure and standards of fit should provide an interesting challenge.
CHAPTER 6. SUMMARY

The goal of this research was to develop a method of pants pattern alteration that incorporates body measurements, graphing techniques, and measurements of body angles. Profile and back-view somatographs were taken for 36 female volunteers and models were chosen to represent five different figure types (one model per figure type). The figure types used in this study were round, pear-shaped, average, weight in front, and weight in back.

Two computer programs were developed to analyze and plot representations of each of the figure types. Two basic pant patterns were then altered for each model; one by the Unit Method and one by the Experimental Method. The Unit Method used measurements of body length and circumference as a basis for the alteration procedure; the Experimental Method used measurements of body circumference, body angles, and body proportions as a basis for developing seams and waist darts.
Two rating scales were developed to analyze the fit of the pant muslins. The first scale was an evaluative scale, and was used to determine if the fit was bad or good. The second scale was a diagnostic scale, and was used to qualify the ratings given on the evaluative scale. Three judges were trained to use these rating scales to evaluate the fit of the ten first-fit pant muslins (two muslins per model).

The judges' responses were analyzed by a three-way analysis of variance and by examination of the means. Examination of the means showed that the Experimental Method was preferred for the following criteria: front waist placement, front waist dart size, back crotch curve, and the horizontal grain. For all other criteria, the fit produced by the two methods was the same.

Recommendations given in the preceding chapter include recommendations for changes in the evaluation procedure, changes in the alteration procedure, and recommendations for further study.
LITERATURE CITED


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REFERENCE NOTES

1. **Fitting pants.** TC 490Y handout found in teacher file. Available through Textiles and Clothing department Iowa State University. 1972.


ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. Jane Farrell, Dr. Geitel Winakor, Dr. Alyce Fanslow, and Mrs. Phyllis Brackelsberg for their encouragement and guidance throughout this research project. Special thanks is given to Dr. Farrell for her help in the organization and writing of this thesis; to Mrs. Brackelsberg for her guidance in the somatographic method and for her feedback during the developmental stages; to Dr. Fanslow, Dr. Winakor, and Dr. Leroy Wolins for their help in the design, analysis, and evaluation of the statistical data; and to the 36 volunteers, especially the five who became the participants in the final part of this study. Thanks is also offered to Dr. Ruth Deacon, Dean of the College of Home Economics at Iowa State University, for the financial assistance provided through the Home Economics Gift Fund; and to Dr. Agatha Huepenbecker, Head of the Textiles and Clothing department, for the funding received for the development of the computer programs and the statistical analysis.
My most sincere thanks are extended to a patient and loving husband who provided exhaustive help in the program development, and without whose encouragement and understanding I could not have completed this study.
APPENDIX A: GLOSSARY OF TERMS
crotch point - the point that is the intersection of the midpoint of the thigh (profile view) and the dowel rod.

derriere point - the point that has the same x-value as the point where the curve of the back thigh muscle begins and the visible part of the derriere ends, and the same y-value as the level of the dowel rod.

determinant - a numerical value assigned to a square matrix.

ectomorph - characterized by a lean body structure as developed from the ectodermal layer of the embryo, associated with a predominance of the nervous system.

endomorph - characterized by a heavy or fatty body structure as developed from the endodermal layer of the embryo, associated with a predominance of the digestive system.

infinitessimal - denotes a quantity conceived as continually diminishing to zero as a limit.

integrate - to find the value of by summing an infinite number of small parts of a whole.

interactive program - one in which the computer is executing the program simultaneously with the user supplying the necessary information.

interpolate - to compute intermediate values in a series.

leg point - the point of the silhouette where the curve of the front thigh muscle begins and the visible part of the trunk ends.

mesomorph - characterized by a sturdy body structure as developed from the mesodermal layer of the embryo, associated with a predominance of the skeletal and muscular system.

