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Fit of Sari Blouse: Influencing Parameters and Assessment

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ABSTRACT

As fit is a significant problem for women wearing sari blouse, the study examined the physical properties of blouse materials and its influence on fit. Seventeen different blouse materials (100% cotton, polyester/cotton union fabric, polyester/nylon union fabric and 100% polyester) structured in plain weave were chosen for investigation. Front Cup area of the sari blouse was cut in straight, cross and bias grain to understand the effect of fabric grain alignment on blouse fit. The fit was analyzed for 51 blouses through subjective wear trial expressions and visual analysis of fit by judges. The fit attributes: Ease, number of wrinkles and seam line deviations were measured on subjects for overall fit assessment. The results show that the fabric specifications and grain influenced the fit significantly with the p-value 0.001. Furthermore; Positive correlation exists between the scores obtained in subjective wear trial and visual analysis of fit by judges.

Keywords: Sari blouses, fabric grain, wear trial, visual fit, fit analysis

Introduction

Modesty and decoration are directly influenced by the appearance and fit of the clothing. The appearance and fit of the clothed body is a perception of the viewer in a social and climatic context. It involves interaction between body, clothing, the viewer and environment (Delong, 1998). Shim et al. (1991) comments that clothing is an extension of the bodily self and has important symbolic meanings in social interactions. Fit in a garment is one important factor that contributes to the confidence and comfort of the wearer. Well-fitted clothes are considered vital to an individual's psychological and social well-being (Smathers & Horridge, 1978-79). According to Huck et al. (1997) proper fit in a garment depends on the relationship of the size of the garment compared with the size of the wearer. According to Chamber and Wiley (1967), clothing that fits well conform to the human body and has adequate ease of movement, has no wrinkles and has been cut and manipulated in such a way that it appears to be part of the wearer.

The Sari blouse is a traditional and close fitting garment worn by Indian women under a sari. It can also be referred to as a choli or ravika. Sari is a strip of unstitched cloth ranging from four to nine meters in length that is draped over the body in various styles. It is a popular style in India, Nepal, Bangladesh, Pakistan, Sri Lanka, Bhutan, Burma and Malaysia. The Sari blouse has short sleeves and a low neckline in front and back that is designed to support and molds the soft tissues of the upper female form. The garment is shaped to fit exactly the contour of the body. *Medha (2008) comments that proper* fit *was found to be a major* problem *for females wearing* Sari blouse. Radha (2006) stated that the common problems faced by women in getting the blouses stitched were of color matching, stitching and proper fitting. Considering the problems related to the fit of blouse, it is imperative to ascertain the comfort and fit obtained in commercially available sari blouse materials.

Background

Selection of fabric is one of the initial step in the garment design process. Fabric characteristics, fabric grain alignment and proper seam placement are the important factors to be considered in garment designing, as these factors affects the appearance of the garment. “The visual appearance of any garment is directly affected by the characteristics of the fabric in which it is made” (Aldrich & Aldrich, 2007). The fabric characteristics that influence the fabric drape will also influence the fit of a garment (Burns & Bryant, 2007). According to Gersak (2002) the elements determining the quality of clothing fit are directly linked to the mechanical properties of fabric which affect the aesthetic drape and 3D-shape. The goal when measuring fabric drape characteristics is predicting the behavior of the fabric when it is placed on a three dimensional form. Fabric drapes “involves three dimensional double curvature deformations” (Hunter & Fan, 2004). Taya et al. (1996) studied on the influence of clothing size and material on clothing waveform reported that material type significantly affects clothing fit. When the clothing material varied, the change of waveform was larger than that caused by a change in size. Growther (1985) investigated the comfort and fit of 100% cotton jeans and based on series of experiments concluded that the inherent properties of the fabric construction might be utilized to reduce skin strain and enhance body contouring . The appearance and drape of a garment varies with the properties of the fabric, and a single design may look very different when constructed in different fabrics. Fabric drape depends on the mechanical and constructional properties of the textile materials and, on the other hand, on the form - construction of the cloth, and their connected positions at the seams. The seams in a garment influence the drape of the fabric. Jevsnik and Lojen (2007) investigation on drape behavior of seamed fabrics confirmed that the number of folds on the samples with seams was greater. Drape coefficient was greater on samples with seams than samples without seam.

Moore (1992) reported that "Fabric grain alignment is one of the most important factors to consider when analyzing a garment's fit and drape”. Grain line refers to the orientation of the yarns in a woven fabric. The grain in a woven fabric is straight or lengthwise grain, crosswise grain, and bias. The lengthwise grain is parallel to the selvedge and has less stretch due to a higher twist in the yarn that provides strength to the warp yarn that is required to maintain the tension on the loom. The crosswise grain is perpendicular to the selvedge and has more stretch than the lengthwise grain in woven fabrics. Bias refers to any angle along the straight or cross-grain. This true bias at 45 degrees from the crosswise and lengthwise grain has the maximum stretch in a woven fabric. Vaitkeviciene and Masteikaite (2006) studied the evaluation of flared garment drapeability using a mathematical model and reported that the differences in number of folds formed were different depending on the direction of the fabric grain. Due to gravity forces all fabrics deform owing to bending of yarn. The fabric in bias directions has added deformation due to the shear of yarns. The garment symmetry was influenced when the bias directions on the front and back of the garment were at the same or opposite bias directions.

