Developing innovative pattern designs for jacquard woven athletic footwear fabrics

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Abstract:
This study aims to experiment with different weaving structures with the same fabric construction and innovative patterns needed to fulfill customer needs for this product. However, it could affect the fabric's physical and mechanical properties. Hence, this study represents (4) samples produced from (Polyester filament, chenille P.E. (micro flat), and polyester/lycra by using double weave wadding structure techniques. The statistical analysis results for correlation coefficients show a direct correlation between the properties and the textile compositions of different pattern designs. Also, the statistically significant differences between the results are weak, which in turn is reflected in allowing the freedom of design using these different patterns by athletic footwear fabric designers and thus meeting the desires of customers for different designs for this type of athletic footwear without affecting on the mechanical properties of the fabrics involved in their manufacture.

Keywords:
pattern designs; woven jacquard fabrics; athletic footwear

Paper received September 18, 2023, Accepted December 14, 2023, Published on line January 1, 2024

Introduction

Footwear science addresses aspects of all types of footwear, such as dress footwear, working footwear, athletic footwear, or medical footwear. [Sterzing et al., 2012]. Athletic footwear with canvas uppers became a generic product during the early and mid-twentieth century. The innovative use of textiles in athletic footwear has played a major role at each significant stage in the evolutionary and revolutionary history of the branded athletic footwear industry. [Frederick and Wojcieszak, 2005].

Daily, people wear athletic footwear. This type of footwear provides the wearer with comfort and simultaneously protects their feet from harsh conditions such as cold, wet, and uneven surfaces. The fabrics used in footwear play a crucial role in athletic footwear, as they directly impact both durability and comfort. Producing athletic footwear fabrics with different pattern structures is needed to fulfill customer needs for this product. However, it could affect the fabric's physical and mechanical properties. This study aims to experiment with four different weaving structures with the same fabric construction and four different innovative pattern designs to show whether these patterns affect the mechanical properties of these fabrics negatively or not.

Problem Statement

Producing athletic footwear fabrics with different pattern structures in the same upper athletic footwear fabric could affect the fabric's physical and mechanical properties. So, it could negatively affect the mechanical properties of this kind of fabric. The main question of this research is whether producing different patterns with the same fabric construction will affect the mechanical properties of this kind of fabric or not to forecast the durability of this fabric.

Aims and objectives

This research aims to test whether using innovative pattern designs from only one weaving structure produced for athletic footwear fabrics affects the mechanical properties of fabric or not.

Hypothesis

Employing different pattern designs with only one weaving construction in the same upper footwear fabric could negatively affect the mechanical properties of the fabrics.

Methodology

The research follows the statistical analysis experimental method.

1. Proposed Framework

1.1. Athletic Footwear

Footwear is essential in protecting the foot from injuries and facilitating efficient and comfortable movement during a wide range of routine, recreational, occupational, and sporting activities [Menz and Bonannom, 2021]. Modern footwear is designed to fulfill a range of purposes by three criteria: form, function, and fit [Witana et al., 2004] [Goonetilleke et al., 2000]. Form relates to the visual attractiveness and aesthetic appeal of footwear, whereas function refers to the ability of footwear to accomplish its intended purpose [Buldt and Menz, 2018]. The primary functions of the foot are to serve as a base for supporting the body and as a lever for facilitating movement. Our feet are, however, unique, and they have specific requirements. One style will not fit all; therefore, it isn't easy to make a standard for appropriate athletic footwear [Nebo, 2005]. Moreover, athletic footwear requires robust construction, reliable closures, and a prolonged lifespan that withstands deterioration in any environmental conditions [Wang, 2013].

1.2. Structure of Athletic Footwear

Textile design composition results from design elements' interaction, such as fiber composition, yarn patterns, fabric structure, colour, and texture, all of which govern the characteristics and qualities of the fabric. [Rowe, 2009] [Ahmed et al., 2022] [Mathur and Seyam, 2011] [Yoo and Barker, 2005]. Consequently, a thorough understanding of the properties of multi-layered materials and their optimal configuration can serve distinct purposes in designing and developing sports footwear, ultimately enhancing wearers' thermal comfort. [Nam, 2019]. [Song, 2011]. The athletic footwear structure has three main components: upper, insole, and midsole (Fig. 1). [Ozdemir, 2020].

Fig. 1. Main footwear components [Ozdemir, 2020].

Conventionally manufactured athletic footwear is composed of numerous components from various materials. Every single component undergoes different processes, assembled in a labor-intensive process. This is where Digital Manufacturing creates a significant advantage. While a traditionally produced athletic upper might have about 20 components, it is possible to manufacture a one piece upper by digital knitting. (Fig. 2). [Ozdemir, 2020].

Fig. 2. Components of a traditional shoe upper (left) and a Fly knit upper (right).