polynomial - a mathematical function of the form
\[ y = a_1 x^n + a_2 x^{n-1} + \ldots + a_n x + a_{n+1} \]

quadratic - pertaining to or designating an equation, curve surface, etc., of the second degree.

upper back hip - in the profile-view somatograph, the part of the hip that is above the widest point of the derriere and below the waist point.
waist point - the narrowest part of the trunk in both the profile and the back-view somatograph, at the waist position.
APPENDIX B: SOMATOGRAPHS OF THE FIVE MODELS
Figure 34: Model 8, weight in back figure type
Figure 37: Model 27, weight in front figure type
Figure 38: Model 32, round figure type
APPENDIX C: BODY MEASUREMENT CHART
<table>
<thead>
<tr>
<th>Model ____</th>
<th>Size ____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern Body Ease Amount Alteration Needed + or -</td>
<td></td>
</tr>
</tbody>
</table>

Waist

Hip
7.6 cm (3") down
17.8 cm (7") down

Fullest depth at left side

Crotch depth
Pattern back
Measurement from chair
Measurement from somatograph

Crotch length

Thigh
Fullest depth at left side

Knee level

Outseam

Inseam
APPENDIX D: BODY ANGLE MEASUREMENT CHART
<table>
<thead>
<tr>
<th>(1) Body deg.</th>
<th>(2) Body length</th>
<th>(3) Pattern deg.</th>
<th>(4) Pattern length</th>
<th>Calculated length (use column 2)</th>
</tr>
</thead>
</table>

Front waist
  degrees after length change

Back waist
  degrees after length change

Left sideseam

Right sideseam

Distance of knee midpoint to plumbline (profile view)
  forward
  back
APPENDIX E: PATTERN MEASUREMENT COMPARISON CHART
<table>
<thead>
<tr>
<th>(1) Body + ease</th>
<th>(2) Unit Method Pattern</th>
<th>(3) Diff. (2-1)</th>
<th>(4) Experimental Method Pattern</th>
<th>(5) Diff. (4-1)</th>
</tr>
</thead>
</table>

Waist

Hip
- 7.6 cm down
- 17.8 cm down
- Fullest

Crotch depth

Crotch length
- Front
- Back

Thigh
- Fullest
APPENDIX F: COVER SHEET FOR RATING SCALE
Judge Evaluation Scale for Fit of Pants Muslins

Please evaluate the fit of Pant ___ by responding to the following 99-point scale.

A rating of 1 indicates that the fit is very bad, and cannot be corrected within the 5/8" allowances of the pant.

A rating of 50 indicates that the fit is neither particularly good nor bad.

A rating of 99 indicates that the fit is very good or the best possible fit that can be achieved in muslin.

Any rating between 51 and 99 indicates that the fit is more good than bad. The closer to 51, the more unsure you are that the fit is good, and the closer to 99, the more sure you are of the goodness of fit. For example,

<table>
<thead>
<tr>
<th>1 10 20 30 40 50 60 70 80 90 99</th>
</tr>
</thead>
<tbody>
<tr>
<td>neither bad</td>
</tr>
<tr>
<td>nor good</td>
</tr>
<tr>
<td>good</td>
</tr>
</tbody>
</table>

A second scale evaluates more specific aspects of fit. This 99-point scale evaluates the fit in terms of too little, the correct amount, or too much.

A rating of 1 indicates that the amount of ease, length, etc., is too little or too short.

A rating of 50 indicates that the amount of ease, length, etc., is correct.

A rating of 99 indicates that the amount of ease, length, etc., is too much or too long.
Any rating between 1 and 49 indicates that the fit is bad because the amount of ease or the length is either too little or too short. The closer to 1, the more sure you are that the amount is too little or short, and the closer to 49, the more acceptable the length or amount of ease.

Any rating between 51 and 99 indicates that the fit is bad because the amount of ease or the length is either too much or too long. The closer to 51, the more acceptable the length or amount of ease, and the closer to 99, the more sure you are that the amount is too much or too long.

