

THE PERFORMANCE THROUGH FIFTEEN WEAR/LAUNDERING PERIODS OF  
ALL COTTON AND COTTON-POLYESTER BLENDS  
IN WOMEN'S TENNIS APPAREL

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## CHAPTER I

### INTRODUCTION

According to buyers recently surveyed by the Celenese Corporation, 65 percent of them believed there would be an increase in the purchase level of tennis and other racket sportswear in the spring of 1982, and 57 percent stated there will be another increase in the fall of 1982.(9) Figures like these confirm the fact that this particular category of apparel in the active sportswear area is growing substantially, and there seems to be no end to this growth in the near future.

The rise in tennis apparel usage is important to both manufacturers of tennis apparel and retailers who market tennis wear. The National Sporting Goods Association reported that there were \$282 million spent on tennis in 1973, and predicted that in 1978 that figure would have risen to \$6 billion.(9) These figures, representing phenomenal increases, include rackets, balls, shoes, clothes, instructions, camps, courts, and construction.(9) With this amount of money being spent for tennis equipment and apparel manufacturers of tennis apparel are continually participating in market research to find out exactly what consumers are looking for and then trying to supply

it for them.

In the market today one can find a variety of tennis apparel which ranges from dresses to a set consisting of a pair of shorts and a top, in colors which range from being very bright and bold to pastels and finally to white. The variety in colored tennis apparel was not always available to the consumer and in particular to the female tennis player.

When women started to get seriously involved with the playing of tennis they were faced with the fact that they did not have a specific costume to wear while playing the game. In 1874, Mary Ewing Outerbridge (who is considered by many to be the "mother" of American tennis) (4), appeared on the tennis court wearing an outfit described as, "A dress down to the bottom of her high button shoes, a corset, large brim hat, and a half dozen slips".(4) This outfit was similar to the clothing which was being worn by women for everyday wear at that time.

The costume remained the acceptable attire for women who were playing tennis until the 1920's, when a French woman by the name of Suzanne Lenglen initiated a change in womens tennis apparel. She appeared at Wimbledon in the early twenties in a one-piece, sleeveless dress, cut low at the neck with a skirt rising to mid-calf.(4) Even



though this was a significant change, women were still trying to play tennis in outfits that were not suited for that type of activity. The length was still too long and the outfit was still bulky with extra material which made playing the game difficult if not impossible.

In the late 1930's and early 1940's tennis outfits worn by most women consisted of baggy blouses which were paired with either loose skirts or culottes.(4) In 1949, on the courts at Wimbledon, Gussie Moran wore a costume which had been designed by Ted Tingling, an English designer.(10) The outfit consisted of a sleeveless short dress with the hem falling at about mid-thigh. Because this dress was shorter than the traditional tennis outfit of the time, Miss Moran had to wear panties underneath her dress, which were designed to match her outfit. Since no color was allowed in tennis apparel at Wimbledon, Mr. Tingling added the now famous white lace to Miss Moran's panties.(10) The reason for the lace trimming was to add a little decoration to the otherwise dull outfit.

Most professional tournaments at the time allowed no color to be used on the tennis clothes worn by participants whether male or female. Consequently the clothes worn by contestants were for the most part dull and unappealing.

Through the 1950's and 1960's tennis apparel changed in design and fabric. Skirts could be found as wrap arounds, flared, pleated, or split. Tops could be sleeveless, capped or short sleeves, having collars or no collar at all, V-necked, or having a scooped neck. Nylon, polyester, and acrylic are just a few of the fibers which were introduced into tennis apparel at this time.

White was the only color found in tennis apparel up to this time and for years to come. A restriction at the majority of tennis clubs and tournaments stated that no one with colored tennis wear would be allowed to participate in a match. Color was seen only in the warm-up sweater which was worn over the tennis clothes and off the court.  
(10)

In 1971, Evonne Goolagang appeared in a tennis match wearing an outfit which had colored trim on it.(10) This was the beginning of acceptance of color in tennis wear. In July of that same year, pastel colors were officially accepted as permissible during competition for the first time in international tennis history at Forest Hills, N.Y.(10)

Since that time colors in tennis apparel have become popular with many tennis players whether it be in a solid color, stripes, or a geometric design. A majority of

today's tennis clothes will have a touch of color somewhere. Today the white tennis outfit is just as popular if not more so, than a colored one. Many players prefer white to color, as they find it looks bright and clean and they feel cooler while wearing it.(10)

Today a tennis costume may be a one-piece dress, shorts and a top, or a top and skirt. Most consumers prefer to mix-and-match when choosing tennis apparel today.

Amdur(3) stated that women are one of the main reasons why tennis popularity is expanding at such a fast rate, as more women are discovering the game at an earlier age. The availability of expanded collegiate physical education programs for women and public facilities are helping to bring more women into tennis.(3) With the number of tennis players, plus the fact that women are getting more involved than ever before, manufacturers of tennis apparel are keeping a close watch of the market trends of the purchaser of tennis apparel.

The appearance of a tennis outfit on today's player has come a long way since Mary Ewing Outerbridge walked out on the tennis court in her street-length dress in 1874.(4) The consumer has a seemingly endless supply of tennis apparel from which to choose.

### Statement of Purpose

The purpose of this study was to evaluate the wear life performance of two types of tennis apparel. One type consisted of a polyester-cotton (50/50) blend and the other was 100 percent cotton.

### Objectives

This study was designed to determine how certain fabric types perform under specific active wearing and normal laundering procedures. The apparel was purchased from local retail stores and funded by the Natural Fibers and Food Protein Commission of Texas.

Specific objectives for the study were:

- 1) To subject the tennis clothes to 15 periods of wear, of two hours each, during physical activity outside, and laundering at a temperature of  $105^{\circ}\pm 5^{\circ}\text{F}$ .
- 2) To evaluate the performance of the tennis outfits at various intervals during the wearing and laundering periods with reference to:
  - a. durable press appearance
  - b. dimensional stability
  - c. color change
  - d. pilling
- 3) To determine the bursting strength initially and at the end of the study
- 4) To conduct an evaluation by the wearers of the tennis apparel by means of a questionnaire, at the end of the study.

### Justification for Study

In 1978, it was estimated that there were 27 million tennis players in the United States.(3) This figure includes professional players as well as players who play a match or two on the weekends. Tennis, a year-round sport, can be played indoors or outdoors, consequently the market for tennis goods is rising rapidly. Tennis apparel is not restricted to the courts as many people find tennis clothes comfortable to wear while working in the yard, bicycling, or working around the house.

The results of this study hopefully determined how tennis apparel made from all cotton and a cotton-polyester blend reacted to repeated outdoor physical activity and laundering. The players were asked to evaluate the performance and comfort of the specific tennis outfit.

### Assumptions

In conducting this study the following assumptions were made:

- 1) That the participants selected for the wear panel would be dependable subjects
- 2) An outfit would be worn by the participants a minimum of one two-hour period between launderings
- 3) The outfit would be worn while the participant is actively involved in playing tennis outside.

### Delimitations

This study was limited in the following manner:

- 1) The 16 tennis outfits; one outfit being 100 percent cotton the other being a polyester-cotton (50/50) blend
- 2) Eight Texas Woman's University female students who were on the Denton campus during summer sessions I and II, 1982
- 3) The 15 wear/laundrying periods for each outfit.

## CHAPTER II

### REVIEW OF LITERATURE

Although tennis is a popular sport there has been very little research done in the area of tennis apparel. Research which has been done in this area deals mainly with comfort and design not how the different fibers perform under laboratory tests.

Porter(8) in her study on tennis costumes which she conducted at Florida State University found in the section on fiber content and fabric construction that 42 percent of the men surveyed preferred 100 percent cotton, 26 percent preferred 100 percent polyester, and 16 percent preferred a 50/50 cotton-polyester blend in their shorts. For their shirts, 60 percent wanted all cotton and 14 percent chose the 65/35 polyester-cotton blend. From these figures we can see that in both the shorts and the shirts the men surveyed preferred cotton to polyester.

