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Analysis of Tensile Strength of Fabrics Used in Production of Sportswear

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Abstract: *Sportswear fabric need to provide a comfortable wear for sport activities /game and consequently provide a good strength, woven fabric has greater tensile strength than the knitting fabric. Meanwhile, knitting fabric required less force for it to extend, which made it more advantage in manufacturing of sportswear than the woven fabric that required more force for it to extend. Fabric with less tensile strength have ability to handle moisture vapour and sweat produced by the body during strenuous activity in sports to feel good. In general, knitting fabric is best for manufacturing of sportswear than the woven fabric.*

Key words: *Sportswear, Comfort, Tensile Strength, Fabric.*

TRODUCTION

Background to the Study

Tensile strength is one of the most important mechanical properties for fabrics. To quantify the tensile strength of a piece of fabric, two testing methods are often used, namely the grab test and the strip test. Each testing method has its own advantages and disadvantages. Specimens in the grab test are easier to prepare, and the testing condition is closer to the load application on a fabric in practical use. However, the results of the grab test may not be as accurate and interpretable as those of the strip test, but the preparation of unraveled strip specimens usually takes up time. Both testing methods have been standardized as the ASTM standard D5034-95 for the grab test and D5035-95 for the strip test, respectively.

Given the wide application of both striping methods, it is desirable to establish the relationship between these two methods from both theoretical and experimental viewpoints. A few studies have been reported establishing the relationship between the grab and strip tests. These early investigations attempted to explore the relationship from empirical approaches. However, the tensile mechanisms and physical implications involved cannot be obtained from those studies. Recently, Pan (1984) conducted a theoretical investigation to relate the grab and strip tensile strengths of a fabric. In his model a grab specimen is basically divided into two portions, the gripped part held by the machine grips, acting essentially like a strip specimen, and the ungripped parts on each side of a grip. A herringbone deformation mode was adopted for the ungripped portions caused by the tensile load during the test. According to continuum mechanics, the shear forces within the herringbone elements contribute to the generation of tensile stress in the ungripped portion. With the assumptions of roughly linear mechanical behavior of a fabric specimen as well as the negligence of the Poisson effect, the tensile stress in the ungripped portions can be expressed in terms of gauge length, ungripped specimen width, machine clamp width, and tensile and shear modulus of the specimen, among other variables. The overall tensile strength for a grab specimen can thus be calculated as the combination of the contributions from both ungripped and gripped parts. In other words, the tensile strength of the ungripped portions obviously determines the difference between the grab and the strip tensile strengths for a fabric specimen.

FABRIC

Fabric is a manufactured assembly of fibres and/or yarn that has substantial surface area in relation to its thickness and sufficient cohesion to give the assembly useful mechanical strength or tensile strength (Denton and Daniels, 2002). Also, there are many ways of making fabrics from textile fibers. The most common and most complex category comprises of fabrics made from interlaced yarns. These are the traditional methods of manufacturing textiles. The great scope lies in choosing fibers with particular properties, arranging fibers in the yarn in several ways and organizing in multiple ways, interlaced yarn within the fabric. This gives textile designer great freedom and variation for controlling and modifying the fabric. The most common form of interlacing is weaving, where two sets of threads cross and interweave with one another. The yarns are held in place due to the inter-yarn friction. Another form of interlacing where the thread in one set inters locks with the loops of neighboring thread by looping is called knitting. The interloping of yarns results in positive binding. Knitted fabrics are widely used in apparel, home furnishing and technical textiles. Lace, Crochet and different types of Net are other forms of interlaced yarn structures. Braiding is another way of thread interlacing for fabric formation. Braided fabric is formed by diagonal interlacing of yarns. Braided structures are mainly used for industrial composite materials. Other forms of fabric manufacture use fibers or filaments laid down, without interlacing, in a web and bonded together mechanically or by using adhesive.

The former are needle punched nonwovens and the later spun bonded. The resulting fabric after bonding normally produces a flexible and porous structure. These find use mostly in industrial and disposable applications. All these fabrics are broadly used in three major applications such as apparel, home furnishing and industrial. The traditional methods of weaving and hand weaving will remain supreme for high cost fabrics with a rich design content. Based on the nature of the yarn or fibre arrangements, fabrics are classified as woven, knitted, twisted and knotted, non-woven or compound fabric. Among them, woven fabric and knitted fabric are the major materials for apparel use (Dai, Choi and Li, 2006).