<table>
<thead>
<tr>
<th></th>
<th>bad</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
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<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>99</th>
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</thead>
<tbody>
<tr>
<td>nor</td>
<td>good</td>
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Any number between 1 and 99 may be used on the two types of rating scales. Numbers do not necessarily have to end in 0.
APPENDIX G: FINAL RATING SCALE
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<td>correct</td>
<td>too</td>
</tr>
<tr>
<td></td>
<td>tight</td>
<td>amount</td>
<td>loose</td>
</tr>
<tr>
<td></td>
<td>1 10 20 30</td>
<td>40 50 60 70</td>
<td>80 90 99</td>
</tr>
<tr>
<td>High hip circumference</td>
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<td>correct</td>
<td>too</td>
</tr>
<tr>
<td></td>
<td>tight</td>
<td>amount</td>
<td>loose</td>
</tr>
<tr>
<td></td>
<td>1 10 20 30</td>
<td>40 50 60 70</td>
<td>80 90 99</td>
</tr>
<tr>
<td>Full hip circumference</td>
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<td>40 50 60 70</td>
<td>80 90 99</td>
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<td></td>
<td>too</td>
<td>correct</td>
<td>too</td>
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<tr>
<td></td>
<td>tight</td>
<td>amount</td>
<td>loose</td>
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<tr>
<td></td>
<td>1 10 20 30</td>
<td>40 50 60 70</td>
<td>80 90 99</td>
</tr>
<tr>
<td>Front waist placement</td>
<td>1 10 20 30</td>
<td>40 50 60 70</td>
<td>80 90 99</td>
</tr>
<tr>
<td>1&quot; too low</td>
<td>correct</td>
<td>placement</td>
<td>1&quot; too high</td>
</tr>
<tr>
<td>1 10 20 30</td>
<td>40 50 60 70</td>
<td>80 90 99</td>
<td></td>
</tr>
<tr>
<td>Back waist placement</td>
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<td>placement</td>
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<tr>
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<td>Description</td>
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<td>correct length</td>
<td>1&quot; too long 99</td>
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<td>points to fullness</td>
<td>too close SS 99</td>
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<td>correct size</td>
<td>too large 99</td>
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<td>1&quot; too long 99</td>
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<td>points to fullness</td>
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### Front crotch curve

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<td>Neither bad nor good</td>
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### Back crotch curve

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<td>Bad</td>
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### Upper sideseams (above hipline)

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<tr>
<td>Too flat</td>
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### Lower sideseams (below hipline)

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<tbody>
<tr>
<td>Leans/ slopes to front</td>
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<tr>
<td>Leans/ slopes to back</td>
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<td>Vertical grain</td>
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<tr>
<td>bad</td>
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<td>nor</td>
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<td>down at</td>
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APPENDIX H: FIRST-FIT MUSLIMS
Figure 39: First-fit muslins constructed for Model 8
Figure 41: First-fit muslins constructed for Model 12
Figure 42: First-fit muslins constructed for Model 27

Unit Method

Experimental Method
Figure 43: First-fit muslins constructed for Model 32
APPENDIX I: INSTRUCTIONS TO JUDGES
INSTRUCTIONS TO THE JUDGES

Please begin by reading the cover sheet of the evaluation scale.

(After reading.) Note the two different types of scales. In the first type of scale, you are deciding whether the fit is bad, good, or neither bad nor good. The second type of scale qualifies your first rating by determining why the fit is bad, good, or neither bad nor good. In the first type of scale, a rating of 50 indicates a neutral sentiment. In the second type of scale, a rating of 50 indicates the best possible fit.

You may use any whole number between and including 1 and 99.

During the judging process, the models will stand so that you may see the front, back, and sideseam views. You are allowed to touch the models if you desire. When you have finished the rating of the standing model, the model will sit in a chair for any further evaluation.