Porter(8) also surveyed women in this same study. With regard to tennis dresses, 38 percent stated that they preferred 100 percent polyester, 24 percent liked 100 percent cotton and 22 percent wanted a blend of 65/35 polyester-cotton. Regarding blouse choices, almost half of

the women preferred 100 percent cotton with the polyester-cotton blends second. Finally, in women's shorts again cotton was preferred by almost a third of the group. The cotton-polyester blends were preferred by 55 percent of the women and 20 percent wanted 100 percent polyester. Almost all of the areas surveyed in the study showed a high preference for all cotton tennis apparel. Only in the section of tennis dresses for women was all polyester preferred over cotton.

In relation to comfort of tennis apparel, Gold(5) stated that active sportswear must withstand greater stress than normal outerwear, thus quality is an important selling point in tennis apparel. Porter(8) found that women were not happy with the styles available in the retail stores. They wanted tennis costumes which have features such as V-shaped necklines, sleeveless blouses, and pockets. Manufacturers are not supplying these design features for the consumer.(8)

Research in the area of comfort and performance in tennis clothing is needed. With the variety of fabrics and styles being used today in the manufacturing of tennis apparel it is important to try and determine how the consumer can best be satisfied.

With the interest in tennis apparel being relatively



new, information concerning research is difficult to locate. Further research concerning tennis apparel may be cited as the study progresses.

### CHAPTER III

#### PLAN OF PROCEDURE

The following is a description of the procedure which was used to study the wear life performance of two types of tennis costumes - one consisting of a 50/50 polyester-cotton blend and the other being made from 100 percent cotton. Both fiber categories were represented in tennis shorts and tops.

#### Tennis Apparel

Sixteen tennis costumes, used as experimental outfits for the study, were purchased from local retail stores. Garment sizes were selected according to the size requirements of the women selected to participate in the study.

The apparel was divided into two groups according to fiber content. Group I consisted of eight each of all-cotton tennis shorts and tops. Group II consisted of equal items in a blend of 50/50 polyester-cotton. Both groups contained items of bright colors and all white.

#### Wear Panel

Participants of this study included eight female students who were attending summer school at Texas Woman's

University. Each student was issued two tennis costumes having one from each group. Each outfit was worn for a minimum of two hours during physical activity outside, and picked up daily. The tennis costumes were laundered and evaluated (at specified intervals) before returning to the participants. The procedure continued until all tennis outfits had been subjected to 15 wear/laundrying periods.

#### Laundrying Procedures

The laundrying method was that recommended in washing condition of AATCC Test Method 124-1975, Method II.

Four pounds constituted each washing load, with the use of 90 grams of AATCC laundry detergent. The tennis costumes were removed immediately after completion of the washing cycle and transferred to the dryer. Tumble drying was done according to AATCC Test Method 124-1975, with four-pound loads constituting each drying load. After the drying period the tennis apparel was removed and marked before returning them to the participants.

#### Equipment

Washing was done in a domestic Whirlpool (model LHA-7800) washer. The design of this machine includes three wash cycles. The regular-heavy setting was used for a twelve-minute cycle. The rinsing system includes a power

spray and an agitated deep rinse. Drying was done in a Whirlpool (model LHE-9800) automatic dryer, set on knits-gentle for 25 minutes.

### Evaluation Procedure

Throughout the study the tennis apparel was evaluated with regard to wash-and-wear performance and physical properties. Table 1 gives the type of evaluation, test method, and frequency of evaluation.

TABLE 1  
PERFORMANCE EVALUATION

Type of Evaluation	Test	Frequency of Evaluation *
Durable Press Appearance	AATCC 124-1975	5, 10, 15
Dimensional Stability	ASTM D-1905	1, 5, 10, 15
Bursting	CCC-T-191A	0, 15
Pilling Resistance	ASTM-1375-67	0, 15
Color Evaluation Whiteness Retention	Color Differ- ence meter D25D3	0, 5, 10, 15
Participant Evaluation of Tennis Costume Perfor- mance		15

\*Wear/Laundering Period

Values for durable press appearance were assigned to the tennis outfits after 5, 10, and 15 wear/laundrying periods, using AATCC 124-1975, test method. A panel of

three trained observers evaluated the tennis wear on the back areas of the tops and shorts. Shrinkage values were taken from shrinkage squares which had been hand-stitched inside the garments previous to the issuing of the garments to the participants. Three-inch squares were placed on the lower left front of the tops and the left back of the shorts (See Fig. 1). A total of four measurements was taken, two in the warp direction and two in the filling direction on the tops and shorts, according to ASTM D-1905-73 after 1, 5, 10, and 15 wear/laundrying periods.

The fabrics used in the tennis wear were evaluated with regard to bursting strength by means of a Scott Tester Model DH2, with ball burst attachment initially and following the 15th wear/laundrying period. According to Federal Test Method CCC-T-191A, four specimens were tested from each piece of apparel. These specimens were taken from designated positions on the garments as shown in Fig. 1.

Whiteness readings were taken on the white control garments and on the worn garments initially and after 10 and 15 wear/laundrying periods by means of a Color Difference Meter D25D3. The direct whiteness reading function was used to automatically display the whiteness value using the following formula:

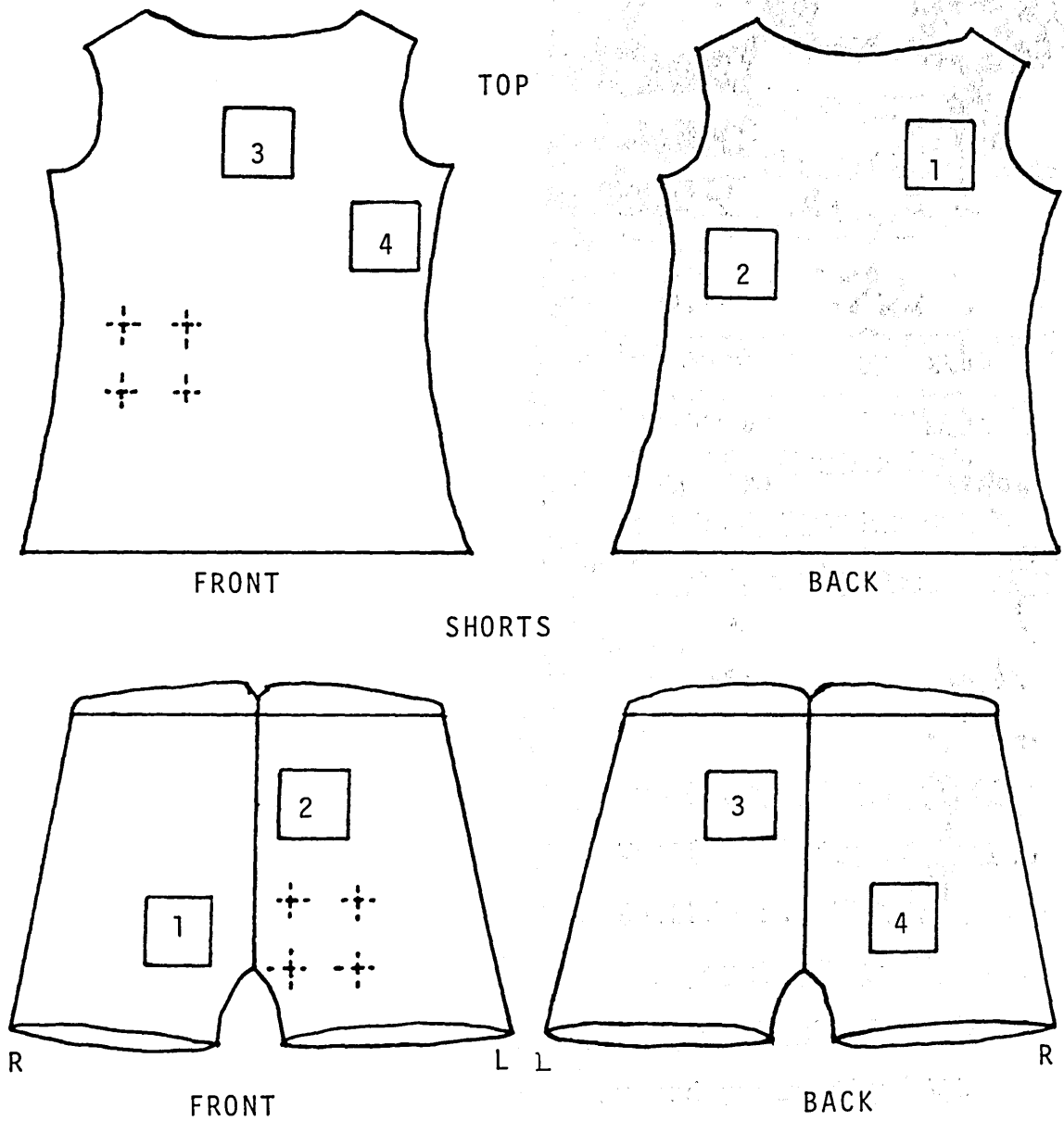


FIGURE 1. Shrinkage Square Placements and Cutting Diagram for Bursting Strength Specimens

$$W = 4B - 3G$$

Where W = Whiteness, B = blue reflectance, G = green reflectance. This calculation is in accordance with AATCC Test Method 110-1975. Readings were taken using four thicknesses of the fabric.