1.3. Jacquard Athletic Footwear Design

One of the most important study directions in modern textile technology and science is digital textile design, which has a special place in footwear design. Weaving has transformed remarkably into a highly sophisticated and advanced manufacturing process. Weaving technology creates a lightweight and breathable upper for athletic footwear that provides excellent ventilation and comfort to the wearer [Loschek, 2009]. Weaving also allows for intricate and complex designs, enhancing athletic footwear's style and aesthetics [Roy et al., 2023]. Fabric appearance, texture, and end-use suitability are all influenced by the fabric-forming process or fabrication procedure. [Ahmed, 2022] [Mathur and Seyam 2011]. With the development of our current world, there has also been a great development in the field of textiles; woven fabrics compete with strength, especially in jacquard design. Fabric structure innovation is thus critical to future jacquard fabric design innovation. [Radwan, 2023].

Digital jacquard technology includes design technology elements with the help of CAD jacquard systems such as; (Scotweave, Pointcarré, EAT, or Ned Graphics.). [Redmore, 2011]. Design and production procedures of jacquard textiles under the application of digital technologies are shown in Figure (3).

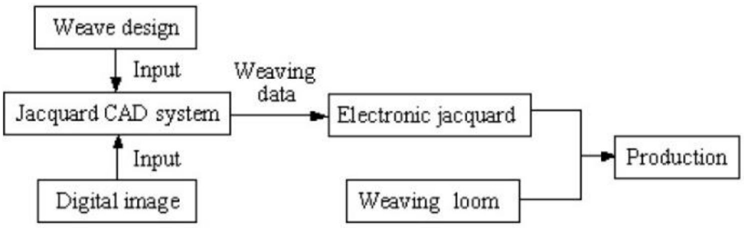


Fig 3. Workflow of digital jacquard and production [Zhou, (2008)].

High-density jacquard fabrics with multiple coluors and layers can be produced, such as patterned fabrics, brocade, damask, and so on. [Redmore, 2012]**.** Jacquard designs can also be geometric, organic, oversized, or form an all-over repeat. [Redmore, 2011]. These fabrics are available in various compositions and weights and serve various purposes. [Watson and Grosicki, 1975].

In terms of weaving structures, jacquard fabric can be classified into four main types: single-layer, backed structure (weft-backed, warp-backed), double-layer, and multi-layer. Every category offers unique characteristics and applications, enhancing the versatility and desirability of jacquard fabrics in the textile industry. Jacquard fabrics are known for their durability, stability, strength, and resilience. They exhibit wear and wrinkle resistance and boast decorative aesthetics, making them a favored choice in various applications. [Seyam, 2011].

Jacquard looms are used to create elaborate, intricate, larger-scale designs that cannot be produced on a dobby loom and where the warp yarns are individually controlled by a patterning mechanism that can be mechanical or linked to a computer-aided design (CAD) system. [Redmore, 2012]. Designing for the Jacquard loom involves the designer selecting their own design or repeat pattern and then choosing which weave structures to incorporate into the design. Colour is primarily introduced into Jacquard fabric through the weft yarns. Additionally, the selected weave structures will produce different textures and a varied proportion of warp-to-weft colour. [Holyoke, 2013]. [Stankard, 2015].

1.4. Double Weave

Double fabrics are a compound class of weave in which fabric is constructed from two or more than two sets of warp and weft. This type of fabric has two separate layers interlaced by parent yarns (yarns used to form two layers). The movement of threads between the layers leads to the development of intricate patterns and surface textures, offering a variety of purposes, including enhancing the thermal resistance value of the fabric. Additionally, the process aims to enhance the air permeability of the fabric, ensuring better breathability. Thus, the production of double fabrics addresses functional and aesthetic aspects to meet specific performance and comfort requirements. [Akter and Chowdhury, 2018]. [Shenton, 2014].

1.5. Textile Materials in Athletic Footwear.

Textile materials are an essential part of all athletic as athletic wear, athletic equipment, and athletic footwear [Paul, 2019]. Textile materials have gained growing significance in the design and production of athletic footwear owing to their numerous advantages. [Bullon et al, 2017]. The utilisation of synthetic materials, such as polyester, has become more common in the production of athletic footwear. [Staikos et al, 2006]. Polyester is known for its lightweight and durable nature. Its moisture-wicking and quick-drying properties contribute to enhanced comfort during physical activities. Additionally, polyester exhibits dimensional stability and excellent wear resistance. [Ahmad et al, 2023] [Tambunan et al, 2022]. The property of resilience and recovery from creasing and wrinkling is excellent in polyester fibers and exhibits good resistance to sunlight [Murthy, 2016]. Polyester in athletic footwear ensures a better fit and offers athletes greater comfort and durability [Özdil and Anand, 2014] [Mia et al., 2017]. Athletic footwear manufacturers should consider the advantages of textile materials when designing and producing their products to provide their customers with maximum comfort, style, and performance. [Roy et al., 2023].