Woven fabrics

Woven fabrics are structures produced by interlacing two sets of threads: the warp which runs in a lengthways direction and the weft which runs in a width ways direction. There are three basic weaves used to produce woven fabrics: plain weave, twill weave and satin weave. Within the structure of these basic weaves are variations. Other weaves are variations and/or combinations of the basic weaves and are classified as complex or novelty weaves. By their very nature, woven fabrics are rigid or semi-rigid in the vertical and horizontal directions with only slightly more flexibility in the bias direction (Gioello, 1982).

Knitted fabrics

Fabric is produced by several parallel yarns that form one stitch for each yarn in each course. Each stitch in a course is made of different yarns (Gioello, 1982). Knitted fabric is structure that is formed by the intermeshing of loop yarn (Denton and Daniels, 2002). There are two types of knitted fabric structure: weft knitted and warp knitted. Weft knitted fabrics is produced by a system of interlocking loops in the weft direction. The loops are in horizontal courses with each course built on top of the other and all the stitches in the course are made by one yarn. Warp knitted fabrics are produced by a system of interlocking loops in the warp direction. Knitted fabric is the most common fabric structure for the base layer, as it possesses high stretch and recovery, providing greater freedom of movement, shape retention and tailored fit. Knitted fabrics also have relatively uneven surfaces, which make them feel more comfortable than smooth-surfaced woven fabrics of similar fibre compositions. Knitted fabrics are the most commonly used for functional sportswear garments due to their good handle and ability to provide greater freedom of movement. The types of fibers used play an important role in the heat and moisture management capabilities of knitted fabrics. For example, synthetic fibers (e.g. polyester) are often used preferably over natural fibers in sportswear fabrics because of their lower capacity for absorbing moisture and ability to transport water vapor. However, several fabric studies have shown that the yarn and structural aspects of the fabric, which determine variables such as fabric thickness and porosity, can play a greater role in the thermophysiological comfort properties than fiber type alone (Denton and Daniels, 2002) measured the moisture vapor transport behavior of polyester knit fabrics and found similar trends in both cotton and polyester knit fabrics on thermal comfort properties. Measures of thermal conductivity and thermal resistance increased with fabric thickness, while water vapor permeability was lower for thicker fabrics. A positive relationship between fabric thickness and thermal resistance was also seen in a study by (Denton and Daniels, 2002), evaluated heat and moisture transfer properties in a group of commercially produced underwear fabrics designed for sportswear applications.

This effect results from the fact that fabric that has uneven surfaces has less direct contact with the skin (Higgins and Anand, 2003). Knitted fabric can be structured as multi-layer knitted fabric. Multi-layered fabrics, produced by either warp or weft knitting, have been developed for use in sportswear and active wear. It is possible to knit a simple two-layer construction, which facilitates relatively fast removal of sweat from the skin and in which evaporation remains unhindered by multiple layers of fabric. Such a fabric might have a structure in which the inner layer is produced from a textured synthetic filament yarn which is hydrophobic and has good capillary action while the outer layer is made hydrophilic yarn that absorbs the moisture and then allows it to evaporate (Higgins and Anand, 2003).

Research into the design of knitted fabric showed that the double layer fabrics are an ideal structure. For the doubled layer fabric, it is recommended that the inner layer, which touches the skin, is made from synthetic materials that have good moisture transfer properties such as polyester, acrylic, nylon or polypropylene. For the outer layer, materials that have good moisture absorption properties such as cotton, wool, viscose or their blends are recommended. The perspiration built up on the surface of the skin will be transferred to the outer layer of the fabric by way of the inner surface and consequently it will be absorbed by the outer surface. When absorptive material is used as inner layer, skin will have continuous contact with a wet layer and this feeling will irritate the wearer (Ceken, 2004).

Knitted fabric is the most suitable fabric structure for next-to-skin sportswear, as it possesses high stretch and recovery, providing greater freedom of movement, shape retention and tailored fit. Knitted fabrics also have relatively uneven surfaces, which make them feel more comfortable than smooth-surfaced woven fabrics of similar fibre compositions and have less direct contact with the skin. Multi-layer knitted fabrics made of different fibres with different water absorption will create base layer fabrics that have good moisture transfer properties and keep the skin dry.

