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Effects of Yarn Count, Loop Length, Course per Inch (CPI), Wales Per Inch (WPI), Fabric Count on Spirality of Plain Weft Knitted Fabric

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Abstract: ***Spirality is a major issue for single jersey knitted fabrics due to their asymmetrical loop formation. The reported study studied the effects of yarn count, loop length, course per inch (CPI), wales per inch (WPI), and fabric counts on spirality of five single jersey knitted fabric of different yarn counts. The reported study tested all controlled specimens of 100% cotton and untreated fabrics. Six hypotheses were developed to test the relations. The American Society for Testing and Materials' (ASTM) standard were used to determine standard atmospheric conditions for conditioning (ASTM D1776) and fabric count (ASTM-D3887). Industrial method was used to measure spirality, and loop length. All the statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS) software. Collected data were analyzed by statistical means, t-test analysis, and Analysis of Variance (ANOVA). Significant correlations were found for yarn count, course per inch (CPI), wales per inch (WPI), and fabric counts to the spirality, but no significance found between the loop length and the spirality.***

Keywords: Knit, Single Jersey, Yarn Count, Loop Length, CPI, WPI, Spirality, Fabric Count

1. Introduction

Single jersey weft knitted fabrics experience dimensional changes causes by different fiber, yarn, knitting, and finishing parameters. Spirality is well known problem in weft knitted single jersey fabric. Previous studies stated that it causes by the relaxation of torsional stresses in the yarn of the fabric [1] [2] [3]. Plain weft knitted fabric is prone to spirality if it is made from single cotton yams. Due to spirality wales stand diagonally to the course instead of perpendicular. Spirality can be found at any state of fabric such as grey, dyed, washed or finished. However, it does not exist in double jersey knits (e.g. interlock and rib) because they have technical face on both sides [4], [5], [6] . Wales on the both faces create balance by supporting each other. Study found spirality impacts functional and aesthetic performance of knitwear [7]. Spirality is the measurement of degree of angle caused by the distortion of wale to course rather than a 90^{o} relationship. Researcher stated that fabrics with around 10^{o} spirality are typically acceptable, although acceptability varies on many factors such as quantity, quality, price, end use and so on [8]. The changes in the spirality of single jersey knit fabrics by machine gauge, yarn, fabric properties, and knit structure has been analyzed by researchers in past [1], [9], [10], [11].

The yarn count determines the fineness or coarseness, thickness or thinness of yarn by a numerical expression [12], [13] . The Textile Institute defined "Count is a number which indicates the mass per unit length or the length per unit mass of yarn". Yarn count is an important parameter that impacts many fabric properties [12], [14]. Researchers found that knits made with same loop length but yarns of different counts exhibits different physical properties such as drape, openness, permeability, handle and spirality . [15], [16]. For a given twist factor, the spirality of loose weft knitted fabrics generally increases with yarn count. On the other hand, for tight weft knitted fabric, researcher found no evidence of any relationship between fabric spirality and yarn count [15], [17].

Loop length/ Stitch length is the Distance from a point of a knit loop to the same point of subsequent loop is called stitch length. It also determines the tightness of knit fabrics. The loop length is inversely related to fabric tightness [18]. Previous study explained this incident as ease of freedom of the loop movement in knitted fabric structure. The movement of a knitted loop is confined in tight knit fabric and thus spirality decreases [15] [19].

The horizontal row of loops or stitches running across the width of a knitted fabric corresponding to course of a knitted fabric. Numbers of course in an inch in knitted fabric is called course per inch (CPI). On the other hand, the column of loops running lengthwise the fabric is known as wales. Numbers of wales in an inch in knitted fabric is called wales per inch (WPI). Researcher stated that there are relationships between stitch length and other parameters such as courses and wales per inch or yarn diameter [20].

The purpose of reported study was to evaluate the impact of yarn count, loop length, course per inch (CPI), wales per inch (WPI), and fabric count on the spirality of weft knitted fabric. This study also assessed the combine effect of yarn count and loop length, course per inch and wales per inch on spirality. In past researchers investigated effects of fiber, yarn, knitting, and finishing causes on spirality and they derived some relationship between above parameters and spirality. A limited study focused to evaluate the combined effect of two parameters on spirality. Based on the literature review six hypotheses were developed.