1.6 Functional Athletic Footwear

Functional features of athletic footwear are comfort, performance, protection, support, and shock absorption; therefore, innovative structures, materials, smart technologies, and manufacturing methods have been used. [Sterzing, 2012]. Footwear enhances performance by improving traction and biomechanical efficiency. Athletic footwear serves to protect the foot at the interface with the ground and the entire body against the forces generated from repeated feet-ground impacts [Lafortune, 2008]. Optimal functionality is achieved through the correct design of the upper and lower parts of the shoe, the correct last shape with technically chosen materials and components, the correct shoe construction, and the appropriate shoemaking technique. Functional footwear design also means knowing about technical materials and components. Testing the design in the laboratory and the natural environment makes it easier to develop and gain more knowledge about functional designs that fit their purpose. Naturally, marketing and price issues are always part of functional footwear design, just as they are in the development and production of any product [Nebo, 2005].

The following aspects of functionality are important: shoes need to be supportive, and they need to be light. Shoes also need to feel flexible and comfortable in running. The comfort of wearable products can be predicted by considering the material's weight, thickness, durability, air permeability, thermal resistance, and water vapour resistance, primarily because of its impact on wearers' fatigue and discomfort. [Nam, 2019] [Song, 2011]. With more future-oriented technology and more functional characteristics. Technology facilitates the design and production of athletic footwear to meet the more specialised demands of an athlete. [Nebo, 2005].

2. Experimental Work

2.1. Creating athletic footwear designs: [Salah and Eletreby, 2021]

All fabrics were designed on Nedgraphics CAD/CAM software, following these steps:

2.1.1. Putting the design ideas for athletic footwear fabrics:

This step has to be done with the aid of one of the most renowned Textile CAD/CAM software, such as (Nedgraphics - Texcell).

- Design resizing:

Resizing the design is a vital process, applied to adjust its properties to make it suitable for weaving. The purpose of this process is to define the following properties:

Pixel X: The number of warps ends per repeat.
Pixel Y: The number of weft yarns per repeat.
Size X: Repeat width / (Cm, mm, inch, or pixels).
Size Y: Repeat height / (Cm, mm, inch, or pixels).
Resolution X: The number of warp ends ends/Cm.
Resolution Y: The number of weft yarns/Cm.

2.1.2. Weaving structures preparation (Weave editor): [Salah, 2017]

This process is about creating the amended weaving structures, which will be used to create the specific needed fabrics.

The process involves creating the amended weaving structures, which will be used to create the specific fabrics required, so the overall process to create these weaves will be described sequentially next, as to how to create a complex weave.

The first step is to create a new weave (complex): This could be done by selecting "New" from the file menu. The first dialog that appears is the "Select Weave Type" dialog. enabling the choice between creating a simple or complex weave with the current (complex weave). Following the selection of weave type, the "Give New Weave Sizes" dialog appears. The options in this dialog, called hooks and picks, when creating a simple weave are to be chosen. However, they are called warps and wefts when creating a complex weave, as illustrated in Fig. (4), (5).