SPORTSWEAR

Sportswear textiles belong to a category called sporttech, which is one of the mainstream technical textiles (Anand and Horrocks 2000). The consumption of textile fibres and fabrics in sportswear and sporting related goods has seen a significant increase in the last decade or so. The requirement of sportswear depends on the sport participants and the sport level activity. For instance in case of winter sports which are normally performed in the cold environmental conditions. In a condition of 0^{o}C without wind, humans can exercise at sufficient levels to adequately maintain core temperature while wearing one cold of thermal insulation .The cold unit is an index of clothing thermal resistance. One cold represents the clothing necessary to allow a resting individual to be in a comfortable state when the ambient temperature is 21^{o}C. As the ambient temperature decreases, a significantly greater amount of clothing is required to maintain core temperature. In contrast to the small amount of clothing are commonly worn during exercise in warm or hot environments, also exercise in cold environments requires that selections of clothing insulation be made at appropriate levels (Crow and Osczevski 1998; Gavin, 2003).

In an analysis by Rigby (2002), it was stated that the worldwide consumption of textiles for sports increased from 841,000 tons in 1995 to 1,153,000 tons in 2005. The forecast made for 2010 was 1,382,000 tons. This reflects to a large extent the significant rise in interest of the population worldwide in active indoor and outdoor sports as well as in outdoor leisure pursuits (Shishoo, 2005)

Clothing selection for outdoor sports activities is a complex task. The ideal role of a clothing system is to maintain the thermal balance of the user in various environmental conditions despite the user's level of activity. The balance between heat production and heat dissipation is difficult to maintain. Too little clothing with low thermal insulation may

lead to hypothermia while an excessive amount may lead to discomfort due to significant increases in body temperature and excessive sweating and skin wetness.
This rising interest is due to a number of social factors that include increased leisure time, increased considerations of wellbeing and good health, growth of indoor and outdoor sports facilities and the ever-increasing pursuit of the adult population of activities outside the home or workplace. Textile materials in various shapes and forms are being used in a wide range of applications in sportswear and sporting equipment, and the manufacturers of these products are often at the forefront of textile manufacturing technologies for enhancing the properties of performance fabrics and sportswear in order to fulfil various types of consumer and market demands.

Sportswear as a technical textile

Technical textiles are textile materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics. Terms such as performance textiles, functional textiles, engineered textiles and high-tech textiles are also used in various contexts, sometimes with a relatively specific meaning (performance textiles are frequently used to describe the fabrics used in activity clothing), but more often with little or no precise significance (Anand and Horrocks, 2000).

TENSILE STRENGTH

Tensile strength is the ability of a material to withstand a pulling (tensile) force. It is customarily measured in units of force per cross-sectional area. This is an important concept in engineering, especially in the fields of material science, mechanical engineering and structural engineering. The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. Tensile strength is important in the use of brittle materials more than ductile materials.

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure, such as breaking or permanent deformation. Tensile strength specifies the point when a material goes from elastic to plastic deformation. It is expressed as the minimum tensile stress (force per unit area) needed to split the material apart. For example, if a metal rod one square inch in cross section can withstand a pulling force of 1,000 pounds but breaks if more force is applied, the metal has a tensile strength of 1,000 pounds per square inch. The tensile strength for structural steel is 400 megapascals (MPa) and for carbon steel is 841MPa. Tensile strength is different for different densities of steel.

METHODOLOGY

In this chapter, the material and methods used for this research work will be discuss, in order to achieve the aims and objectives of the study, as it has be stated in chapter one. In general, the steps during which research data are collected, processed, analyzed, and presented manually or electronically will also be discuss. Fasakin (2006), defined research methodology as the different processes, measures, principles and methods by which data and information are sourced, specified, defined, collected, processed and analyzed.
There are two basic methods of testing Tensile Strength of fabric used in textile industries, namely:

i. Grap testing method/procedure and
ii. Strip testing method/procedure

In this study, strip-testing method was used in testing the Tensile Strength of fabric used in the manufacturing of sportswear. The raveled strip test in this test method is considered satisfactory for acceptance testing of commercial shipments of woven textile fabrics, since the method has been used extensively in the trade for acceptance testing.