Hypothesis 1 (H1): Yarn count will impact fabric spirality.
Hypothesis 2 (H2): Loop Length will impact fabric spirality.
Hypothesis 3 (H3): Course per inch will impact fabric spirality.
Hypothesis 4 (H4): Wales per inch will impact fabric spirality.
Hypothesis 5 (H5): Fabric count will impact fabric spirality.
Hypothesis 6 (H6): Yarn count and loop length combined will impact fabric spirality.

2. Experimental

2.1 Materials

Total five single jersey weft knitted materials made with different yarn count were used in the reported study. The count varied among specimens ranged from 22 Ne to 30 Ne. All specimens were manufactured in Knit Concern Group Limited, situated at Narayanganj, Bangladesh. Fiber compositions of all specimens were 100% cotton. All specimens tested for the proposed study were greige (unfinished) fabric. Specimens were numbered from 1 through 5 (e.g. 1 = 22 Ne, 2 = 24 Ne, 3 = 26 Ne, 4 = 28 Ne, and 5 = 30 Ne) The specimens were preconditioned for 12 hours before the measurements were taken as suggested by ASTM D1776. The standard atmospheric conditions were 21+/-1^{o}C and 65%+/-2% of relative humidity.

2.2 Method

Fabric count was measured as accordance to ASTM test standard D3887-2004 which defines it as number of wales and courses per inch on the face of the fabric. Counting started with wales and, then the same operation was repeated for the course. This whole procedure repeated 5 times from 5 random places for each specimen and confirmed that places are not closer than 5 cm or less.

Industrial method was used to measure spirality, and stitch length. Marked a wale and a course on fabric face and then measured the angle between the wales and course by means of a protector. It was confirmed that the specimen was relaxed and free from any kind of stress and tension. Total five readings were taken per specimen and calculated the mean. Degree of spirality was defined by following formula.

$$\text{Degree of spirality} = \text{Measure angel} - 90^{o}$$

To determine loop length 5 courses from a 10 X 10 inch^2 fabric specimen were unraveled. Measured length of unraveled courses in mm by means of industrial scale and it was confirmed that the yarn was straight but relaxed. Total 5 readings were taken from each specimen. The loop length was calculated by following formula as described by previous study [21].

Loop length: Length of course in mm / 10 X Number of wales per inch

The reported study followed both industrial method and test standard set by American Society for Testing and Materials (ASTM). Collected data were analyzed by statistical means, t-test analysis, and Analysis of Variance (ANOVA). All the calculations were carried out using Statistical Package for the Social Sciences (SPSS) software. The confidence level of 95% was used to accept or reject the hypotheses.

3. Result and Discussion

Table 1: Descriptive statistics of evaluations

Properties	*Specimen*	*n*	*Mean*	*SD*
Loop Length	1	5	2.44	.02
	2	5	2.74	.04
	3	5	2.53	.03
	4	5	2.75	.03
	5	5	2.37	.04
CPI	1	5	52.2	.84
	2	5	53.4	.89
	3	5	55	1
	4	5	55.6	.55
	5	5	56.2	.84
WPI	1	5	38.2	.45
	2	5	35.8	.45
	3	5	36.4	.55
	4	5	37.4	.55
	5	5	38.8	.45
Spirality	1	5	5	.94
	2	5	6	1.12
	3	5	7	1.87
	4	5	10.5	2.32
	5	5	13.5	1.77
Yarn Count	1	5	22	0
	2	5	24	0
	3	5	26	0
	4	5	28	0
	5	5	30	0
Fabric Count	1	5	90.4	1.14
	2	5	88.8	1.30
	3	5	91	1
	4	5	93.2	.84
	5	5	94.8	.84

Table 1 displays no. of specimens evaluated, mean and standard deviation (SD) for loop length, CPI, WPI, Spirality, Yarn Count, and Fabric Count. Evaluation of hypotheses are following.