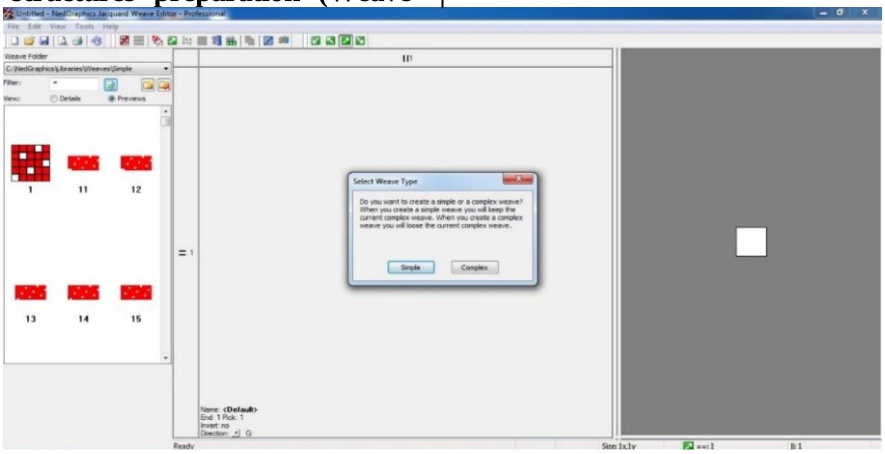


Fig. 4 Dialog for select weave type

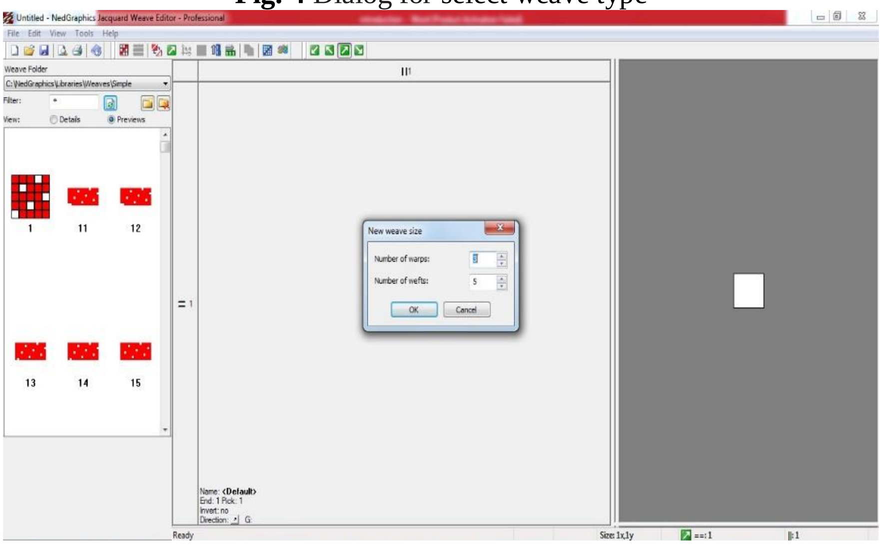


Fig. 5 Dialog for select warp and weft scales.

The next step is to put the right of each simple weave structure in the correct position to create the amended complex weave structure, as depicted in Fig (6); this is achieved by selecting the weave structure directly from the weaves library and dropping it in its right position.

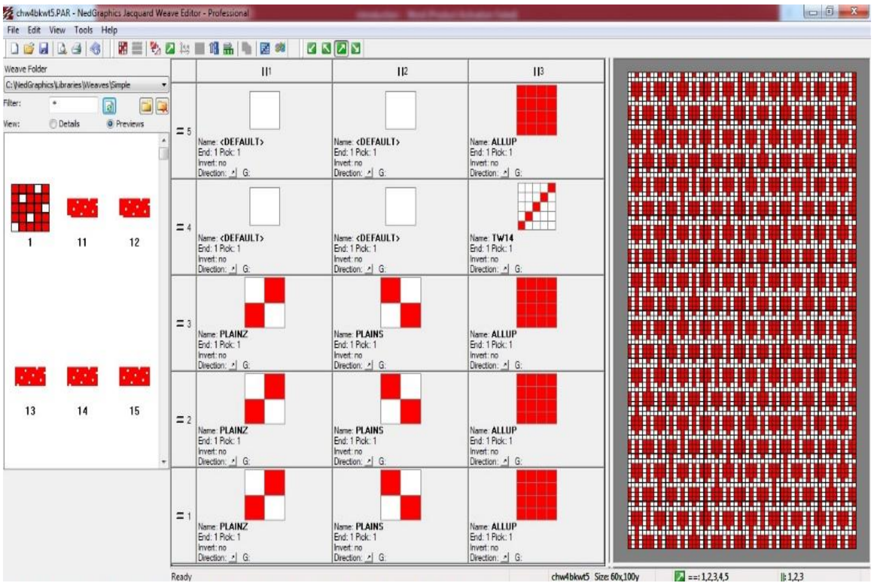


Fig. 6 Complete double weave structure

2.1.3. Jacquard harness Preparation (Loom Editor):

Before advancing to the final step (product creator), the machine or the harness layout must be created; describing the map of the jacquard hooks and its capacity is essential information for creating the amended fabric.

2.1.4. Executive Design preparation (product creator):

By reaching this stage, all the necessary data and information should be prepared and saved in the program archive, as Design, weaving structures, and harness system; the process of producing the executive design has to be applicable according to the following procedures:

- **Design properties:**

When selecting "New Order" from the file menu, the properties dialogue box automatically opens, asking to input the information needed to generate the amended fabric.

- **Card production:**

Once the weave structures are completed, the fabric electronic card is ready to be generated, and this could be done simply by refreshing the card view.

2.2. Materials and Methods

2.2.1. The produced athletic footwear fabrics are using the following specifications:

The jacquard athletic footwear fabrics were prepared at (Home Fashion Factory for upholstery fabrics, Qalyub City, Egypt), using a Rapier loom with the specifications in Table (1). Yarn of count 150/1 Denier, 120 EPI was used as warp, and Yarns of four different counts such as (600/1 dn, 1800/1 dn, 2250/1 dn, 150/40 dn) were used as Wefts, with weft sequence (3F, 2W, 1 B), three types of weft yarns were used (PolyEster filament, chenille P.E. (micro flat), and polyester/lycra. All fabrics were produced in Double weave wadded structure with 120 EPI, and (128) PPI. Tables (2), (3), (4), (5), and (6) show the fabric specifications of samples.

Table 1. The specifications of a machine used for preparing samples.