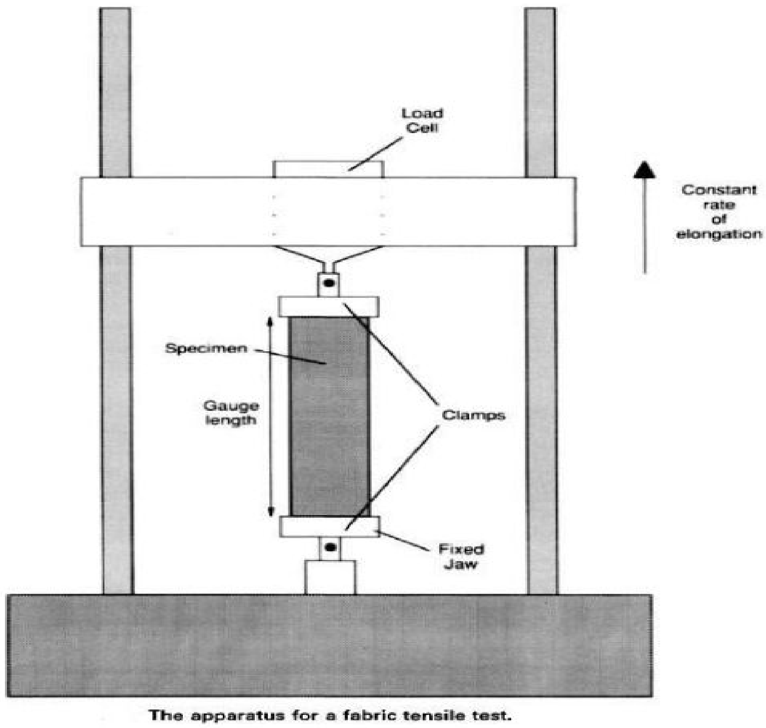

Figure 1: The Apparatus for Fabric Tensile Test.

REGRESSION ANALYSIS

Regression is a tools developed for parameter estimation and model verification, it is a very useful class of models encountered in science and engineering. A commonly occurring situation is one in which random quantity, Y, is a function of one or more independent (and deterministic) variables $X_1, X_2, \ldots, X_m$. Given a sample of Y values with their associated values of X_i, for i= 1, 2, . . . , n, we are interested in estimating on the basis of this sample the relationship between Y and the independent variables $X_1, X_2, \ldots, X_m$.

In general the model for regression can be written as:

$$y_i = \beta_0 + \beta_i X_i + \varepsilon_i \; ; \text{ for } i = 1, 2, \cdots n. \qquad 3.1$$

Where;

β_0 = Slope

β_i = Intercept

x_i = Independent variable's

Y = Dependent variable

ε_i = Error term/component.

As one approach to point estimation of regression parameters $\hat{\alpha}$ and $\hat{\beta}$, the method of least squares suggests that their estimates can be chosen so that the sum of the squared differences between observed sample values y_i and the estimated expected value of Y, is minimized. Which can be written as;

$$\varepsilon_i = y_i - \left(\hat{\alpha} - \hat{\beta}_i x_i\right); \text{ for } i = 1, 2, \cdots n. \cdots\cdots 3.2$$

The least-square estimates $\hat{\alpha}$ and $\hat{\beta}_i$, respectively, of and are found by minimizing

$$Q = \sum_{i=1}^{n} \varepsilon_i^{\,2} = \sum_{i=1}^{n} \left[y_i - \left(\hat{\alpha} - \hat{\beta}\right)\right]^2 \cdots\cdots 3.3$$

In the above, the sample-value pairs are $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, and ε_i, $i = 1, 2, \ldots, n$, are called the *residuals*. The estimates are easily found based on the least-square procedure.

$$\hat{\alpha} = \bar{y} - \hat{\beta}\bar{x} \cdots\cdots 3.6$$

$$\hat{\beta} = \frac{\left[\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})\right]}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdots\cdots 3.5$$

Where;

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i, \cdots\cdots 3.6$$

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \cdots\cdots 3.7$$

MULTIPLE LINEAR REGRESSION

Multiple regression is one in which the random quantity, Y, is a function of more than one independent (and deterministic) variables $X_1, X_2, \ldots, X_m$. For the case of this research multiple regression is used, because to the research involves more than one independent variables that is, in particular two independent variables (woven and knitting fabric) which are to be used to predict the dependent variable, i.e the product (sportswear).