Solinger (1988) describes the different stresses on the yarn depending on the direction of the grain line. The gravitational pull is dependent on the direction of the pattern piece in relationship to the warp and weft yarn. Orzada, Moore, and Collier (1997) examined the relationship between fabric drape and grain alignment, twelve tilt combinations were examined and reported that shear stiffness and hysteresis value increased as tilt angles increased across all fabrics. Orzada et al. (1997) studied the effect of grain alignment on fabric and garment drape and found that there was no consistent relationship between the tilt angle and the drape values; relatively it was dependent on the fabric. The study found that as the tilt amount increased, the garment symmetry changed, and the tilt affect the folds which formed as the garment draped. Orzada (2001) studied the effects of grain alignment on fabric mechanical properties and reported that shear properties were more sensitive than bending properties to variations in grain alignment. Sidabraite and Masteikaite (2002) concluded that seam lines and grain direction have a significant influence on garment drape. The garments constructed in bias grain changes the drape of the silhouette. Bryant (1993) in facets of Madeleine Vionnet's cut looked at the methods used by Vionnet to create shape in garments, by examining photographs, prototypes, and garments and found that Vionnet slashed the fabric to manipulate the grain through inserting gussets or other wedge shaped pattern pieces. Partial bias was used rather than true bias in few garments. The straight grain is used as a stabilizing force at hemlines and necklines. Knowles (2005) used bias stretch, when designing garments using the flat pattern method. Knowles states that the pattern layout will influence the drape of the garment, and a spiraling grain will sew differently than mitered grain direction at the side seams. The stretch varies from the right and left sides of the garment because of differing tensions in the warp and weft grain. Fabric grain as it is draped on the body has to be studied to work with bias stretch in garments.

Garment fit is examined on the three dimensional form. When a garment is designed and cut, the fabric grain is oriented with the lengthwise grain line parallel to center front, crosswise grain that is horizontal at the bust and hips and parallel to the floor. Side seams are perpendicular to the floor and shoulder seams are on the top and center of the shoulder (Minott, 1991; Moore, 1992). The poor fit in garment is due to wrong measurement between any back and front length or width. The garment should lie smoothly on the body without any strain or gaps caused by excess fabric (Minott, 1991). According to Yu (2004) fit is the most important element to customers in clothing appearance and that definitions of fit may vary over time. The five factors of good fit: according to Erwin, Kinchen, and Peters, (1979, as cited in Brown and Rice, 2000) are ease, line grain, balance, and set. A well-fitting garment is a garment that has vertical seams perpendicular to the floor, shoulder seams positioned at the shoulder point allowing a smooth fit and the garment back has ease but no vertical or horizontal wrinkles, sleeves should not have wrinkles that run across the cap or up and down, necklines are relaxed, waistline seams are not too tight or too loose and has no wrinkles. Hems are parallel to the floor and garment armscye do not constrict the body (Betzina, 2003). Garment ease provides comfort and movement in a garment. Line follows the outline and circumference of the garment. The grain runs horizontally at bust, waist and hip level and is usually the cross grain of the fabric. The center front and center back are parallel to the lengthwise grain. Balance is the garment symmetry from side to side and front to back. Set describes a smooth garment with no wrinkles. With the advent of three dimensional body scanning, innovative companies have created dress forms shaped more like the human body on three-dimensional scan data (Haber, 2006). Ashdown et al. (2004) tested the effectiveness of using 3D scans of clothed participants in the fit analysis process; Ease, line, balance and set, elements of fit were also clearly seen on the visualization of the scans and concluded that 3D scans could be substituted for the live fit analysis process in research and industry.

McKinney (2007) developed a model to study fit as the relationship of the human body to the garment. Fit evaluation with objective measurements involves measuring the volume of space between the body and the garment. Subjective measure is studied by analyzing the observer's perception of the garment fit and the wearer's perception of how the garment fits. Wearer's perception of physiological fit and psychological fit is also considered. Physiological fit refers to the physical comfort in wearer's perception of the space of the body in the garment. Psychological fit is the wearer's satisfaction or dissatisfaction with the fit. Ashdown and Dunne (2006) reported that 'perception of fit' is a very important aspect of fit that is difficult to predict by body measurements. Huck et al. (1997) and Shen and Huck (1993) have used wearer acceptability scales to examine the fit satisfaction of consumers and their perception of fit of various clothing items at specific areas. Fit analysis of apparel has been effectively conducted by panels of trained judges to provide reliable and valid data (Choi & Ashdown, 2002). Yu (2004) commented that due to the complexities involved in fit analysis, studies based on live models were confined to a limited sample size.

Purpose

The objective of this research is to analyze the effect of materials, fabric specifications and fabric grain on the fit of sari blouse. Fifty-one sari blouses were constructed from seventeen different commercially available materials in three different grains namely warp, weft and bias. The manuscript focuses on the subsequent fit evaluation analysis such as subjective wear trial expressions (Physiological and Psychological fit) and visual analysis of fit by a set of judges. To objectively quantify the fit, fit attributes such as ease measurement, number of wrinkles and seam line deviation was measured on subjects and the values obtained were related with the subjective score ratings.

Method

Selection of Materials

Sari blouse materials commercially available in the market were used in this study. All the fabrics were structured in plain weave. The fabrics used included (1) a 2/2 full voil-100% cotton, (2) 2/1 polyester/cotton union fabric, (3) 100% polyester, (4) polyester/nylon union fabric. Details of the fabrics used in this study can be found in Table 1.