Loom	Specifications
Machine type	Somet
Country of manufacture	Italy
Date of Manufacturing	1994
Jacquard type	Staubli cx860
Jacquard capacity	2688 hooks
Machine speed	230 pick/min.
Design hooks	2400 hooks.
Repeat width	35 cm.
Harness	Straight.
Fabric width	2300 cm.
Weft Insertion	Rapiers
Repeats/fabric width	6 Repetitions.
Reed density	16 Dent/cm
Denting	3 Ends/dent

2.2.1.1: Samples Fabric specifications:

Table (2) shows the fabric specifications of samples:

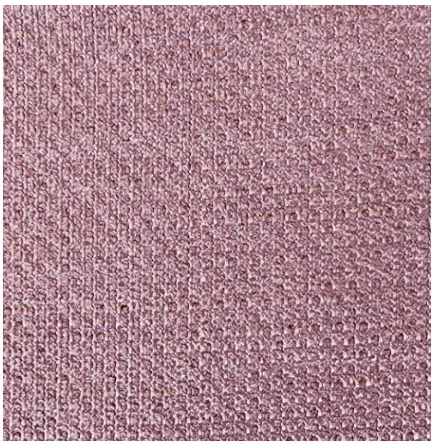
Table (2): Fabric specifications

Sample code	Weft Sequence	Weave	Densities		Count (Td)		Materials	
			EPI	PPI	Warp	Weft	Warp	Weft
S4 44	(3F:2w:1B)	Double weave	120	128	150/1	600, (1800,2250) 150/40	P.E. filament	P.E. (P.E., chflat), Lycra

2.2.1.2: Samples Fabric Designs:

Table (3) shows the fabric specifications of samples:

Table (3): Fabric Designs

Design S4 44	Design S4 Hc
	
Design S4 p11	**Design S4 net**
	

3. Results

Examine different pattern designs with the same fabric construction of upper athletic footwear fabric in the same design and their affection on the mechanical properties.

3.1. Weight.

Table 4. Weight of the analysed samples.

Sample No	Sample Code	Fabric Weight g/m^2
1	**S4 44**	592.96
2	**S4 Hc**	591.03
3	**S4 p11**	593.26
4	**S4 net**	552.03

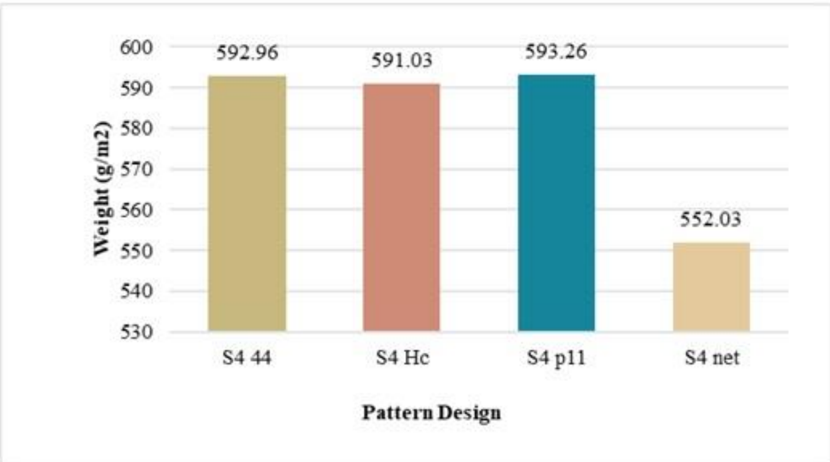


Fig. 7. Shows the average weight test scores in pattern designs.

Table (4) and Figure (7) show statistically significant differences in the weight test for four pattern designs at a significance level of 0.01. One of the advantages of athletic footwear fabrics is their lightweight nature, contributing to a reduction in the overall weight and enhancing comfort and ease of movement, as sample **S4 net** represents the lowest weight per meter square because of its low shrinkage ratio of the tight of weaving structure, followed by **S4 Hc**, **S4 44**, then **S4 p11**.

3.2. Thickness.

Table 5. The thickness of the analysed samples.

Sample No	Sample Code	Fabric Thickness (mm)
1	**S4 44**	1.59
2	**S4 Hc**	1.67
3	**S4 p11**	1.87
4	**S4 net**	1.65

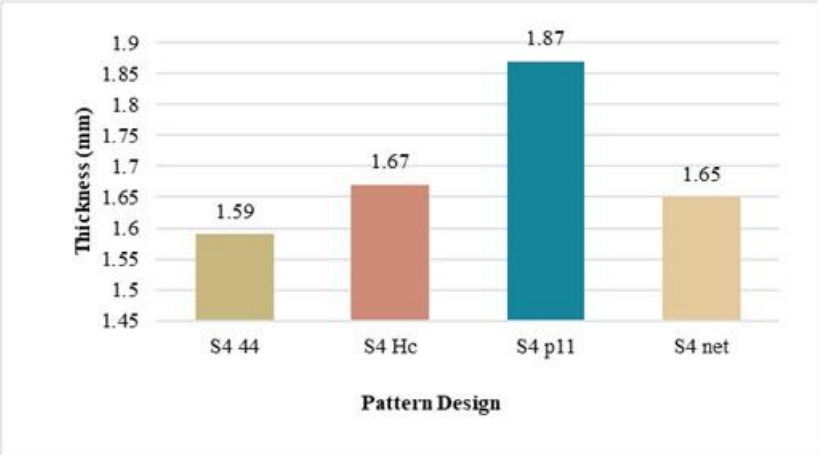


Fig. 8. Shows the average thickness test scores in pattern designs.