Color differences in the tennis apparel were analyzed by comparing initial readings with readings following 5, 10, and 15 wear/laundrying periods. The Hunter Lab Color Difference Meter D25D3 was used to determine color values. The following formula was used to calculate Delta E for color difference determinations:

$$E = \sqrt{(\Delta L)^2 + (\Delta A)^2 + (\Delta B)^2}$$

The tennis wear was evaluated with regard to pilling resistance by means of the Random Tumble Pilling Tester as specified in ASTM Designation: D-1375-67. Three specimens were taken from each garment. A panel of two trained observers evaluated the specimens under a Macbeth Spectralight cabinet for pilling initially and after the 15th wear/laundrying period.

The overall performance of the tennis apparel was evaluated by the participants. The tennis apparel was rated for performance and appearance after 15 wear/laundrying periods. The following scale was used to rate

the garments:

5. Excellent
4. Very good
3. Good
2. Fair
1. Poor

All physical testing was done under controlled conditions according to ASTM D: D-1776-67 with a temperature of  $70^{\circ}\pm 2^{\circ}\text{F}$ . and relative humidity of  $67\%\pm 2\%$ . Specimens were conditioned a minimum of four hours prior to testing.

#### Analysis of Data

The mean and standard deviation were calculated for each garment for bursting, shrinkage, pilling resistance, durable press appearance, and color difference at selected intervals. One-way and two-way analysis of variance was used to determine if significant differences exist between the two fabric types. The Q-statistic Multiple Comparison Test was used at the 0.05 percent significance level to see if significant differences exist between the various tennis costumes with regard to property and wear/laundrying period. The participants' evaluation of the apparel at the end of the wearings was calculated as frequency and percentage.



## CHAPTER IV

### PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

This study dealt with the evaluation of the wear life performance of 16 tennis outfits (shorts and tops) of two fabric types, one composed of all cotton and the other a 50 percent cotton/50 percent polyester blend. Two outfits were assigned to each of eight women who wore the garments 15 times for a 2½-hour period during which they participated in an outside physical activity. The outfits were purchased from local retail stores. Funding for the study was provided by the Natural Fibers and Food Protein Commission of Texas. Parameters important to the consumer were evaluated at intervals throughout the study.

The data which resulted from the evaluations of the performance of the tennis outfits are summarized in Tables 1-11, and Figures 2-7. The data are representative of the durable press appearance, pilling, shrinkage, color change, and whiteness retention after specified wear/laundrying intervals and of bursting strength initially and after 15 wear/laundrying periods. An evaluation by the participants was conducted after the fifteenth wear/laundrying period.

### Durable Press Appearance

The durable press appearance of the tennis apparel was rated after 5, 10, and 15 wear/laundrying periods. The garments were evaluated at each period by a panel consisting of three trained observers.

Table 2 shows the mean values and standard deviations of the durable press ratings of the tennis outfits at each of the three laundrying periods. The eight cotton-polyester tops had higher mean ratings than the all-cotton tops at each evaluation period. The ratings ranged from 3.91 after 5 wear/laundryings to 3.75 after 15 laundryings. After the 15th laundrying period, the eight all-cotton tops had a mean value of 3.29 which is still considered a good rating in relation to durable press appearance. The eight cotton-polyester shorts had the highest rating after 10 and 15 wear/laundryings, while the all-cotton shorts were higher in durable press readings after five laundryings with a mean score of 3.84.

In Figure 2 the line shows the slight decline in durable press ratings for the cotton-polyester blend tops as wear/laundryings increased. The all-cotton tops show the sharpest decline between the 10th and 15th wear/laundryings. The tennis shorts made of the blended fabric show an increase in durable press ratings as the line

TABLE 2  
 MEANS AND STANDARD DEVIATIONS OF DURABLE PRESS  
 APPEARANCE VALUES OF THE TENNIS APPAREL AFTER  
 5, 10, AND 15 WEAR/LAUNDERING PERIODS

Mean Values FABRIC TYPES	Number of Launderings		
	5	10	15
Tops			
All Cotton	3.58	3.48	3.29
Cotton-Polyester (50/50)	3.91	3.81	3.75
Shorts			
All Cotton	3.84	3.49	3.42
Cotton-Polyester (50/50)	3.79	3.72	3.89
<u>Standard Deviations</u>			
Tops			
All Cotton	0.10	0.07	0.25
Cotton-Polyester (50/50)	0.12	0.18	0.19
Shorts			
All Cotton	0.11	0.14	0.18
Cotton-Polyester (50/50)	0.16	0.21	0.18

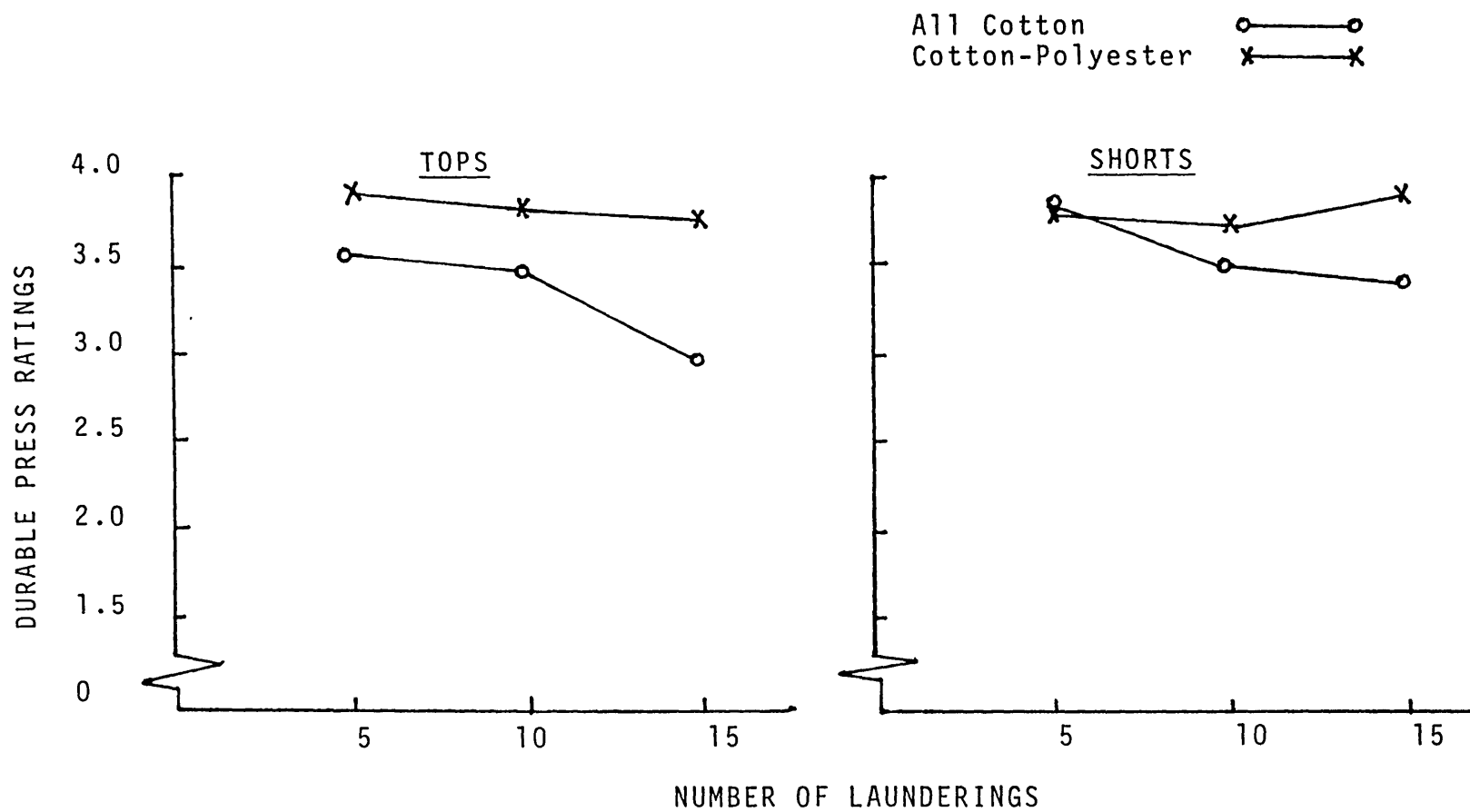


FIGURE 2. Means of Durable Press Appearance Values of Tennis Apparel After 5, 10, and 15 Wear/Laundering Periods

swings upward after 15 wear/laundryings. The all-cotton shorts, as both types of tennis tops, decreased in smoothness as laundryings increased.