Table 1. Specification and physical properties of fabrics

Sample code	Fabric sett/ inch (warp * weft)	Yarn count (warp ×weft) (Ne)	Weight g/m^2	Thickness mm	Cover factor	Drape co-efficient (%)	Type of material
1	85*69	38's × 37's	86.4	0.112	19.54	48.13	100% cotton
2	74*84	37's × 47's	87.2	0.116	19.09	51.01	100% cotton
3	86*60	35's × 43's	78.4	0.122	18.92	49.99	100% cotton
4	86*69	36's × 45's	79.6	0.116	19.97	51.25	100% cotton
5	91*72	41's ×34's	91.2	0.146	20.29	46.48	100% cotton
6	81*70	39's × 37's	87.2	0.118	19.14	58.60	100% cotton
7	84*65	39's × 46's	77.6	0.114	18.23	48.03	Polyester/cotton
8	74*72	37's × 45's	86.4	0.114	19.31	47.65	Polyester/cotton
9	80*74	31's × 53's	71.2	0.116	18.42	49.60	Polyester/cotton
10	140*68	31's × 197's	55	0.19	25.83	77.5	100% Polyester
11	140*80	34's × 106's	59	0.19	25.12	79.0	100% Polyester
12	144*76	34's × 161's	74	0.2	25.48	66.5	100% Polyester
13	144*74	37's × 177's	72	0.2	24.37	77.5	100% Polyester
14	144*72	32's × 161's	75	0.19	25.83	70.8	100% Polyester
15	132*92	51's × 47's	49	0.08	23.01	41.5	Polyester/nylon
16	136*98	52's × 47's	47	0.09	23.61	57.5	Polyester/nylon
17	136*98	40's × 46's	43	0.08	24.85	51.8	Polyester/nylon

Subjects

British size (BS3666) for women clothes, Size 16 was chosen as the desired size criteria. Ten women aged between 25 and 35, who met the desired size criteria were mothers and were selected as subjects to participate in subjective wear trial expressions. Aall the subjects wore cloth bra of size 36B under the sari blouse during the subjective wear trial expressions and visual analysis of fit by judges. The mean, standard deviation and range of subjects' body measurements are shown in Table 2. Subjects were given orientation about the research purpose, methodology and fit evaluation scales before the conduct of subjective wear trial.

Table 2. Body measurements of the subjects

Measurement	Mean (cm)	Standard Deviation	Minimum (cm)	Maximum (cm)
Height	163.1	2.37	159	166
Bust circumference	97.04	0.164	95.8	96.3
Upper Waist circumference	78.91	0.235	78.5	79.4
Upper arm circumference	33.06	0.168	32.8	33.4
Blouse length	36.01	0.110	35.9	36.2
Shoulder to bust point	23.95	0.084	23.8	24
Front neck depth	16.91	0.296	16.8	17.2
Back neck depth	21.03	0.094	20.9	21.2
Sleeve length	18.04	0.096	18	18.3
Sleeve open	30.09	0.159	29.8	30.3
Armhole circumference	42.05	0.084	42	42.2
Back width	39.99	0.152	39.8	40.2
Shoulder length	13.05	0.0849	13	13.2
Distance between bust points	21.06	0.107	20.9	21.2

Pattern Design and Garment Construction

The standard measurements and pattern drafting procedure was used for drafting sari blouse (Zarapkar, 2008). The measurements required for drafting sari blouse is shown in figure 1. The pattern pieces were developed and pattern drafting procedure and the type of measurements required was confirmed after a series of sample garments have been fitted and adjusted on three live models chosen from the subjects. A pattern consisting of front, back, midriff yoke and sleeve were drafted. Four darts were used in the cup area of front pattern to achieve correct shape. Two darts were utilized in the back waist. It is traditional to cut the blouse back and sleeve on straight grain oriented vertically, perpendicular to the hem as warp yarns hold the shape well and resist bagging and stretching. Midriff yoke (waist band) was cut on cross grain for all the materials, as it reduces *stretch horizontally and gives stability around the waist line, when a person moves or bends*. Fabric cut on bias stretches and drapes well over the body contours. Therefore, the cup area on the blouse front was cut in straight (warp), cross (weft) and bias grains respectively to understand the fit of sari blouse in different grain. Pattern layouts cut in straight, cross, bias grains is shown in figure 2. All the garments were constructed with the obtained mean measurement of the subjects in order to understand the fabric behavior and its influence on blouse fit.