Table (5) and Figure (8) show statistically significant differences in the thickness test for four pattern designs at a significance level of 0.01. The thickness characteristics of athletic footwear fabrics are regarded as advantageous. The thickness of the fabric influences its flexibility, which is crucial for athletic footwear that needs to flex and bend during wear; the result shows that sample **S4 p11** represents the largest thickness of the fabric because of weak binding between the layers. While sample **S4 44** represents the lowest thickness because of the strength binding between layers. However, This difference has a weak effect on the physical properties of the produced fabrics.

3.3. Air permeability.

Table 6. Air permeability of the analysed samples.

Sample No	Sample Code	Air permeability ($cm^3/cm^2/s$)
1	**S4 44**	29.5
2	**S4 Hc**	37
3	**S4 p11**	44.4
4	**S4 net**	28.7

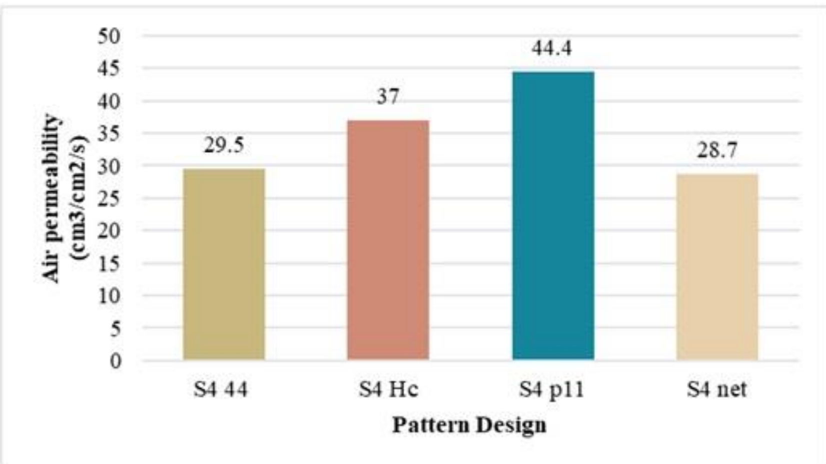


Fig. 9. Shows the average air permeability test scores in pattern designs.

Table (6) and Figure (9) show statistically significant differences in the air permeability test for four pattern designs at a significance level of 0.01. Air permeability is a crucial requisite for athletic footwear fabrics, offering significant comfort to the wearer by facilitating the transport of moisture vapor from the skin to the external atmosphere. The result shows that sample **S4 p11** represents the highest air permeability of the fabric because of weak binding between the layers. However, sample **S4 net** represents the lowest air permeability because of the strength binding between layers.

3.4. Tensile Strength.

Table 7. Tensile strength of the analysed samples.

Sample No	Sample Code	Tensile Strength (N)
1	S4 44	1608.12
2	S4 Hc	1612.56
3	S4 p11	1504.56
4	S4 net	1542.3

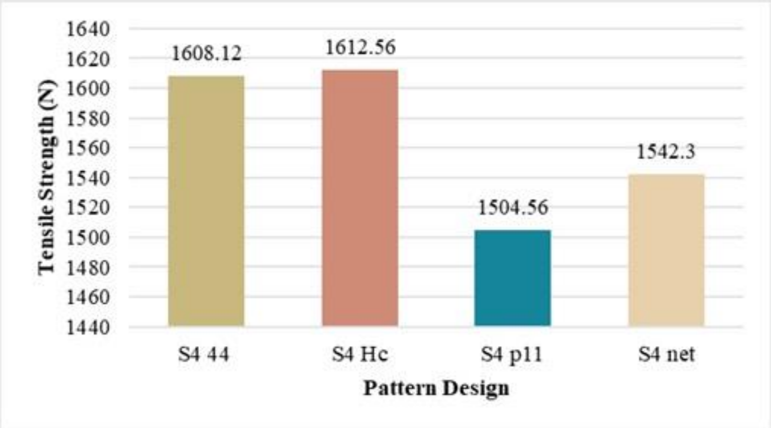


Fig. 10. Shows the average tensile strength test scores in pattern designs.