The results of the analysis of variance test on durable press appearance are shown in Table 3. A significant difference, at the 0.05 level, was found between laundering periods and between fabric types for tops and shorts. No significant difference was found between laundry period and fabric type for tennis tops.

The Q-statistic comparison ratings of durable press appearance are shown in Table 4. The tops both in the all-cotton and the cotton-polyester blend showed no significant difference at any of the three laundering periods. The shorts showed a significant difference at the 10th and 15th laundering periods between the all-cotton and the cotton-polyester blend fabrics.

#### Shrinkage

To determine the percentage of change in the dimensions of each fabric type, shrinkage squares with benchmarks three inches apart were hand-stitched on the inside of the experimental garments. Following 1, 5, 10, and 15 wear/laundrying periods, measurements were taken both in the warp and filling directions, and the dimensional change was determined for each garment.

TABLE 3

ANALYSIS OF VARIANCE OF DURABLE PRESS APPEARANCE VALUES OF  
THE TENNIS TOPS AFTER 5, 10, AND 15 WEAR/LAUNDERING  
PERIODS

Source of Variance	d.f.	Mean Square	F-Ratio	Probability of F
Fabric	1	1.72	61.47*	0.00
Error	7	0.03		
Laundry	2	0.20	12.56*	0.00
Error	14	0.02		
Fabric/Laundry	2	0.02	0.78	0.48
Error	14	0.03		

ANALYSIS OF VARIANCE OF DURABLE PRESS APPEARANCE VALUES OF  
THE TENNIS SHORTS AFTER 5, 10, AND 15 WEAR/LAUNDERING  
PERIODS

Source of Variance	d.f.	Mean Square	F-Ratio	Probability of F
Fabric	1	0.56	20.05*	0.00
Error	7	0.03		
Laundry	2	0.18	9.74*	0.00
Error	14	0.02		
Fabric/Laundry	2	0.26	13.10*	0.00
Error	14	0.02		

\* Indicates significance at the  $\alpha = 0.05$  level

TABLE 4

COMPARISONS OF DURABLE PRESS APPEARANCE RATINGS  
ON TENNIS APPAREL AFTER 5, 10, AND 15  
WEAR/LAUNDERINGS

LAUNDERING PERIOD	TYPE MEANS		MEAN DIFFERENCE	Q- STATISTIC
	ALL COTTON	COTTON- POLYESTER		
<u>Tops</u>	No Significant Differences			
<u>Shorts</u>				
5	3.84	3.79	0.05	1.72
10	3.49	3.72	0.23	8.20*
15	3.42	3.89	0.47	15.96*

\*  $p \geq 0.05, Q^{(2,14)} = 3.03$

The means and standard deviations of shrinkage both in the filling and warp directions are shown in Table 5. Figures 3 and 4 depict graphically the shrinkage data on the tops and shorts each in the warp and filling directions.

In the warp direction the tops and shorts in both fabric types showed a continuous increase in shrinkage throughout the wear/landerings. The all-cotton tops in the filling direction showed the greatest shrinkage at the 5th wear/laundering; in comparison the cotton-polyester tops showed the greatest shrinkage at the 10th laundering period. The shorts in the cotton-polyester blend showed a continual increase in shrinkage in the filling direction

TABLE 5

MEANS AND STANDARD DEVIATIONS OF PERCENTAGE OF SHRINKAGE IN TENNIS  
APPAREL AFTER 1, 5, 10, AND 15 WEAR/LAUNDERINGS  
(WARP AND FILLING DIRECTIONS)

Mean Values FABRIC TYPES	Warp				Filling			
	Number of Launderings				Number of Launderings			
	1	5	10	15	1	5	10	15
<b>Tops</b>								
All Cotton	3.22	4.31	5.66	7.02	3.76	4.44	2.66	2.49
Cotton-Polyester	3.18	4.38	4.75	5.10	3.25	3.25	3.65	2.69
<b>Shorts</b>								
All Cotton	3.52	5.18	5.96	7.11	2.80	0.60	1.12	1.78
Cotton-Polyester	0.65	0.91	0.99	1.64	0.96	1.25	1.36	1.41
<b>Standard Deviations</b>								
<b>Tops</b>								
All Cotton	2.00	2.07	1.95	2.51	2.43	1.91	2.93	1.96
Cotton-Polyester	1.94	1.82	1.64	1.62	2.12	2.63	3.08	2.57
<b>Shorts</b>								
All Cotton	1.59	1.21	1.57	2.46	2.70	2.37	3.66	1.69
Cotton-Polyester	0.54	0.82	0.96	0.95	1.70	1.63	1.58	1.70