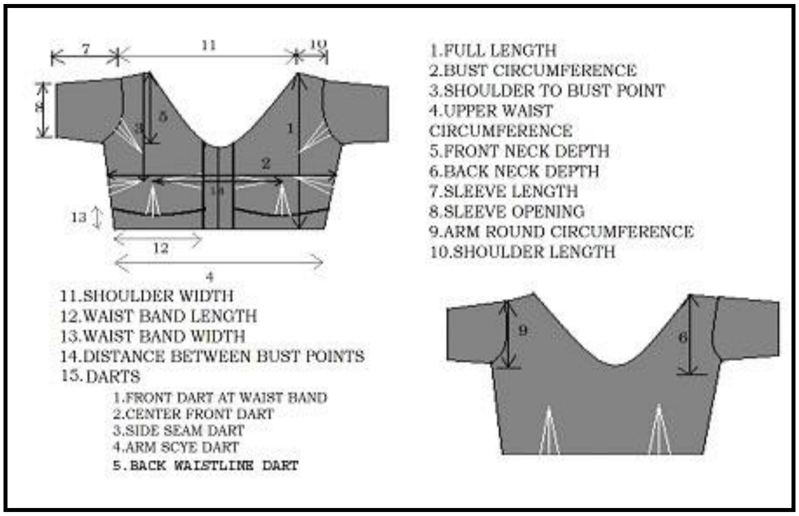

Figure 1. Body Dimension

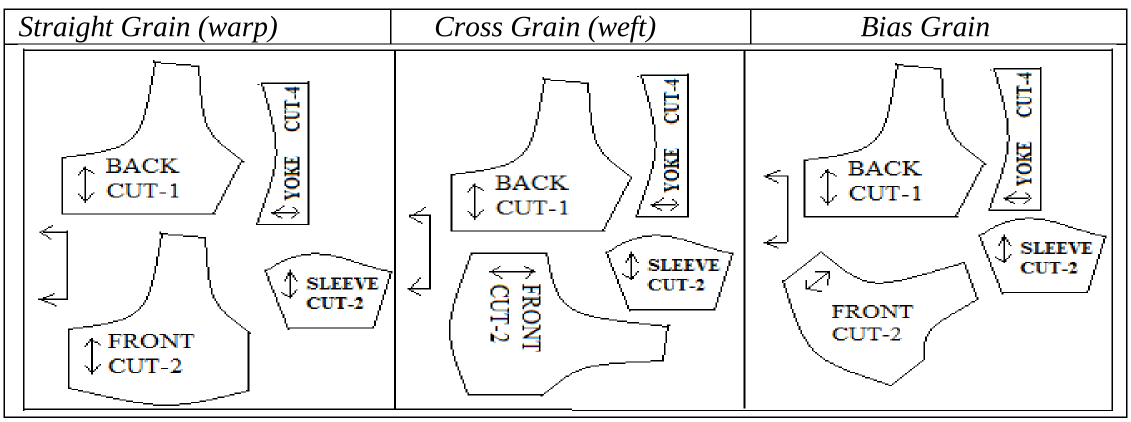

Figure 2. Pattern Layouts

Subjective Wear Trial

Wearers perceived fit evaluation consisting of seven attributes was used to attain feedback from the subjects regarding wearing comfort and fit. Subjects were asked to express their agreement or disagreement on a five point response scale from 1(strongly disagree) to 5(strongly agree). Questions 1 to 4 inquired on wearing comfort, flexibility, tightness and freedom of movement Questions 5 and 6 concentrated on donning and doffing the garment. Question no. 7 focused on garment fit. Each subject filled the questionnaire for perceived fit of blouse constructed in three grain (warp, weft and bias). To minimize the error in wearers rating, subjects were grouped into two. First group consisting of five subjects wore 18 blouses (6×3 grains) in 100% cotton and 9 blouses (3×3grains) in polyester/cotton first and expressed their evaluation on a five point scale. The second group wore 15 blouses (5×3grains) in 100% polyester and 9 blouses (3×3grains) in polyester/ nylon blouses first and expressed their evaluation on a five point scale. Then it was changed vice-versa.

Visual Fit Evaluation

Three subjects among the ten only volunteered to participate in visual fit evaluation. Visual fit of the garment was evaluated by five judges (faculty members) on three subjects. The five judges evaluated the fit of fifty-one blouses constructed in three grain (warp, weft and bias) on each subject (while wearing). Blouse was segmented into 20 areas, 12 front parts, 6 back parts and 2 side parts (Figure 3). Judges were given orientation on the fit evaluation scales and procedures. Evaluation was carried out for both right and left side of the subject. Each judge was asked to assign their extent of agreement/disagreement towards the point of fit for all 20 areas using a five point scale with 5 representing strongly agree and 1 representing strongly disagree.

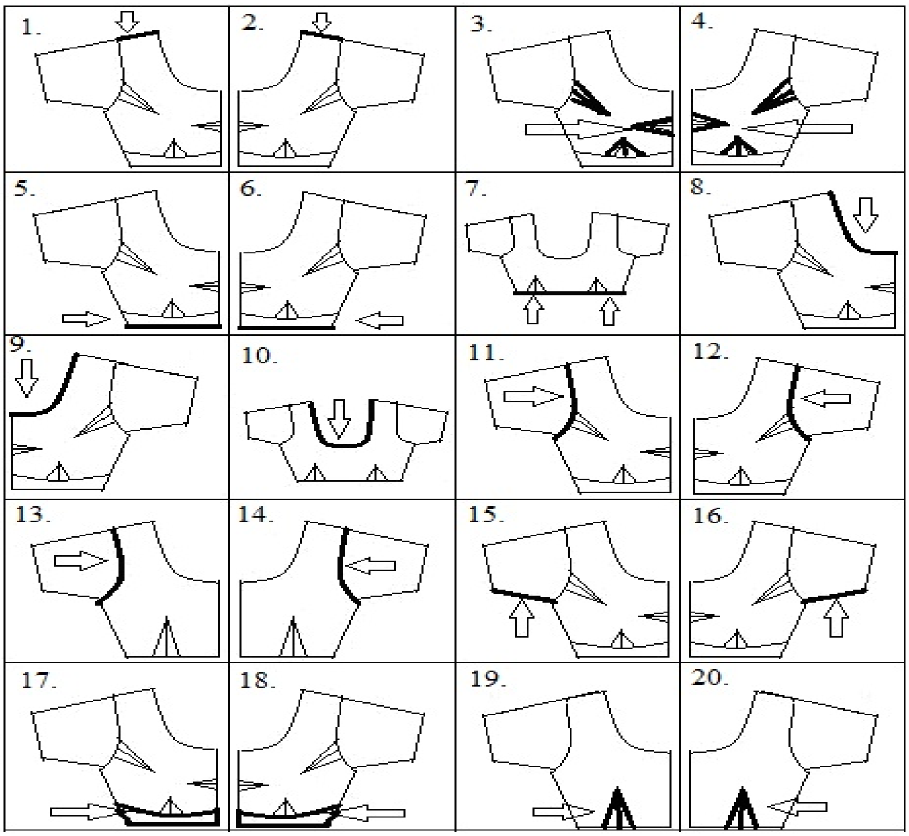

Figure 3. Visual fit evaluation

1. Front right shoulder 2.Front left shoulder 3. Front right bust 4. Front left bust
5. Front right waist 6. Front left waist 7. Back waist 8. Front right neckline
9. Front left neckline 10. Back neck line 11. Front right armscye 12. Front left armscye
13. Back right armscye 14. Back left armscye, 15. Right side underarm 16. Left side underarm
17. Front right midriff, 18. Front left midriff, 19. Right mid back, 20. Left mid back

Fit Assessment

Fit analysis in clothing is a complex phenomenon in which the relationship between the human body and clothing is assessed to judge how well the clothing conforms to a set of requirements. These requirements or elements of fit are commonly categorized as ease, line, grain, and balance and set.