Table (7) and Figure (10) show statistically significant differences in the tensile strength test for four pattern designs at a significance level of 0.01. High tensile strength is one of the crucial and desirable properties of athletic footwear fabrics. The result illustrates that samples **S4 Hc & S4 44** have the highest tensile strength of the fabric while samples **s4p11 & s4 net** have the lowest tensile strength because of the different ratio of binding strength between layers. However, this difference is not very significant. That means we can use these four structures in the same sample without any problem.

3.5. Elongation.

Table 8. Elongation of the analysed samples.

Sample No	Sample Code	Elongation (%)
1	S4 44	30.30
2	S4 Hc	31.27
3	S4 p11	29.37
4	S4 net	31.83

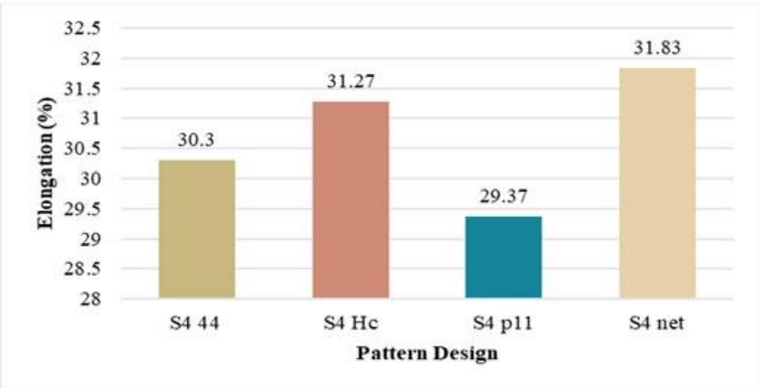


Fig. 11. Shows the average elongation test scores in pattern designs.

Table (8) and Figure (11) show statistically significant differences in the elongation test for four pattern designs at a significance level of 0.01. A desirable property for athletic footwear fabrics is

high elongation, ensuring that the material can be stretched before reaching the breaking point, thereby increasing the overall lifetime of the athletic footwear.
The result illustrates that samples **S4 net, S4 Hc, and S4 44** have the highest elongation of the fabric. In contrast, samples **S4p11** have the lowest elongation because of the difference ratio of binding strength between layers. However, This difference does not strongly affect the mechanical properties of the fabric. Hence, It is clear that textile compositions with tight binding can be used in the same sample in different areas without causing a defect in the mechanical properties of the fabric. Also, textile compositions with weak binding can be used, but in small areas, so as not to negatively affect the properties of the fabric.

3.6. Friction Resistance.

Table 9. Friction resistance of the analysed samples.

Sample No	Sample Code	Friction Resistance (g)
1	**S4 44**	4
2	**S4 Hc**	7
3	**S4 p11**	6
4	**S4 net**	1

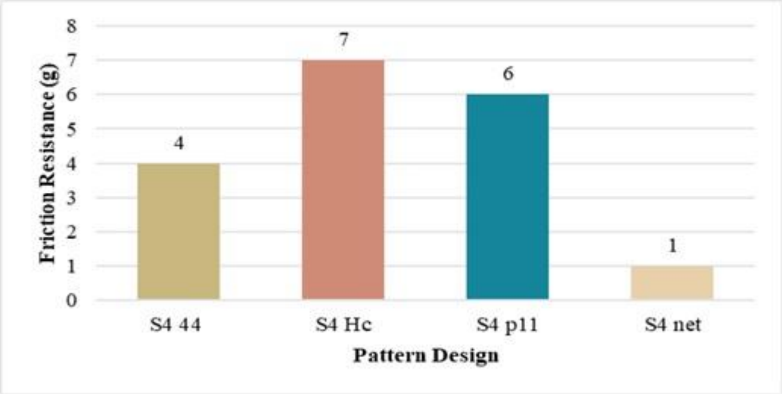


Fig. 12. Shows the average friction resistance test scores in pattern designs

Table (9) and Figure (12) show statistically significant differences in the friction resistance test for four pattern designs at a significance level of 0.01. High friction resistance is essential in the mechanical properties of athletic footwear to increase durability; the result illustrates that samples **S4 Hc and S4p11** have the lowest friction resistance of the fabric. In contrast, samples **S4 net and S4 44** have the highest friction resistance because of the difference ratio of binding strength between layers. However, This difference has a weak effect on the mechanical properties of the fabric. Hence, It is clear that textile compositions with tight binding can be used in the same sample in different areas without causing a defect in the mechanical properties of the fabric. Also, textile compositions with weak binding can be used, but in small areas, so as not to negatively affect the properties of the fabric.

3.7. Pilling Resistance.

Table 10. Pilling resistance of the analysed samples.