In multiple linear regression, the model takes the form

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_m X_m + \varepsilon_i \cdots\cdots 3.8$$

Where;

β_0 = Slope

β_i = Intercept

$X_{m's}$ = Independent variable's

Y = Dependent variable

ε_i = Error term/component

Subscript i denotes the observational unit

Again, we assume that the variance of Y is σ^2 and is independent of $X_1, X_2, \ldots, X_m$. As in simple linear regression, we are interested in estimating $(m+1)$ regression coefficients 0, 1,

. . . , and m, obtaining certain interval estimates, and testing hypotheses about these parameters on the basis of a sample of Y values with their associated values of (X_1, X_2 , . . . , X_m). Let us note that our sample size n in this case takes the form of arrays $(x_{11}, x_{21}, \ldots x_{m1}, Y_1), (x_{12}, x_{22}, \ldots x_{m2}, Y_2), \ldots, (x_{1n}, x_{2n}, \ldots x_{mn}, Y_n)$. For each set of values, k = 1, 2, . . . m, of X_i, Y_i is an independent observation from population Y defined by

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_m X_m + \varepsilon_i \quad \cdots 3.9$$

The least square equation used to (determine) fit the model for multiple regression is as follows:

$$\sum y = \beta_0 + \beta_1 \sum X_1 + \beta_2 \sum X_2 + \cdots + \beta_m \sum X_m + \varepsilon_i \quad \cdots 3.10$$

LEAST SQUARES METHOD OF ESTIMATION

To estimate the regression coefficients, the method of least squares will again be employed. Given observed sample-value sets $(x_{11}, x_{21}, \ldots x_{m1}, y_i)$, for; $i = 1, 2 \ldots n$ the system of observed regression equations in this case takes the form;

$$y_i = \beta_0 + \beta_1 X_{11} + \beta_2 X_{12} + \cdots + \beta_m X_{1m} + \varepsilon_i \quad \cdots 3.11$$

Matrix form component of multiple regression can be written as:

$$c = \begin{pmatrix} a_{11} & a_{12} \cdots & a_{1n} \\ a_{21} & a_{22} \cdots & a_{2n} \\ \vdots & \vdots \ddots & \vdots \\ a_{m1} & a_{m2} \cdots & a_{mn} \end{pmatrix}, \quad y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix},$$

$$\beta = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_n \end{pmatrix}, \quad \varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \beta_n \end{pmatrix}$$

As from the given matrices above, we can put the matrix into model as:

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \cdots & a_{1n} \\ a_{21} & a_{22} \cdots & a_{2n} \\ \vdots & \vdots \ddots & \vdots \\ a_{m1} & a_{m2} \cdots & a_{mn} \end{pmatrix} \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_n \end{pmatrix} \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix} \quad \ldots 3.12$$

The element of a particular row of a , are the coefficients on the corresponding parameters. In β that gives E(y_i). Note that β_o has a constant multiplier of one for all observations. Hence, the column vector one is the first column of a multiplying the first row of a by β and adding the first element of ε contains that the model for the first observation as in equation 3.6.

NORMAL EQUATION FOR MULTIPLE REGRESSION

In matrix notation, the normal equation are written as:

$X'X\hat{\beta} = X'Y$ 3.13

The normal equations are always consistent and hence will always have a solution of the form.

$\hat{\beta} = (X'X)^{-1}(X'Y)$ 3.14

If $(X'X)$ has an inverse then the normal equation have a unique solution given as in equation 3.14.

The multiplication $(X'X)$ generates, $m^1 \times m^1$ matrix where the diagonal elements are the sums of equations of each of the independent variables and the off-diagonal elements are the sums of products between the independent variables. The general form of $(X'X)$ is,

$$\begin{pmatrix} n & \sum a_{11} & \sum a_{12} & \cdots & \sum a_{1n} \\ \sum a_{11} & \sum a^2_{11} & \sum a_{11} a_{12} & \cdots & \sum a_{11} a_{1n} \\ \sum a_{21} & \sum a_{11} a_{22} & \sum a^2_{21} & \cdots & \sum a_{21} a_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \sum a_{m1} & \sum a_{11} a_{m1} & \sum a_{12} a_{m1} & \cdots & \sum a^2_{mn} \end{pmatrix}$$

The elements of the matrix product XY are one the sums of product between each independent variables in turn and the dependent variable.