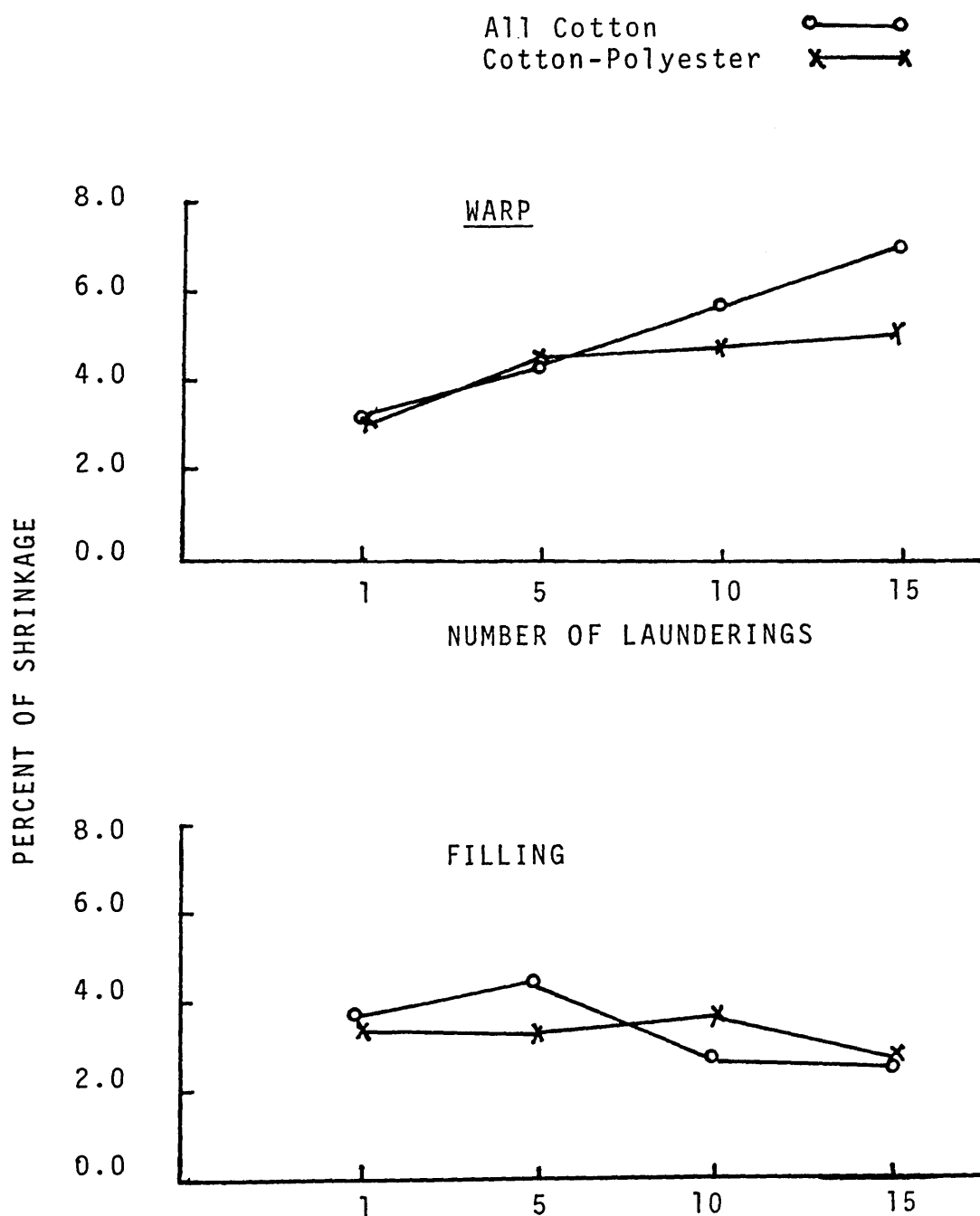


FIGURE 3. Percent of Shrinkage in Tennis Tops After 1, 5, 10, 15 Wear/Launderings in the Warp and Filling Directions.

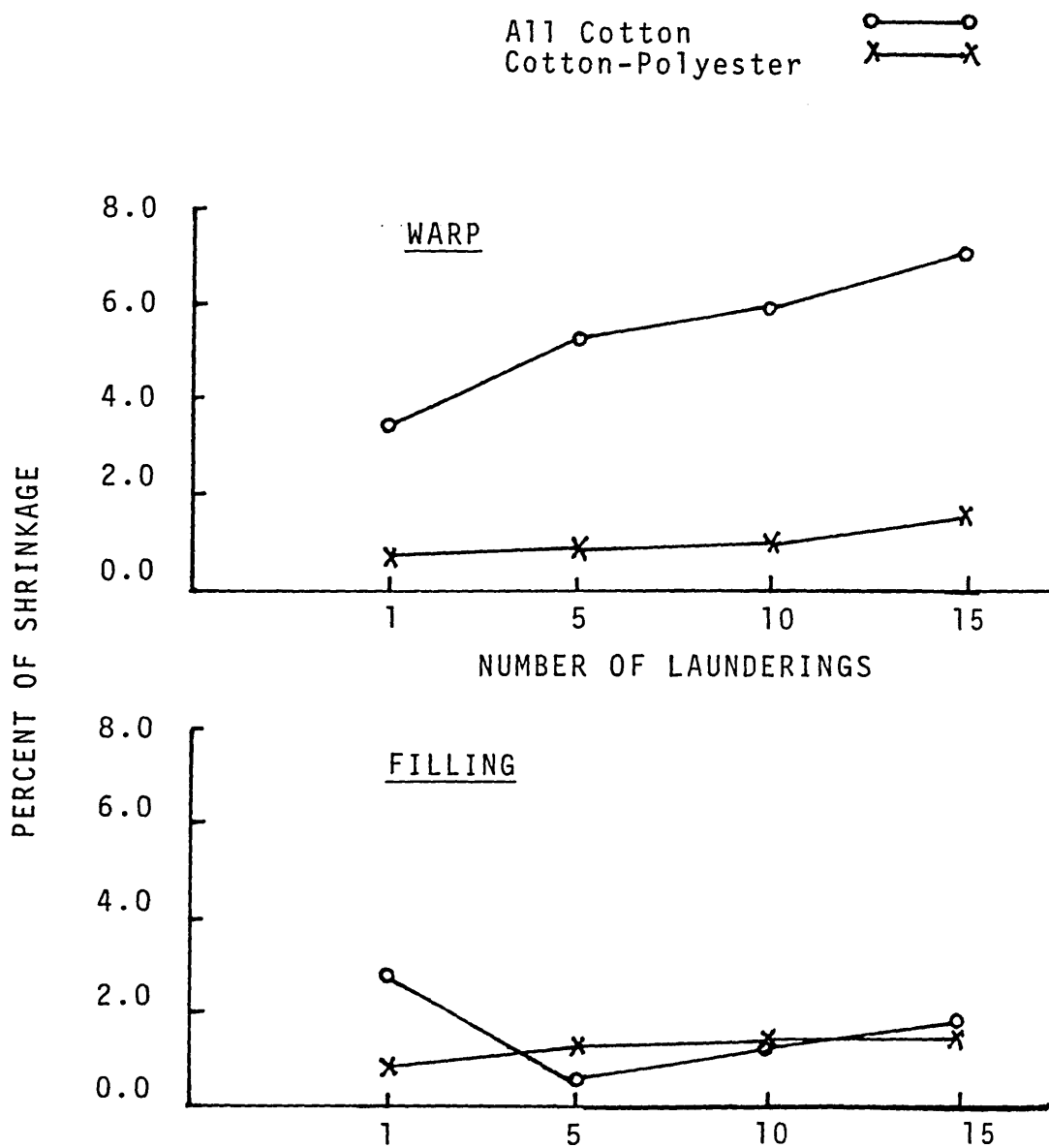


FIGURE 4. Percent of Shrinkage in Tennis Shorts After 1, 5, 10, 15 Wear/Launderings in the Warp and Filling Directions.

throughout the study.

The two-way analysis of variance of shrinkage of the fabric squares after 1, 5, 10, and 15 wear/laundrying periods is shown in Table 6. The tops had a significant difference at the 0.05 level in regard to laundry period and between laundry period and fabric type in the filling and warp directions. The shorts showed a significant difference in the fabric type, laundry period, and between laundry period and fabric type only in the warp direction.

The results of analysis using the Q-statistic comparison ratings of shrinkage of the fabrics after 1, 5, 10 and 15 wear/laundryings are shown in Table 7. In the warp direction a significant difference was found at the 10th and 15th laundryings on the tops and shorts. In the warp direction the shorts showed a significant difference at all laundrying periods. In the filling direction the tops showed a significant difference only at 1, 5, and 10 wear/laundryings. No significant differences were found in the two fabric types in the filling direction shrinkage of the shorts.

#### Bursting Strength

Bursting strength of the tennis garments was determined initially and after 15 periods of wear/laundrying. The mean and standard deviations are presented in Table 8

TABLE 6  
ANALYSIS OF VARIANCE OF SHRINKAGE MEASUREMENTS OF THE TENNIS APPAREL AFTER 1, 5, 10 AND 15 WEAR/  
LAUNDERINGS  
(Warp and Filling Directions)

Source of Variance	Warp				Filling			
	d.f.	Mean Source	F-Ratio	Probabi- lity of F	d.f.	Mean Square	F-Ratio	Probabi- lity of F
<u>Tops</u>								
Fabric	1	7.98	1.38	0.28	1	0.26	0.02	0.89
Error	7	5.78			7	12.44		
Laundry	3	23.94	15.89*	0.00	3	4.60	3.90*	0.02
Error	21	1.50			21	1.18		
Fabric/Laundry	3	3.40	3.45*	0.04	3	3.50	3.73*	
Error	21	0.99			21	0.94		0.03
<u>Shorts</u>								
Fabric	1	309.23	57.42*	0.00	1	1.72	0.13	0.73
Error	7	5.39			7	13.02		
Laundry	3	14.45	14.10*	0.00	3	2.77	1.44	0.26
Error	21	1.02			21	1.92		
Fabric/Laundry	3	5.11	4.47*	0.01	3	4.74	2.97	0.06
Error	21	1.14			21	1.60		

\*Indicates significance at the  $\alpha = 0.05$  level

TABLE 7  
COMPARISONS OF SHRINKAGE OF TENNIS APPAREL AFTER 1, 5, 10  
AND 15 WEAR/LAUNDERING PERIODS  
(WARP AND FILLING DIRECTIONS)  
(Percentage)