Hypothesis 1 (H1): Yarn count will impact fabric spirality

The result of regression ANOVA (Table 2) between spirality and yarn count shows significant result (F= 71.96 and p<0.00). It can be predicted that yarn count can reliably predict the spirality. The value of R Square was 0.76. This value indicates that yarn count explains 76% of the variance.

Table 2: ANOVA results of yarn count on spirality

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	231.125	1	231.125	71.96	.000b
Residual	73.875	23	3.212		
Total	305.000	24			
a. Dependent Variable: Spirality, b. Predictors: Yarn Count					

Figure 1 exhibits the linear co-relation of spirality and yarn count. Graph shows a positive co-relation between spirality and yarn count. Since, spirality and yarn count are co-related, hypothesis 1 (H1) was accepted. Which contradicts the findings of previous literature [15], [17].

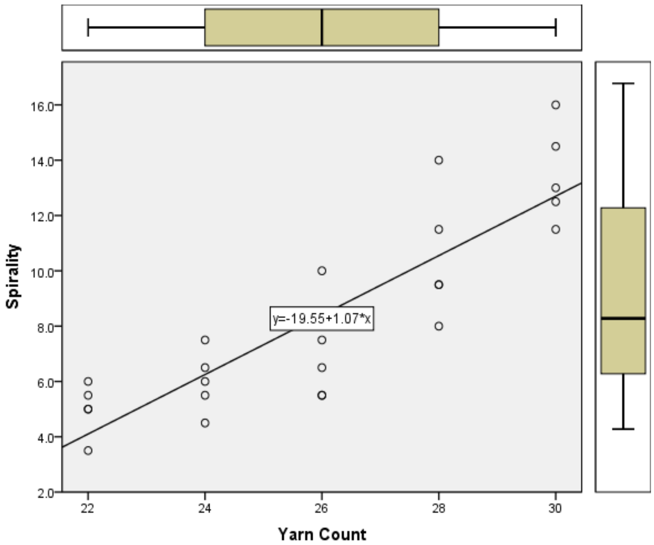

Figure 1: Linear regression between spirality and yarn count

Hypothesis 2 (H2): Loop Length will impact fabric spirality.

The result of regression ANOVA (Table 3) between spirality and loop length exhibits insignificant result. Therefore, it can be predicted that loop length cannot dependably predict the spirality (F= .65 and p<0.429). The value of R Square (R^2 = 0.27) indicates weak negative relationship between spirality and loop length and the loop length explain only 27% variability around its mean. Which contradicts the findings of previous literature [18].

Table 3: ANOVA results of loop length on spirality

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	8.377	1	8.377	0.65	.429b
Residual	296.623	23	12.897		
Total	305.000	24			
a. Dependent Variable: Spirality, b. Predictors: Loop Length					

Figure 2 represents the linear co-relation for spirality and loop length. The line graph exhibits a weak negative co-relation between spirality and loop length. Since, spirality and loop length are not significant, hypothesis 2 (H2) was rejected.

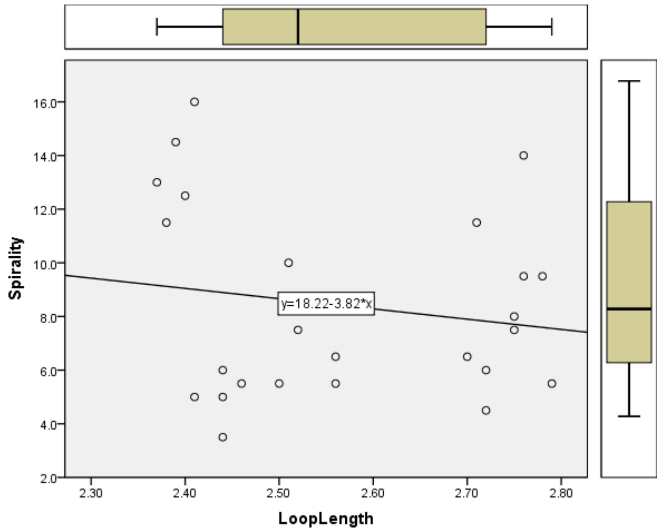

Figure 2: Linear regression between spirality and loop length

Hypothesis 3 (H3): Course per inch (CPI) will impact fabric spirality.