Areas where the body is compressed can be assumed to be tight and areas of looseness can be seen as folds in the fabric. Algebraic comparisons of measurements between the garment and the body are used to calculate ease values or linear index. The linear index measures the difference in the linear measurement between the garment and the body representing an ease allowance. Linear index (LI) = (LM garment –LM body)/LM body (Ng, Chan, Pong & Au, 1996). The bust circumference was measured on ten subjects with and without the garment (over the cloth bra) to calculate the linear index. The value of linear index for a close fitting garment is equal to zero like a second skin. Tight fitting garments would give negative linear index. Based on the range of linear index values obtained, the ratings were assigned on a five point scale as shown in Table 3.

Developed methodology

Ease, Wrinkles and Seam line deviation were measured on ten subjects along with the subjective wear trial. Folds or number of wrinkles formed in the garment were counted for fifty-one blouses constructed in three grain (warp, weft and bias) on ten subjects. The total number of wrinkles found in the garment on each subject was counted while wearing and as per the range of wrinkle values obtained, the ratings were assigned on a five point scale as shown in Table 3. Higher the number of wrinkles, the rating assigned was 1- very poor and for lower number of wrinkles, the rating was assigned as 5- excellent.

"Line" refers to the angle of the seams and other linear elements in the design (Ashdown, Loker, Schoenfelder & Layman-Clarke, 2004). Deviations in seam line from the body line were measured on ten subjects at shoulder, sleeve, armscye, midriff, waistline, side seams subjectively by making line assessment of fit possible. The seam line exactly at the bodyline was given the value as 0 with the rating 5-excellent. The deviation in seam line measured at each bodyline provided a range of values that was assigned with the ratings 1- very poor, 2- poor, 3-good, 4-very good, 5- excellent (See Table 3).

Table 3. Rating scale for ease of measurement, number of wrinkles and seam line deviation

Sl.No	Ratings	Range		
		Ease (Linear Index)	Number of wrinkles	eam lin eviation (mm)
1.	Very poor	±0.009 - ±1	26-30	8-10
2.	poor	±0.006 - ±0.008	21-25	6-7
3.	Good	±0.003 - ±0.005	16-20	3-5
4.	Very good	±0.001 - ±0.002	11-15	1-2
5.	Excellent	0	0-10	0

Results and Discussion

Analysis of Wearers' perceived fit

The wearers' perceived fit responses to seven questions on each sample were analyzed to compare the wearers' responses for each sample. Mean score ratings and total scores for 10 subjects were calculated. Scores on the scale ranges from7 to 35, higher scores indicated good fit in garment. The validity of subjective experimental results is examined by ANOVA test using Design expert 8.0 software. An ANOVA was performed for materials, fabric specifications and grain as independent variables and fit of blouse based on subjective score rating as a dependent variable to study their significance. The summary of mean score and standard deviation of wearers' perceived fit rating in different blouse materials are given in Table 4. From Table 4, it is observed that sample 5 in. 100% cotton and sample 12 in 100 % polyester in warp grain received higher ratings and maximum score in subjective fit trial expressions. This is because of the specifications of material with higher thickness, weight, cover factor and lower drape coefficient that makes it to drape well through the body contours giving proper fit to the wearer. Blouses stitched in warp grain received highest ratings in subjective wear fit trial expressions in all the materials. This is because the weft threads in the fabric gave good extension due to higher crimp during weaving. Hence, when cut in warp grain, weft threads took stretch and formed the profile of the body allowing the fabric to ease as the yarns flex with the body movement. In general, blouse design is in such a way that while wearing it, horizontal stretch is required for fastening. Donning and doffing of the garment (question 5 and 6) received lower ratings in all the blouses stitched in bias in subjective wear trial. Among the blouse materials, sari blouse constructed from polyester/nylon materials received higher ratings and maximum score in subjective wear fit trial expression. This is because polyester/nylon fabric is smooth, shiny, stretches and draped well through the body contours giving good fit and free from wrinkles.

Table 4. Mean score and standard deviation of wearers' perceived fit rating in different blouse materials

Sample	Grain	Mean score	Standard deviation	Sample	Grain	Mean score	Standard deviation
100% Cotton materials				100% Polyester materials			
S1	Warp	32.8	1.31	S10	Warp	30.4	1.26
	Weft	27.5	0.84		Weft	27.4	1.07
	Bias	30.3	1.50		Bias	28.6	0.96
S2	Warp	31.4	1.77	S11	Warp	29.7	1.15
	Weft	28.4	1.26		Weft	26.8	0.73
	Bias	29.6	1.64		Bias	28.3	0.67
S3	Warp	30.3	0.94	S12	Warp	32.7	1.15
	Weft	27.7	0.48		Weft	27.9	0.56
	Bias	29.3	1.05		Bias	30	0.63
S4	Warp	30.8	0.99	S13	Warp	30.3	1.33
	Weft	26.8	1.68		Weft	27	1.24
	Bias	28.6	0.84		Bias	29	1.15
S5	Warp	33.2	1.13	S14	Warp	33	0.87
	Weft	28.3	1.25		Weft	29	0.70
	Bias	30.2	1.39		Bias	28.5	0.84
S6	Warp	31.1	1.47				
	Weft	28.2	1.03				
	Bias	29.3	1.58				
Polyester/cotton materials				Polyester/nylon materials			
S7	Warp	33	1.26	S15	Warp	33.9	1.25
	Weft	29.10	1.52		Weft	29.2	1.03
	Bias	30.5	1.08		Bias	31.3	0.94
S8	Warp	30.6	0.96	S16	Warp	32.6	1.52
	Weft	27.6	1.34		Weft	29.7	0.94
	Bias	28.9	0.99		Bias	30	1.10
S9	Warp	32	0.94	S17	Warp	33.6	0.87
	Weft	28.1	0.87		Weft	28.3	0.51
	Bias	29.9	0.99		Bias	31.3	1.05