Now please turn to Page 2 of the evaluation form. Waist circumference refers to the circumference of the waistband. High hip is located at approximately 3" below
the waistband, and full hip is marked by a horizontal grain line drawn with black marker. Waist placement refers to the placement of the waistband. Ideal waist placement is at the narrowest part of the body and parallel to the floor.

Now please turn to Page 3, and look at the third scale under "Front waist darts." On the right side of the scale, you will see "SS," which is an abbreviation for sideseam. Next, look at the section on crotch length. A perfect crotch seam conforms to the body with 1" total ease. If the crotch seam is too short, the pant will wrinkle or bind. If the crotch seam is too long, the pant will bag in the crotch.

Now look at the crotch curve section of Page 4. If the crotch curve is too shallow, vertical folds will result at the crotch. If the crotch curve is too deep, the seam will not conform to the body and will appear to bag or sag.

Now please refer to the sideseam section on Page 4. The perfect sideseam conforms to the upper hip curve, divides the profile in half, at the waist, hip, and ankle, and is perpendicular to the waist and the floor. The sideseam should, however, conform to the posture of the individual or the slant of their leg. Look at the second scale under "Upper sideseam." "Forward on body" and "Back on
"Body" are referring to the location of the seam on the body relative to the midpoint of the profile. Also in this section, "Leans/slopes" pertains to the waist end of the seam, and refers to whether the sideseam is relatively perpendicular to the waist or floor, or whether it deviates markedly from perpendicular.

Horizontal grain is marked at the full hipline, and vertical grain is marked by a line drawn on the lower leg.

Length of pant will not be evaluated.

Ease allowances are given to you on a separate note card so that you may refer to them during the judging process.

You will be presented with two practice models. You will first evaluate Model G02A. Record the number at the top of the first page. After evaluation, we will compare ratings, and discuss any differences. You will then be presented with a second model to evaluate, and again we will compare and discuss until you are all rating in the same way. We will then begin the final judging process.

If you have any additional comments about the fit of the pants, write them on the last page of the evaluation form.
If you have any questions, please ask them before the final judging process begins. No questions will be answered during the final judging.
APPENDIX J: EVALUATIVE SCATTER PLOTS
Figure 44: Waist circumference, bad/good

Figure 45: High hip circumference, bad/good
Figure 46: Full hip circumference, bad/good

Figure 47: Front waist placement, bad/good
Figure 48: Back waist placement, bad/good

Figure 49: Front waist darts, bad/good
Figure 50: Back waist darts, bad/good

Figure 51: Front crotch length, bad/good
Figure 52: Back crotch length, bad/good

Figure 53: Front crotch curve, bad/good
Figure 54: Back crotch curve, bad/good

Figure 55: Upper sideseam, bad/good
Figure 56: Lower sideseam, bad/good

Figure 57: Vertical grain, bad/good
Figure 58: Horizontal grain, bad/good
APPENDIX K: DIAGNOSTIC SCATTER PLOTS
Figure 59: Waist circumference, tight/loose

Figure 60: High hip circumference, tight/loose
Figure 61: Full hip circumference, tight/loose

Figure 62: Front waist placement, low/high
Figure 63: Back waist placement, low/high

Figure 64: Front waist darts, short/long
Figure 65: Front waist darts, CF/SS

Figure 66: Front waist darts, small/large
Figure 67: Back waist darts, short/long

Figure 68: Back waist darts, CB/SS
Figure 69: Back waist darts, small/large

Figure 70: Front crotch length, short/long
Figure 71: Back crotch length, short/long

Figure 72: Front crotch curve, shallow/deep
Figure 73: Back crotch curve, shallow/deep

Figure 74: Upper sideseam, forward/back
Figure 75: Upper sideseam curve, flat/full

Figure 76: Upper sideseam slope, forward/back
Figure 77: Lower sideseam slope, forward/back

Figure 78: Horizontal grain angle, down/up