ANALYSIS OF VARIANCE (ANOVA)

Analysis of Variance (ANOVA) table is used to draw a valid conclusion using the p-valve on the table or student t- table, that is to say student t-table is determined by using statistical t-table. The value obtained is known as F-tabulate ($F_{tab.}$)

i. In the case of using p-value, if the p-value is less than level of significant (α) then we reject H_o. if otherwise, we fail to reject H_o.
ii. In the case of using student t-table, if $F_{calc.}$ is greater than $F_{tab.}$ then we reject Ho. Otherwise, we fail to reject H_o.

The summary of Analysis of Variance (ANOVA) table is show below:

Source	DF	SS	MS	F	P-valve
Regression	m-1	SS Regression.	$MS_{Reg.} = \frac{SS_{Reg}}{m-1}$	$\frac{MS_{Reg.}}{SS_{Reg.}}$	
Residual	n-m	SS Residual.	$MS_{Res.} = \frac{SS_{Res.}}{n-m}$	$\frac{MS_{Res.}}{SS_{Res.}}$	
Total	n	SS Total			

Where:

m= Number of parameter

n = Total number of observation/sample size.

HYPOTHESIS OF THE STUDY

H_0: The Tensile Strength of the fabric used in manufacturing of sportswear are not significant.

H_1: The Tensile Strength of the fabric used in manufacturing of sportswear are significant.

RESULTS AND DISCUSSION

Analytical Procedure

This chapter covers the analysis of data provided in table 4.1. The descriptive statistics and test for the relationship between the fabrics, and all other analysis used in this work were done with the use of computer using R-Package (R x648 3.1.2) and MINITAB, and results were presented in a meaningful and concise manner for an average reader to understand.
The analysis was conducted in three stages. The first stage is the summary analysis, which deals with the use of descriptive statistics to explore the data. The second stage is ANOVA analysis which involved the investigation whether the data are related in manufacturing of sportswear and fit the model for the analysis. Third stage is the plot or graph to illustrate pertain of the data set. In other word chart are also used were necessary.
Table 4.1 Tensile strength of sportswear, woven fabric and knitting fabric.

Sportswear (y_i)	Woven fabric(x_1)	Knitting fabric (x_2)
94.18	89.60	63.20
83.43	72.20	62.20
96.56	88.80	76.33
77.35	69.60	56.70
57.91	52.00	36.60
95.12	88.71	70.56
62.19	50.84	53.66
70.27	64.22	59.17

Source: African Textile Manufacturing Industry (ATM), Sharada Kano State.
Regression Analysis: sportswear versus knitting, woven fabric.

The regression equation is
Sportswear = 8.24 + 0.246 knitting + 0.787 woven

Table 4.2 Summary of the Analysis

<table>
<tr><th>Estimate</th><th>Std. Error</th><th>t value</th><th>Pr(>|t|)</th><th>|t|</th></tr>
<tr><td>(Intercept)</td><td>8.23594</td><td>3.86029</td><td>2.134</td><td>0.086022.</td></tr>
<tr><td>Knitting</td><td>0.24648</td><td>0.11795</td><td>2.090</td><td>0.090942.</td></tr>
<tr><td>Woven</td><td>0.78685</td><td>0.08794</td><td>8.948</td><td>0.000291 ***</td></tr>
</table>

Signif. codes: 0 '***' 0.001 '**' 0.01 '*'0.05 '.' 0.1 ' ' 1

S = 1.98962, R-Sq = 98.8% R-Sq(adj) = 98.3%

Table 4.2 Show that the standard Error of the tensile strength of knitting fabric is 0.24648, t value 0.11795 and p-valve of 0.090942, while the tensile strength of woven fabric have standard Error of 0.78685, t valve 0.08794 and p-valve 0.000291 more required in manufacturing of sportswear. Also: Residual standard error: 1.98962, Multiple R-squared: 98.8%, Adjusted R-squared: 98.3%.