It is observed from the ANOVA on total score of wearers' perceived fit rating in 100% cotton blouse materials that the fabric specifications (F= 13.12, p < 0.0001) and pattern grain influenced the fit significantly with (F= 143.03) p- value 0.001 (See Table 5). From ANOVA (Table 5), it is also observed that with polyester/cotton and 100% polyester blouse materials, fabric specifications and the grain influenced the subjective rating of fit significantly. However, in the case of polyester/nylon union fabric, the fabric specification and grain does not significantly influence the subjective rating of fit. There were no significant differences (p > 0.001) between the observations of the subjects in all blouse materials.

Table 5. ANOVA - Total score of wearers' perceived fit rating in different blouse materials

100% cotton blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	770.59	71	10.85	9.24	< 0.0001
A- Between samples	83.69	5	16.74	14.26	< 0.0001
B- Between grain	476.48	2	238.24	202.92	< 0.0001
C- Between subjects	34.01	9	3.78	3.22	0.0017
AB	146.72	10	4.67	3.98	0.0001
AC	129.69	45	2.88	2.45	< 0.0001
Residual	126.80	108	1.17		
Cor.Total	897.39	179			
Polyester/ cotton blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	269.78	4	67.44	52.49	< 0.0001
A- Between samples	58.02	2	29.01	22.58	< 0.0001
B- Between grain	211.76	2	105.88	82.41	< 0.0001
Residual	109.21	85	1.28		
Cor.Total	378.99	89			
100% Polyester blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	492.65	23	21.42	25.45	< 0.0001
A- Between samples	109.71	4	27.43	32.59	< 0.0001
B-Between grain	340.17	2	170.09	202.13	< 0.0001
C-Between subjects	23.07	9	2.56	3.05	0.0025
AB	19.69	8	2.46	2.93	0.0050
Residual	106.03	126	3.37		
Cor.Total	598.67	149			
Polyester/ nylon blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	262.00	29	9.03	7.74	< 0.0001
B- Between grain	13.27	2	6.63	5.69	0.0055
C-Between subjects	46.00	9	5.11	4.38	0.0002
BC	202.73	18	71.26	9.65	< 0.0001
Residual	109.21	85	1.28		
Cor.Total	378.99	89			

The ANOVA on subjective mean score fit rating in overall blouse materials are given in Table 6. It is observed from the ANOVA analysis on mean score rating of wearers' perceived fit in blouse materials that the type of material (F= 24.37, p < 0.0001) and pattern grain influenced the fit significantly with (F= 528.15) p- value 0.001 (See Table 6).

Table 6. ANOVA on subjective mean score fit rating in overall blouse materials

Source	Sum of Squares	Degree of freedom	Mean Square	F Value	P-value Prob > F
Model	3706.64	203	18.26	9.39	< 0.0001
A- Between materials	758.41 16	16	47.40	24.37	< 0.0001
B- Between grain	2054.38	2	1027.19	528.15	< 0.0001
C- Between subjects	52.09	9	5.79	2.98	0.0021
AB	174.49	32	5.45	2.80	< 0.0001
AC	667.28	144	4.63	2.38	< 0.0001
Residual	595.13	306	1.94		
Cor.Total	4301.77	509			

Visual Fit Assessment Data Analysis

Five judges (faculty members) from the department of fashion technology rated the fit while the subjects were wearing the blouses. Thus, a total of 15300 (5 judges*3subjects*20segments*17samples*3 grain) ratings were obtained. Total scores were calculated from the ratings assigned by the judges to 20 segments on three subjects for fifty-one blouses. Scores on the scale ranges from 20 to 100. The group of judges discussed and compared the fit between materials and grain to assess the blouse fit that improved the reliability of the ratings. The summary of mean score and standard deviation of visual analysis of fit by judges in different blouse materials are given in Table 7. It is observed from Table 7 that the blouse stitched in warp grain received highest rating in visual analysis of fit by judges. It was observed that the blouse stitched in bias grain draped well over the body contours giving right shape for the bust but diagonal wrinkles were seen near the neckline and shoulder areas that disfigured the appearance of the blouse. It was also noted that blouse stitched in weft grain with warp yarns running horizontally over the body distorted the shape of the bust, as weft threads stretched vertically. Wrinkles were seen at front and back armscye areas of left and right in all the blouses and received lower ratings at front and back armscye areas of left and right in all three grains in visual fit analysis by judges.