From regression ANOVA (Table 4), it can be decided that spirality and course per inch are significantly different (F= 22.77 and p<0.00). Course per inch can reliably predict the spirality. 50% variations in dependent variable spirality were explained by the independent variables course per inch, since the value of R Square was 0.50.

Table 4: ANOVA results of course per inch on spirality

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	151.716	1	151.716	22.77	.000b
Residual	153.284	23	6.665		
Total	305.000	24			
a. Dependent Variable: Spirality, b. Predictors: CPI					

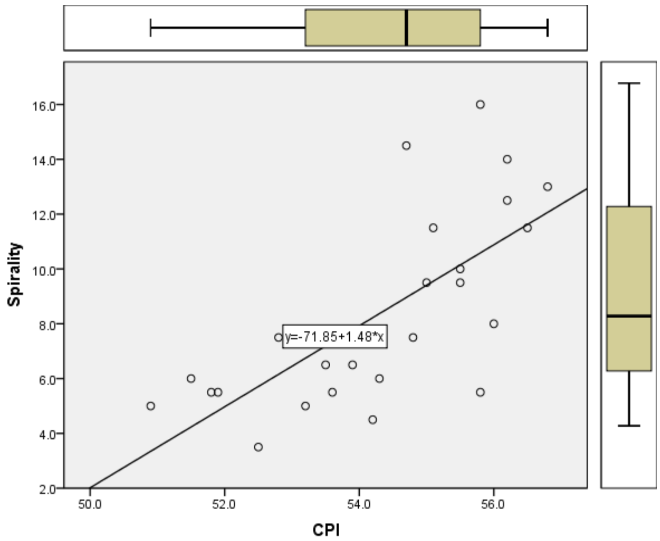

Figure 3: Linear regression between course per inch and spirality

Figure 3 depicts the linear co-relation for spirality and course per inch. A moderate positive correlation has displayed by the graph below. Since, spirality and course per inch are significant, hypothesis 3 (H3) was accepted.

Hypothesis 4 (H4): Wales per inch (WPI) will impact fabric spirality.

The regression ANOVA result from Table 5 shows the significant difference between wales per inch and spirality. Therefore, it can be anticipated that wales per inch can reliably predict the spirality (F= 5.47 and p<0.028). The result of R Square (R^2=.20) exhibits about 20% variations in spirality were explained by the wales per inch.

Table 5: ANOVA results of wales per inch on spirality

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	58.620	1	58.620	5.47	.028[b]
Residual	246.380	23	10.712		
Total	305.000	24			
a. Dependent Variable: Spirality, b. Predictors: WPI					

Figure 4 represents the linear co-relation for spirality and wales per inch. The correlation graph exhibits a weak positive co-relation between spirality and wales per inch. Since, spirality and wales per inch are significant, hypothesis 4 (H4) was accepted.

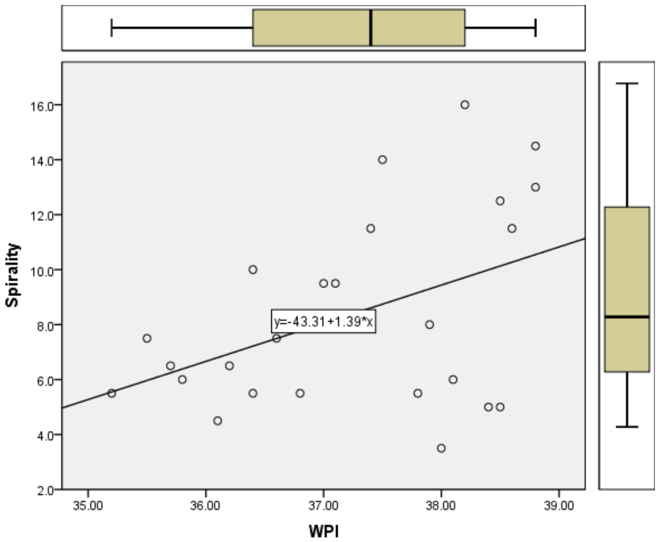

Figure 4: Linear regression between wales per inch and spirality

Hypothesis 5 (H5): Fabric count will impact fabric spirality.