Laundering Periods	Type Means		Mean Difference	Q-Statistic
	All Cotton	Cotton Polyester		
<u>Warp-Tops</u>				
1	3.22	3.18	0.04	0.23
5	4.31	4.38	-0.07	0.40
10	5.66	4.75	0.91	5.18*
15	7.02	5.10	1.92	10.93*
<u>Warp-Shorts</u>				
1	3.52	0.65	2.87	15.18*
5	5.18	0.91	4.27	22.58*
10	5.96	0.99	4.97	26.29*
15	7.11	1.64	5.97	28.93*
<u>Filling-Tops</u>				
1	3.76	3.25	0.51	2.98*
5	4.44	3.25	1.19	6.97*
10	2.66	3.65	-0.99	5.78*
15	2.49	2.69	0.20	1.17
<u>Filling-Shorts</u>	No Significant Differences			

\* $p \geq 0.05, Q(2, 21) = 2.94$

TABLE 8  
MEANS, STANDARD DEVIATIONS, AND MEAN DIFFERENCES IN BURST-  
ING STRENGTH VALUES OF TENNIS TOPS INITIALLY AND AT  
15 WEAR/LAUNDERING PERIODS

(Values in Pounds)

	Means	s.d.	d.f.	
INITIALLY:				
All Cotton	63.5	3.98		
Cotton-Polyester	63.6	7.76	4	
Mean Difference				0.1
AFTER 15 WEAR/LAUNDERINGS:				
All Cotton	52.2	9.18		
Cotton-Polyester	63.2	7.55	7	
Mean Difference				11.00

and the mean values initially and after 15 wear/launderingings are graphically shown in Figure 5. Initially the strengths were almost identical for the all-cotton and cotton-polyester tops with 63.5 and 63.6 pounds, respectively. After 15 wear/launderingings the all-cotton tops had dropped to 52.2 pounds while the cotton-polyester tops lost only 0.4 pounds resulting in a mean difference of 11.0 pounds. Bursting strength was not determined on the tennis shorts because the two types of fabrics (knitted and woven) would make comparisons in strength unrealistic.

#### Pilling Resistance

Evaluations related to pilling resistance were performed initially and after 15 wear/laundering periods. The mean values and standard deviations are shown in Table 9.

TABLE 9  
MEANS OF PILLING VALUES OF TENNIS APPAREL  
INITIALLY AND AFTER 15 WEAR/LAUNDERING PERIODS

Fabric Type	Number of Launderings			
	Tops		Shorts	
	0	15	0	15
All Cotton	2.90	2.35	3.10	2.43
Cotton-Polyester	1.10	1.65	3.0	2.48

The eight all-cotton tops received better scores for resistance to pilling than the eight cotton-polyester blend

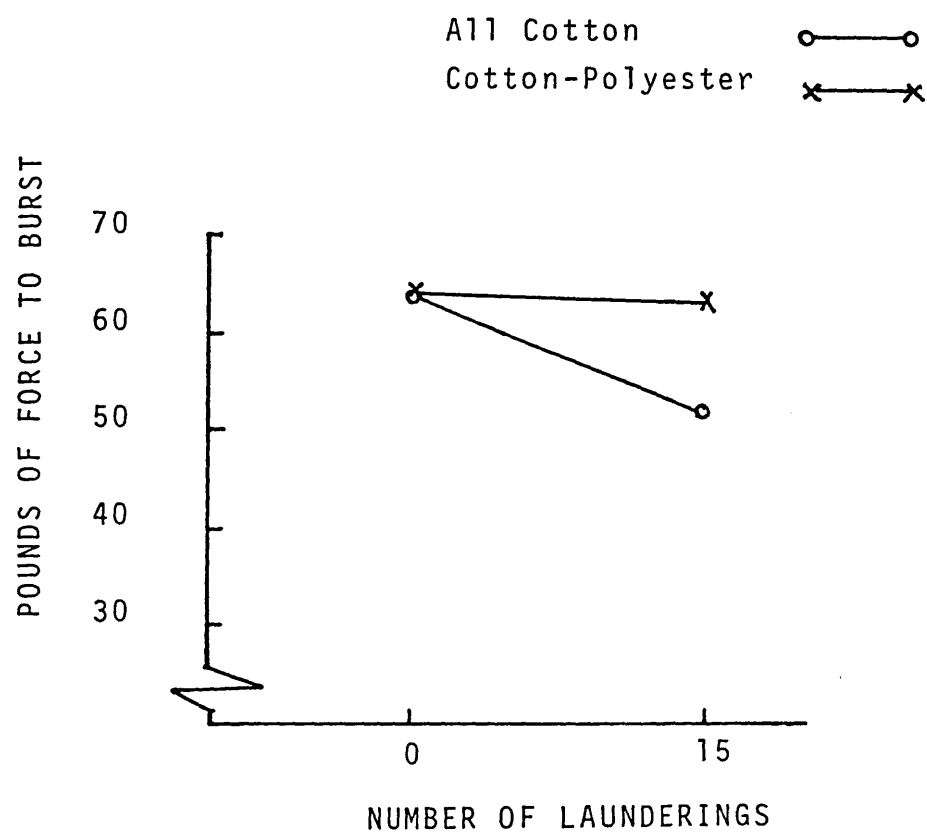


FIGURE 5. Means of Bursting Values of Tennis Tops Initially and After 15 Wear/Laundering



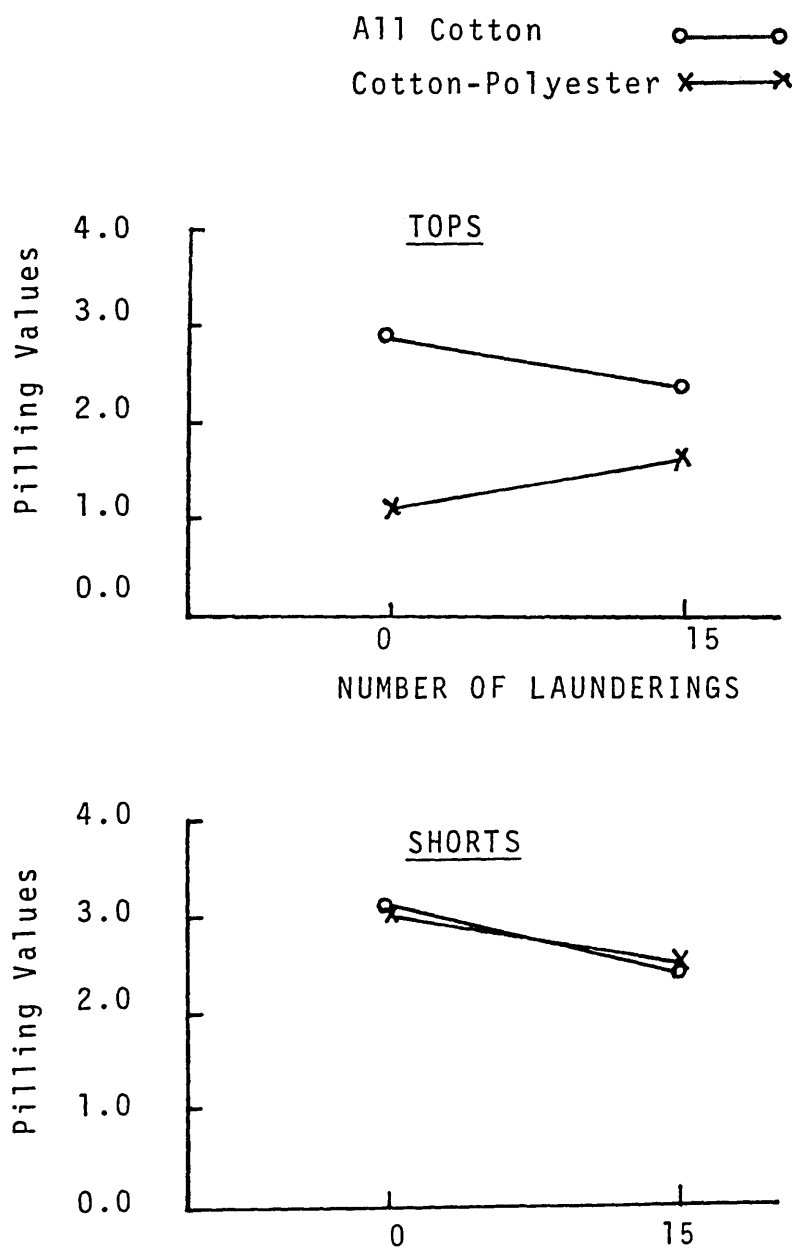


FIGURE 6. Means of Pilling Values of Tennis Apparel Initially and After 15 Wear/Laundering