Table 7. Mean score and standard deviation in visual analysis of fit rating by judges in different blouse materials

Sample	Grain	Mean score	Standard deviation	Sample	Grain	Mean score	Standard deviation
100% Cotton materials				100% Polyester materials			
S1	Warp	80.4	2.65	S10	Warp	80.2	2.07
	Weft	73.9	2.24		Weft	76.3	2.5
	Bias	76.7	2.08		Bias	77.5	1.45
S2	Warp	80.7	2.1	S11	Warp	78.1	1.18
	Weft	74.6	0.99		Weft	76.8	3.06
	Bias	76.6	1.5		Bias	78.4	1.59
S3	Warp	78.3	2.4	S12	Warp	83.8	2.11
	Weft	75.6	1.44		Weft	77.6	2.44
	Bias	76	2.51		Bias	78.9	2.4
S4	Warp	81	1.99	S13	Warp	79.2	1.47
	Weft	77.5	1.54		Weft	76	3.41
	Bias	78.6	2.01		Bias	78.2	2.55
S5	Warp	83.5	2.38	S14	Warp	83.7	2.05
	Weft	78.2	4.3		Weft	77.6	1.68
	Bias	79.1	2.8		Bias	78.4	3.01
S6	Warp	79.4	2.8				
	Weft	76.5	2.09				
	Bias	77.7	2.60				
Polyester/cotton materials				Polyester/nylon materials			
S7	Warp	80.8	2.11	S15	Warp	84.1	1.40
	Weft	75.5	2.94		Weft	77.3	0.9
	Bias	77.2	2.31		Bias	80.4	1.55
S8	Warp	77.8	1.99	S16	Warp	80.5	1.02
	Weft	73.2	2.62		Weft	78.3	1.5
	Bias	74.2	3.3		Bias	80.8	1.42
S9	Warp	80.7	3.12	S17	Warp	84.6	1.4
	Weft	73.1	2.79		Weft	78.2	1.2
	Bias	75.2	3.6		Bias	81.4	1.22

Sari blouse constructed from 100% polyester and polyester/nylon materials received higher ratings and maximum score in visual fit analysis by judges. This is because of the inherent properties of polyester that provided wrinkle recovery and shape retention in addition to luster properties. The ANOVA results of visual analysis of fit by judges in blouse materials are shown in Table 8. It is observed from the ANOVA analysis on different materials that, over all the materials, the pattern grain and fabric specifications influenced the fit significantly with a p value 0.0001. However, in the case of polyester/nylon union fabric, the specification does not significantly influence the fit.

Table 8. ANOVA - Total score of visual analysis of fit by judges in different blouse materials

100% cotton blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	2539.88	71	35.77	11.00	<0.0001
A- Between samples	551.71	5	110.34	33.92	<0.0001
B-Between grain	1318.36	2	659.18	202.65	<0.0001
C-Between judges	88.76	4	22.19	6.82	<0.0001
AC	333.46	20	16.67	5.13	<0.0001
ACD	247.59	40	6.19	1.90	0.0022
Residual	644.05	198	3.25		
Cor. Total	3183.93	269			
100% Polyester/cotton blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	6752.76	31	217.83	41.17	<0.0001
A- Between samples	836.33	5	167.27	31.62	<0.0001
B-Between grain	1336.21	2	668.10	126.28	<0.0001
C-Between judges	4046.50	4	1011.62	191.22	<0.0001
AC	533.73	20	26.69	5.04	<0.0001
Residual	1259.13	238	5.29		
Cor. Total	8011.89	269			
100% Polyester blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	1629.26	26	62.66	16.58	<0.0001
A- Between samples	163.30	2	81.65	21.60	<0.0001
B-Between grain	820.86	2	410.43	108.60	<0.0001
C-Between judges	292.03	4	73.01	19.32	<0.0001
D-Between subjects	11.75	2	5.87	1.55	0.2160
AC	231.44	8	28.93	7.65	<0.0001
CD	109.88	8	13.74	3.63	0.0009
Residual	408.18	108	3.78		
Cor. Total	2037.44	134			
Polyester/nylon blouse materials					
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value Prob > F
Model	479.36	4	119.84	65.32	<0.0001
A- Between samples	30.28	2	15.14	8.25	0.0004
B-Between grain	449.08	2	224.54	122.38	<0.0001
Residual	238.52	130	1.83		
Cor. Total	717.88	134			

Rank correlation coefficient analysis between subjective wear trial expressions and visual analysis by judges

To examine the correlation between the wearers perceived fit and visual analysis of fit, spearman's rank correlation coefficient was analyzed. Total scores of ten subjects in wearers perceived fit and total scores assigned by judges in visual analysis of fit towards seventeen blouse materials was ranked for calculating rank correlation coefficient .The attained scores were replaced by ranks giving rank 1 to highest value and rank 2 to next highest value. As samples stitched in warp grain received higher subjective score ratings in both the wear trial expressions and visual analysis by judges, rank correlation coefficient was analyzed for the samples stitched in warp grain. It is observed that there is a correlation of 0.58 between subjective wear trial expressions by subjects and visual analysis of fit by judges. This result suggests that there is a positive correlation.

Fit assessment by measuring ease, number of wrinkles and seam line deviation

The influence of fit attributes such as ease allowance, number of wrinkles and seam line deviation on the subjects were measured and subjective wearer rating scale as per the attributes is shown in Table 3 and mean fit ratings on ease, number of wrinkle and seam line deviations are shown in Table 9. It is observed from the ANOVA (Table 10) that for all the blouses stitched by changing grain and fabric, ease did not influence the wearer subjective rating but the number of wrinkles varied significantly with respect to the sample specifications. It is also observed that there is a deviation in the seam lines between the samples which influenced the appearance of the garment and hence fit.