The regression ANOVA (Table 6) between spirality and fabric count reveals significant result (F= 32.27 and p<0.00). It can be said that fabric count can dependably forecast the spirality. The value of R Square was 0.58. This value shows that yarn count explains 58% of the variance.

Table 6: ANOVA results of fabric count on spirality

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	178.081	1	178.081	32.27	.000[b]
Residual	126.919	23	5.518		
Total	305.000	24			
a. Dependent Variable: Spirality, b. Predictors: Fabric Count					

Figure 5 represents the positive linear co-relation for spirality and wales per inch. The correlation graph shows a moderate positive co-relation between spirality and fabric count. Since, spirality and fabric count are significant, hypothesis 5 (H5) was accepted.

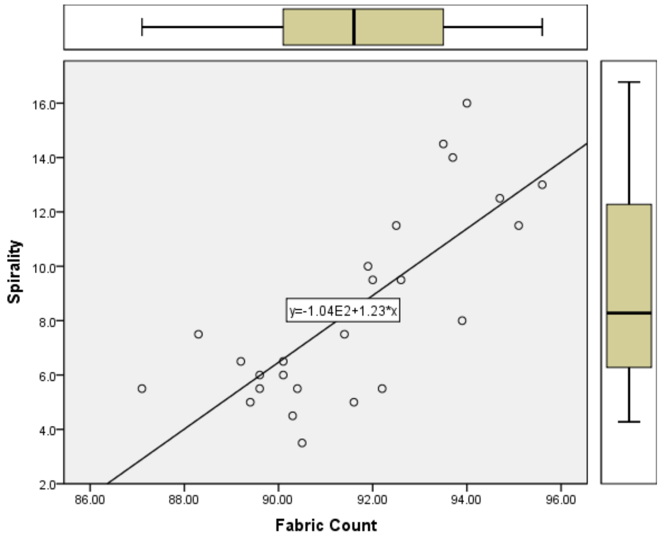

Figure 5: Linear regression between fabric count and spirality

Hypothesis 6 (H6): Yarn count and stitch length combinedly will impact fabric spirality.

The regression ANOVA shows significant result (F= 36.41 and p<0.00) between spirality and combination of stitch length (SL) and yarn count (Table 7). It can be concluded that stitch length and yarn count combinedly can reliably predict the spirality. The value of R Square was 0.77, which explains 77% of the variance. It indicates strong positive correlation between spirality and combination of stitch length and yarn count. Therefore, hypothesis 6 (H6) was accepted.

Table 7: ANOVA results of fabric count on spirality

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	234.236	2	117.118	36.41	.000[b]
Residual	70.764	22	3.217		
Total	305.000	24			
a. Dependent Variable: Spirality, b. Predictors: SL, Yarn Count					

4. Conclusions

The study found the effects of yarn count, loop length, course per inch, wales per inch, and fabric count on the spirality of on plane weft knitted fabric. According to reported study, yarn count affect spirality. The spirality increases as yarn count goes higher or the yarn gets finer. Loop length does not impact the spirality since reported study found insignificance relation between them. The spirality affected by the variation of CPI and WPI. CPI impacted the spirality more significantly than the WPI does. The sum of CPI and WPI which is known as fabric count also affected the spirality. The fabric count measures the combined effect of CPI and WPI on the spirality. Additionally, the yarn count and stitch length combinedly impacted the spirality significantly.

References

[1] M. D. De Araujo and G. W. Smith, “Spirality of Knitted Fabrics: Part I: The Nature of Spirality,” *Text. Res. J.*, vol. 59, no. 5, pp. 247–256, 1989.