TABLE 10

MEANS OF COLOR VALUES OF TENNIS APPAREL INITIALLY AND AFTER 5, 10, AND 15 WEAR/  
LAUNDERING PERIODS

Code No.	Color	ALL COTTON				COTTON-POLYESTER				
		Number of Launderings				Number of Launderings				
		0	5	10	15	Color	0	5	10	15
<u>Tops</u>										
1	Lt.B1.	58.97	57.29	57.34	57.41	Red	63.80	62.28	63.01	62.48
2	Green	62.81	62.86	63.28	63.92	Navy	29.18	29.44	29.44	29.47
3	Lt.B1.	59.00	57.42	57.84	57.22	Navy	29.44	29.91	30.07	30.06
4						Turq- uoise	68.97	69.72	69.93	64.03
5						Roy.B1.	45.74	47.64	47.53	47.97
6						Yellow	85.00	83.75	84.37	84.19
<u>Shorts</u>										
1	Lt.B1.	58.63	58.57	57.94	57.77	Red	62.72	63.43	64.00	63.54
2	Navy	58.88	58.32	58.58	58.48					
3	Navy	20.36	20.53	20.88	20.73					
4	Red	71.96	68.99	69.16	68.99					
5	Green	63.31	63.21	63.39	70.55	Roy.B1.	44.62	45.66	46.20	46.40
6	Lt.B1.	59.56	57.20	56.98	55.81	Lt.B1.	58.74	59.72	59.70	60.30
7	Red	71.50	66.48	67.75	68.24					
8	Green	63.39	61.53	62.76	62.87	Roy.B1.	44.23	45.02	45.59	45.77

tops, initially and following 15 wear/laundryings. With a score of 5.0 representing "no pilling" the all-cotton tops received scores of 2.9 and 2.35, respectively, for the two evaluation periods. The data graphically depicted in Figure 6 show the higher ratings of the all-cotton tops.

The pilling resistance of the shorts showed only slight differences in the two fabric types. The similarities are attributed to the fabric construction of the eight blended-fabric shorts which was a twill weave. This tight weave construction reduced the ability of the fibers to work loose to form pills.

#### Color Evaluation

The tennis garment fabrics were evaluated with regard to color change due to wearing during outside, physical activity and repeated laundryings. Measurements were taken on the initial fabric and after 15 periods of wearing and laundering. The Hunter Lab Color Difference Meter was used to determine color change.

Table 10 presents the readings of the various colors of the two fabric types. The data presented in Table 10 give the values of each of the colored tops or shorts. With a higher number representing lighter color it is noted that the light blue all-cotton tops had not faded after 15 wear/laundryings. The light blue shorts in all

cotton also showed no fading. The all-cotton red shorts had the greatest change in color readings when initial values were compared with the 15th wear/laundering. Generally, navy blue showed only minute change during wearings and launderings. The green garments showed unpredictable change as the green tops and one pair of shorts showed no fading while one pair of green shorts faded noticeably.

The 50/50 cotton-polyester blended tops and shorts remained relatively colorfast also. Among the blended tops, it is noted that the two navy blue and royal blue had faded after 15 wear/launderings, while the red, turquoise, and yellow remained colorfast. The color evaluations of the blended shorts revealed all four colors--red, royal blue, light blue, and navy--to have lost some of the color after being subjected to 15 wearings and launderings.

In general, the color garments were of good color at the end of the study; however, it is noted that only three of the 11 all-cotton garments faded while seven of the 10 cotton-polyester blended garments experienced color loss.

#### Whiteness Retention

Whiteness values were recorded for the tennis tops initially and after 10 and 15 wear/launderings. Table 11

TABLE 11  
MEANS AND STANDARD DEVIATIONS OF WHITENESS  
VALUES OF TENNIS TOPS INITIALLY AND AFTER  
10 AND 15 WEAR/LAUNDERING PERIODS

	Number of Launderings		
	0	10	15
<u>MEAN VALUES</u>			
All Cotton	134.9	132.9	133.0
Cotton-Polyester	110.7	116.8	117.2
<u>STANDARD DEVIATIONS</u>			
All Cotton	0.04	1.83	3.38
Cotton-Polyester	1.54	0.11	2.27

reveals the all-cotton tops to be the whiter at each evaluation period than the 50/50 cotton-polyester blends. Figure 7, depicting the data, shows the blended tops to increase in whiteness as the launderings progressed. The all-cotton tops, however, remained whiter than the blends at each evaluation period.

All-cotton shorts were not available in white; thus, comparison between the two fabrics was not possible for this evaluation.

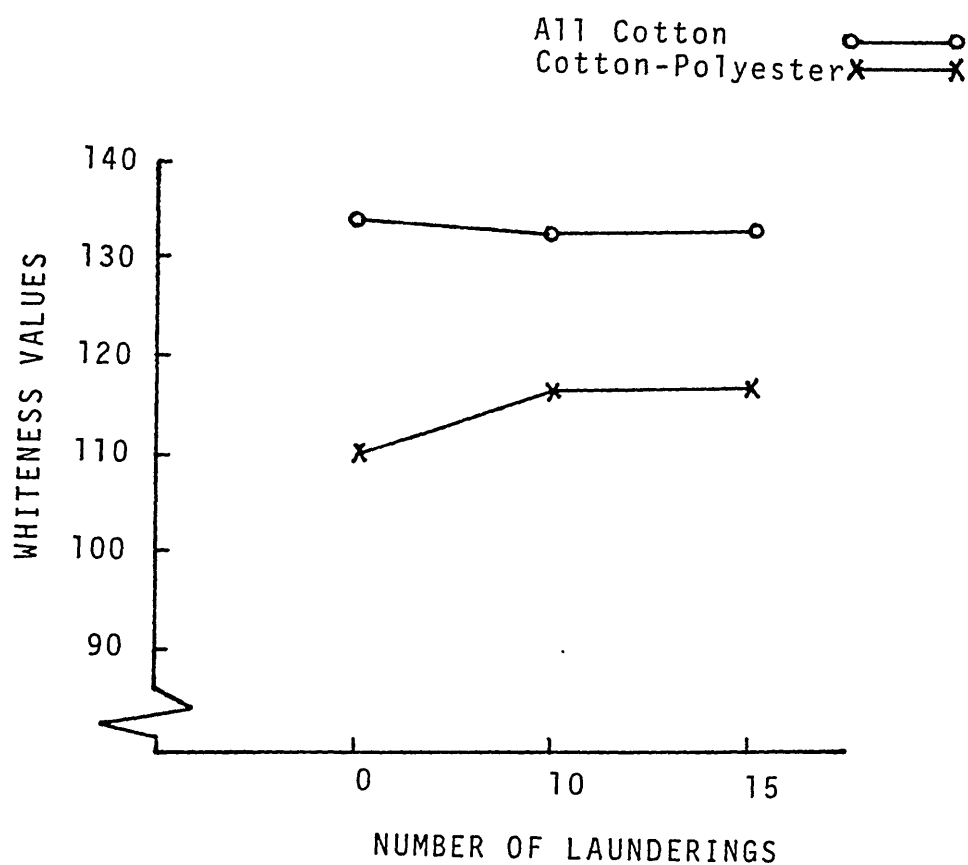


FIGURE 7. Mean Whiteness Values of Tennis Tops Initially and After 10 and 15 Wear/Launderings.

### Participants Evaluation

A questionnaire concerning the performance of the experimental tennis outfits was completed by the eight participants, as participants evaluated the two outfits assigned to her. The tennis apparel was evaluated at the conclusion of the 15th laundering period. Since each outfit consisted of two pieces (top and shorts) the participants completed an evaluation for each of the four pieces they wore throughout the study.

During the evaluation process the garment piece which received a number 5 rating was considered "excellent," rank 4 was "very good," rank 3 was "good," rank 2 was "fair," rank 1 was "poor." The questionnaire used may be found in the appendix.