Table 9. Mean fit ratings obtained in ease, number of wrinkles and seam line deviation

Sample	Grain	Ease	Wrinkle	Line	Sample	Grain	Ease	Wrinkle	Line
100% cotton blouse materials					100% Polyester blouse materials				
S_1	WARP	4.5	3.8	4.4	S_{10}	WARP	4	4	4
	WEFT	3.8	3.4	4		WEFT	3.6	3.8	3.8
	BIAS	4.2	3.5	4		BIAS	3.6	3.4	3.8
S_2	WARP	4	3.5	3.8	S_{11}	WARP	4.2	4.2	3.5
	WEFT	3.8	3.2	3.6		WEFT	3.6	3.6	3.8
	BIAS	4	3.2	3.8		BIAS	3.8	3.6	3.6
S_3	WARP	4	3.6	4.2	S_{12}	WARP	4	4.4	4.2
	WEFT	3.8	3.4	3.8		WEFT	3.6	4	3.6
	BIAS	3.8	3.5	4		BIAS	3.6	3.8	3.8
S_4	WARP	4.2	3.8	3.8	S_{13}	WARP	4.2	4	3.8
	WEFT	3.8	3.5	3.6		WEFT	3.6	3.8	3.5
	BIAS	4	3.6	3.8		BIAS	3.8	3.8	3.8
S_5	WARP	4.5	4	4.4	S_{14}	WARP	4.4	4.2	4
	WEFT	4.5	3.5	4		WEFT	3.8	3.8	3.8
	BIAS	4.2	3.2	3.6		BIAS	4	3.8	3.8
S_6	WARP	4.5	3.6	4.2					
	WEFT	4	3.5	4					
	BIAS	4.2	3.6	3.6					
100% Polyester/cotton blouse materials					Polyester/nylon blouse materials				
S_7	WARP	4.4	3.8	4	S_{15}	WARP	4.2	4.5	4
	WEFT	3.8	3.8	4		WEFT	3.8	4	3.8
	BIAS	4	3.6	3.6		BIAS	4	4	4
S_8	WARP	4	3.8	3.8	S_{16}	WARP	3.8	4.2	4
	WEFT	3.8	3.8	3.6		WEFT	3.6	3.8	4
	BIAS	4.2	3.4	3.6		BIAS	4	4	4
S_9	WARP	4	4	4.2	S_{17}	WARP	4	4.4	4.2
	WEFT	3.8	3.8	4		WEFT	3.6	3.6	4
	BIAS	3.8	3.6	3.8		BIAS	4	4	4.2

Table 10. ANOVA – Ease of measurement, number of wrinkles, and seam line deviation between blouse materials

ANOVA on ease measurement					
Source of Variation	Sum of Squares	Degree of freedom	Mean Squares	F value	p-value
Samples	2.008235	16	0.125515	5.52	2.05
Grain	1.306275	2	0.653137	28.7	7.14
Error	0.727059	32	0.022721		
Total	4.041569	50			
ANOVA on number of wrinkles					
Source of Variation	Sum of Squares	Degree of freedom	Mean squares	F-Value	p-value
Samples	1.746667	16	0.109167	3.33	0.0018
Grain	0.823529	2	0.411765	12.6	9.46
Error	1.049804	32	0.032806		
Total	3.62	50			
ANOVA on seam line deviation					
Source of Variation	Sum of Squares	Degree of freedom	Mean Square	F-Value	p-value
Samples	1.394902	16	0.087181	3.49	0.0013
Grain	0.646275	2	0.323137	12.9	7.71
Error	0.800392	32	0.025012		
Total	2.841569	50			

Number of wrinkles and seam line deviation were found to be comparatively less in blouses stitched in warp grain in 100% cotton, polyester/cotton and 100% polyester fabrics. Considerably fewer wrinkles and seam line deviations were noticed in blouses stitched in polyester/nylon materials. Diagonal wrinkles were seen in the front cup cut in bias in 100% cotton and polyester/cotton fabrics. Sample 5 in 100% cotton and sample 12 in. 100% polyester in warp grain received highest rating on fit assessment on number of wrinkles and seam line deviations.

Conclusions

The work investigated the fit of commercially available sari blouse materials. Seventeen samples of 100% cotton, polyester/cotton fabric, 100% polyester and polyester/nylon fabrics were selected for study. We have examined the influence of material, fabric properties on garment fit and also analyzed the effect of grain (warp, weft and bias) on garment fit. Subjective wear trial expressions by the subjects and visual analysis of fit of 51 blouses on three subjects by judges offered a qualitative assessment of fit. A methodology is designed to quantify the fit attributes like ease measurement ,number of wrinkles and seam line deviation, when the subjects wore the blouses and the range of values obtained were assigned with ratings on a five point scale and mean fit ratings was calculated . It is observed that the wrinkle and seam line varied significantly with grain, fabric specification and material. With reference to the material, it is observed that polyester/nylon union fabrics had considerably lower wrinkles and less variation in seamline from bodyline. It is observed from the ANOVA results that the material, specifications and the grain change influenced the fit of sari blouse significantly.

From the overall analysis of fit, it is concluded that the front cup area cut in warp grain received higher ratings and gave better fit with less number of wrinkles in the armscye and front cup area and less deviation in seamline from bodyline at shoulder, armscye and side seams and thereby improved the appearance of the blouse . Polyester/nylon materials gave the best fit and were much preferred by subjects because of its inherent properties like wrinkle resistance characteristics, shape retention and luster. Fabric properties were so critical in determining the fit of the garment. The sari blouse material with higher thickness, weight and cover factor draped well through the body contours and gave better fit to the wearer. There was a total agreement on the importance of fabric specifications and garment fit. From the results, it is observed that lighter weight blouse materials shows more wrinkles and seam line deviations in blouse and affects the fit of the blouse. Therefore, this study would help the fabric/garment manufacturers to select the blouse material and also to design a blouse with higher ends per inch and picks per inch that would produce a slightly thicker fabric and would drape well and provide good fit to the wearer.

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