[2] W. Davis, C. H. Edwards, and G. R. Stanbury, "7—Spirality in Knitted Fabrics," *J. Text. Inst. Trans.*, vol. 25, no. 3, pp. T122–T132, 1934.
[3] H. John, "Loop Distortion in Plain Knit Fabrics," *Wool Sci.Rev.*, vol. 64, pp. 81–119, 1987.
[4] T. S. Nutting, "Spirality in Weft Knitted Fabrics," *Hosiery Res.Bull.*, vol. 4, pp. 18–31, 1960.
[5] Z. Değirmenci and M. Topalbekiroğlu, "Effects of weight, dyeing and the twist direction on the spirality of single jersey fabrics," *Fibres Text. East. Eur.*, 2010.
[6] E. Khalil, M. Solaiman, J. Sarkar, and M. Mostafizur Rahman, "Evaluation of Physico-Mechanical Properties of 1×1 Interlock Cotton Knitted Fabric Due to Variation of Loop Length," *www.ijraset.com Issue IX*, 2014.
[7] D. L. Munden, "26—The geometry and dimensional properties of plain-knit fabrics," *J. Text. Inst. Trans.*, 1959.
[8] A. A. Ulson de Souza, L. F. Cabral Cherem, and S. M. A. G. U. Souza, "Prediction of Dimensional Changes in Circular Knitted Cotton Fabrics," *Text. Res. J.*, 2010.
[9] M. A. Islam and A. N. M. A. Haque, "Selection of suitable machine gauge by considering the GSM, shrinkage and spirality of single jersey knit fabric," *Res. J. Sci. IT Manag.*, vol. 3, no. 3, pp. 50–55, 2014.
[10] M. D. De Araujo and G. W. Smith, "Spirality of Knitted Fabrics, Part 2," *Text. Res. J.*, vol. 59, pp. 350–356, 1989.
[11] M. A. Islam, "Effect of Wale-wise increased Tuck and Miss Loops on Spirality of Single Jersey Knit Fabrics," *Int. J. Res. Eng. Technol.*, vol. 3, no. 3, pp. 429–432, 2014.
[12] D. J. Spencer, "An introduction to textile technology," in *Knitting Technology*, 2001.
[13] N. Oğlakcioğlu and A. Marmarali, "Thermal comfort properties of some knitted structures.," *Fibres Text. East. Eur.*, 2007.
[14] D. J. SPENCER and D. J. SPENCER, "21 – The Manufacture of Hosiery on Small Diameter Circular Machines," in *Knitting Technology*, 1983.
[15] J. Tao, R. C. Dhingra, C. K. Chan, and M. S. Abbas, "Effects of Yarn and Fabric Construction on Spirality of Cotton Single Jersey Fabrics," *Text. Res. J.*, 1997.
[16] E. Eltahan, "Effect of Lycra Percentages and Loop Length on the Physical and Mechanical Properties of Single Jersey Knitted Fabrics," *J. Compos.*, 2016.
[17] S. W. Park, S. Collie, C. N. Herath, B. C. Kang, and T. Fujimoto, "Spirality related mechanical properties of single knit fabrics of lincLITE® and conventional yarns," *Fibers Polym.*, 2008.
[18] S. Ben Abdessalem, S. Elmarzougui, S. Mokhtar, and R. Heni, "Parameters influencing plain knitted fabric spirality," *Indian Text. J.*, pp. 29–34, 2008.
[19] A. Demiroz Gun, C. Unal, and B. T. Unal, "Dimensional and physical properties of plain knitted fabrics made from 50/50 bamboo/cotton blended yarns," *Fibers Polym.*, 2008.
[20] M. W. Suh, "A Study of the Shrinkage of Plain Knitted Cotton Fabric, Based on the Structural Changes of the Loop Geometry Due to Yarn Swelling and Deswelling," *Text. Res. J.*, vol. 37, no. 5, pp. 417–431, 1967.
[21] C.-O. Jovani, B.-S. Roberto, A. R.-S. Edgar, and B. V.-R. Laura, "Statistical Model for the Prediction of Loop Length in Knitted Fabrics," *IOSR J. Polym. Text. Eng.*, vol. 5, no. 3, pp. 18–28, 2018.

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