### Questionnaire Summary

In the area of shrinkage the ratings for tops in both fabrics ranged from excellent to good. The ratings for the shorts showed the all-cotton ranging from excellent to good with 50 percent of the responses being excellent. The cotton-polyester ratings ranged from excellent to very good. In relation to the stretching of the fabrics the tops in the cotton-polyester were rated excellent to very good. The all-cotton tops received ratings from excellent

to poor. The all-cotton shorts were rated from very good to poor. The tops and shorts in the cotton-polyester blend received excellent and very good ratings in relation to resistance to stretching.

The second question which dealt with the garment's comfort in hot weather, received ratings from excellent to poor. The tops in each fabric received one poor rating, but otherwise were rated fair or better. The shorts in both fabrics were rated from excellent to fair.

Absorption ratings for the all-cotton group ranged from excellent to fair. The cotton-polyester ratings for the shorts ranged from very good to good. The cotton-polyester tops were rated excellent to fair for absorption.

Wrinkle resistance ratings for the all-cotton tops and shorts and the cotton-polyester shorts ranged from excellent to good, with the majority of the ratings being very good. The cotton-polyester tops received ratings ranging from excellent to very good with the majority of the ratings being very good.

Pilling ratings for the all-cotton garments ranged from very good to good with 75 percent of the responses being very good. The cotton-polyester blend garments received ratings ranging from excellent to poor.

Fuzzing resistance was rated for the all-cotton



garments as being very good to fair with the majority of responses being very good. The cotton-polyester shorts received ratings ranging from excellent to good. The cotton-polyester tops had ratings which ranged from excellent to poor.

In relation to color change or fading, the all-cotton shorts received ratings ranging from very good to fair with 50 percent being very good. The all-cotton tops were rated excellent to good with two-thirds of the responses being very good. The cotton-polyester garments received ratings ranging from excellent to fair.

When asked if there was anything the wearer particularly liked about the tennis outfit the most popular response when referring to the all-cotton garments was the comfort and softness of the material. In relation to the cotton-polyester outfit the participants seemed to like the style best, which was unrelated to fiber content.

When asked if there was anything the wearer disliked some of the participants thought the all-cotton outfit seemed to stretch out of shape in some instances. In the cotton-polyester outfit some of the wearers thought the garment was not absorbing their perspiration efficiently. The majority of the participants found both outfits comfortable to wear. Quite a number of the participants

felt the garments would have been more functional if they had had pockets.

## CHAPTER V

### SUMMARY AND RECOMMENDATIONS

This study was designed to determine how fiber content influences perform under specific active wearing and normal laundering procedures. The overall objective of this study was to evaluate the wear life performance of two types of fiber content in tennis apparel. One type was a 50 percent polyester/50 percent cotton blend and the other was 100 percent cotton.

The tennis outfits were worn by eight female students who were attending summer school at Texas Woman's University. Each participant was issued two tennis costumes having a tennis top and shorts from each group. Each outfit was worn for a minimum of two hours during outdoor physical activity.

Parameters important to the consumer were evaluated at intervals throughout the study. Evaluations of the tennis costumes were made at various intervals of wear and laundering concerning their appearance and physical properties. Initially and after 15 wear/laundrying periods the tennis apparel was evaluated with regard to bursting strength, pilling resistance and color evaluation.

Evaluations on durable press appearance and shrinkage were completed at specified intervals throughout the study.

The participants evaluated the garments at the end of the study.

Durable press appearance values obtained after 5, 10, and 15 wear/laundrying periods were found to be higher for the cotton-polyester blended fabric than the all-cotton fabric. The cotton-polyester tops received ratings ranging from 3.91 after 5 wear/laundryings to 3.75 after 15 laundryings. After the 15th laundrying the eight all-cotton tops had a mean value of 3.29 which is still considered a good rating in relation to durable press appearance. The cotton-polyester shorts received the highest rating after 15 wear/laundryings, while the all-cotton shorts were higher in durable press appearance ratings after five laundryings with a mean score of 3.84.

Since all-cotton knits generally experience shrinkage when laundered, some shrinkage was expected. A significant difference was found between the four laundrying periods and fabric/laundrying periods for the tennis tops. No significant difference was found between the two fabric types of the tops in the warp or filling direction. There was a significant difference found between the two fabrics with regard to warp shrinkage of the shorts. This was

expected because the blended-fabric shorts remained stable in the warp direction due to the twill weave. There was no significant difference found in the filling shrinkage of the shorts.

Bursting strength values were analyzed and the 50/50 cotton-polyester fabric received better ratings. Initially the strengths were almost identical for the all-cotton and cotton-polyester with 63.5 and 63.6 pounds respectively. After 15 launderings the all-cotton tops had dropped to 52.2 while the cotton-polyester had dropped to only 63.2. The mean difference changed from 0.1 initially and 11.0 pounds after 15 launderings.

Evaluations related to pilling performance were performed initially and after 15 wear/laundrying periods. The eight all-cotton tops displayed the highest resistance to pilling with scores of 2.9 and 2.35 for the initial and final evaluation period. The pilling resistance of the shorts showed only a slight difference in the two fabric types. Because the blended fabric shorts being constructed of a twill weave it is difficult to make comparisons between one fabric type and the other.

The tennis garments' fabrics were evaluated with regard to color change due to wearing and laundrying. Original color readings were compared with color values at the end

of the study. Over-all the all-cotton garments had greater color retention than the cotton-polyester garments. The light blue all-cotton tops and shorts showed no fading after 15 wear/laundryings. The all-cotton red shorts showed the greatest color change throughout the study. The green all-cotton showed unpredictable change as one piece would fade while another piece would show no fading at all. In the cotton-polyester blended-fabrics the navy blue and royal blue tops showed fading after 15 wear/laundryings, while the other blended fabrics remained colorfast. In the end only three of the 11 all-cotton garments faded while seven of the 10 cotton-polyester blended garments experienced color loss.

In relation to whiteness retention the data show the all-cotton tops to be whiter at each evaluation period than the cotton-polyester blends. The blended fabrics did increase in whiteness as the study progressed, but the all-cotton tops remained whiter than the blended fabrics at each evaluation period. There were no white shorts in the 100 percent cotton fabric, thus no comparison was possible for the evaluation.

A consumer evaluation of the tennis outfits was conducted at the end of the study with regard to performance during wearing and to rate appearance after 15 wear/

laundryings. The results of the evaluation revealed higher scores for the all-cotton tops in areas of shrinkage, cool to wear, absorbency, pilling and fuzzing resistance and fading. The polyester-cotton tops scored higher in stretching resistance and durable press appearance. The all-cotton tops received more comments concerning comfort--especially with regard to softness and absorbency. Some students remarked that the blends were hot, discolored, and clung to the body. Comments from the students included a desire for pockets both in the tennis tops and shorts.

#### Recommendations

Based on the data gathered in this study, the following recommendations are made:

1. Tennis tops be made of a knitted all-cotton fabric while tennis shorts should be made of a woven fabric containing at least half cotton.
2. Both tops and shorts be designed with pockets.
3. Wider selection of colors and styles be made available to the consumer.
4. Further research and study be conducted using garments which are identical for all participants.
5. Further research and study be conducted using more than eight participants.
6. Further research and study be conducted using male participants.

## APPENDIX



## QUESTIONNAIRE - TENNIS APPAREL

NAME \_\_\_\_\_

GARMENT \_\_\_\_\_

USE 5 POINT SCALE: 5 = excellent; 4 = very good; 3 = good;  
2 = fair; 1 = poor

PERFORMANCE AREA	RATING	COMMENTS
1. a. Does not shrink	_____	_____
b. Does not stretch	_____	_____
2. Feels cool in hot weather	_____	_____
3. Absorbs perspiration	_____	_____
4. Wrinkle free	_____	_____
5. Resists pilling	_____	_____
6. Resists fuzzing	_____	_____
7. Does not fade or change color	_____	_____
8. Was there anything you particularly <u>liked</u> about the garment?		
9. Was there anything you particularly <u>disliked</u> about the garment?		
10. Did you find the garment comfortable to wear? _____		
Yes, completely _____.		
Yes, but... _____		
No _____		
If not completely comfortable, please explain:		

Other comments:

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