Table 4.3 Analysis of Variance (ANOVA) for the parameter

Source	DF	SS	MS	F	P
Regression	2	1601.63	800.82	202.30	0.0001
Residual Error	5	19.79	3.96		
Total	7	1621.43			

Table 4.3 shows that the computed Analysis of variance (ANOVA) with variance equal to 3.96 with a p-value equal to 0.001, since the p-value is less than 0.05 (the level of significance) we therefore reject H_0 and conclude that the tensile strength of woven fabric and knitting fabric are not the same in manufacturing of sportswear.

Table 4.4 Analysis of Variance (ANOVA) for the fabrics.

Response: sportswear

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Knitting	1	1284.70	1284.70	324.536	9.681e-06 ***
Woven	1	316.93	316.93	80.062	0.0002906 ***
Residuals	5	19.79	3.96		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 4.4 show that knitting fabric has Mean Square of 1284.70, F-value 324.536, and woven fabric has Mean Square of 316.93, F-value 80.062 with equal degree of freedom and variance (δ^2) 3.96.

Table 4.5 Table of Residual

(Intercept)	knitting	woven
8.2359	0.2465	0.7868

Sportswear	Residuals
1.	-0.1352
2.	3.0525
3.	-0.3620
4.	0.3739
5.	-0.2633
6.	-0.3090
7.	0.7245
8.	-3.0816

Source: Author, 2016

Table 4.5 shows the residual of the analysis or relationship in each case of the variables. Also the residuals are used for plot and graph, in order to determine the relationship if there exist.

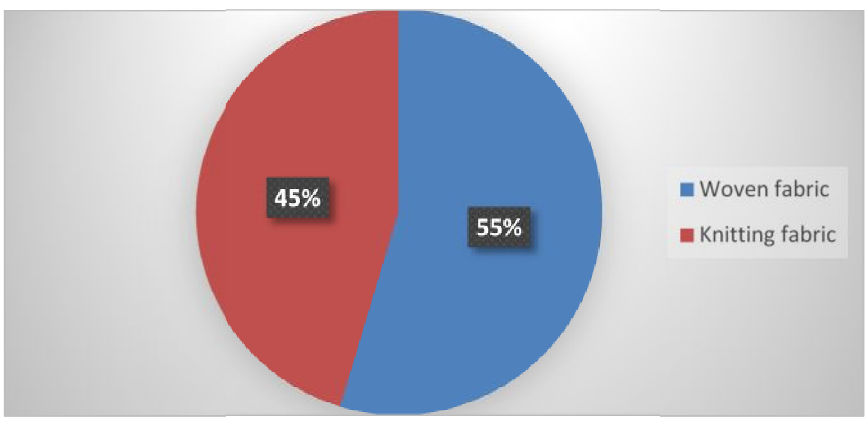

Figure 2. Pie chart showing the percentage tensile strength of the fabrics. From the chart it shows that the tensile strength of woven fabric is greater than the Knitting fabric.

CONCLUSION

Based on the statistical analysis carried out, evidence shows that knitting fabric is the best for the manufacturing of sportswear than the woven fabric, even as woven fabric has higher tensile strength than Knitting Fabric, at α equal to 0.5 level of significant, that is to say p-value is greater than 0.05 level of significant. Also, Table 4.3 shows that there is no relationship between the tensile strength of fabric used in manufacturing sportswear at alpha (α) 0.05 level of significant. That is, to say P-value for the relationship is less than 0.05 level of significant. In general, we reject Null Hypothesis (Ho) for the relationship between the tensile strength of the fabric, and we fail to reject Null Hypothesis for the Knitting Fabric, and we reject Null Hypothesis for the woven Fabric in regard to the significant in the manufacturing of sportswear. Therefore, woven fabric has the higher tensile strength than the knitting fabric, but knitting fabric is more significant in manufacturing of sportswear compare to woven fabric, that is to say, p-value for woven fabric less than 0.05 level of significant (0.000291 is less than 0.05) and p-value for knitting fabric is greater than 0.05 level of significant (0.090942 is greater than 0.05). In general, the relationship between woven fabric and knitting fabric are also not significant in manufacturing of sportswear for p-value less than 0.05 level of significant, (0.0001 is less than 0.05).

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