Sample No	Sample Code	Pilling Resistance
1	**S4 44**	4.5
2	**S4 Hc**	4.6
3	**S4 p11**	1.5
4	**S4 net**	3.4

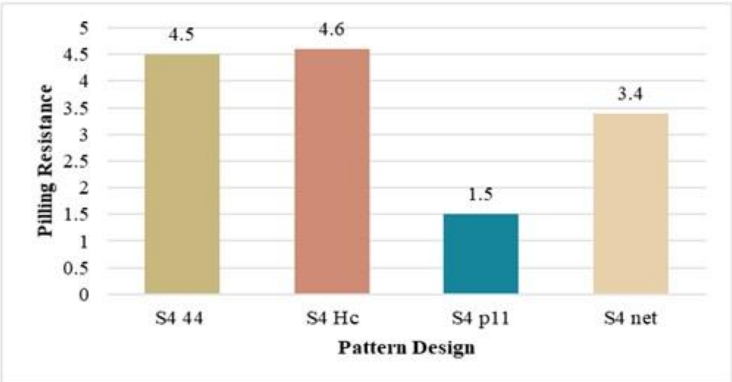


Fig. 13. Shows the average pilling resistance test scores in pattern designs.

Table (10) and Figure (13) show statistically significant differences in the pilling resistance test for four pattern designs at a significance level of 0.01. The desirability of high pilling resistance in athletic footwear fabrics significantly impacts the overall appearance of the material. Sample **S4 p11** represents the highest pilling resistance of the fabric because of tight binding between the layers. However, Sample **S4 Hc** represents the lowest pilling resistance because of the weak binding between layers.

1.6. The Statistical Analysis

Cheema SM*, Shah TH, Anand SC and Soin N

The impact of different weaving structures with the same fabric construction and innovative different patterns of jacquard woven athletic footwear fabrics on the physical and mechanical properties (weight, thickness, air permeability, tensile strength, elongation, friction resistance, and pilling resistance) was tested using analysis of variance (ANOVA).

Table 11. Results of one-way ANOVA.

ANOVA for Weight Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	13286.242	1	3321.561	4	46.864	0.01
Between Groups (without or with)	708.769	1	70.877	10		
ANOVA for Thickness Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	15751.938	1	3937.985	4	13.010	0.01
Between Groups (without or with)	3026.913	1	302.691	10		
ANOVA for Air Permeability Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	13536.802	1	3384.201	4	37.893	0.01
Between Groups (without or with)	893.089	1	89.309	10		
ANOVA for Tensile Strength Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	13103.922	1	3275.981	4	56.045	0.01
Between Groups (without or with)	584.529	1	58.453	10		
ANOVA for Elongation Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	14124.230	1	3531.057	4	25.603	0.01
Between Groups (without or with)	1379.135	1	137.913	10		
ANOVA for Friction Resistance Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	14953.363	1	3738.341	4	17.219	0.01
Between Groups (without or with)	2171.041	1	217.104	10		
ANOVA for Pilling Resistance Results						
Source of Variation	*SS.*	*df*	*MS.*	*F*	*P-value*	D
Between Groups	17432.243	1	4358.061	4	8.625	0.01
Between Groups (without or with)	5052.641	1	505.264	10		

(The differences are statistically significant at ($p \leq 0.01$))

Sum-of-squares (S.S.) column with no repeated measures, degrees of freedom (df), mean squares (M.S.), F-ratio (F), p-value, (D) indication.

1.7. The Correlation Coefficients

Table 12. Results of the Correlation Coefficients between different weaving innovative patterns structures the four pattern designs and "weight, thickness, air permeability, tensile strength, elongation, friction resistance, pilling resistance."

Sample Code	Weight (g/m^2)	Thickness (mm)	Air permeability ($cm^3/cm^2/s$)	Tensile Strength (N)	Elongation %	Friction Resistance (g)	Pilling resistance
S4 44	*0.639	**0.717	**0.892	**0.737	*0.616	**0.782	**0.849
S4 Hc	**0.868	**0.834	**0.913	*0.608	**0.953	**0.805	**0.753
S4 p11	**0.743	*0.641	**0.708	**0.889	**0.797	*0.621	**0.878
S4 net	*0.617	**0.906	**0.851	**0.944	*0.634	**0.727	**0.814

Table (12) shows a direct correlation between the four pattern designs and "weight, thickness, air permeability, tensile strength, elongation, Friction resistance, pilling resistance" at a significance level of 0.01, 0.05.

4. Discussions

- There is a direct correlation between weight (g/m^2) and its low shrinkage ratio of the tight weaving structure.
- There is a direct correlation between thickness (mm), air permeability ($cm^3/cm^2/s$), tensile Strength (N), elongation %, friction resistance (g), pilling resistance, and the difference ratio of binding strength between layers of fabrics.

Hence, it is evident that textile compositions with tight binding can be used in the same sample in different areas without causing a defect in the mechanical properties of the fabric. Also, textile compositions with weak binding can be used, but in small areas, so as not to negatively affect the properties of the fabric.

5. Conclusion:

The experimental result indicates that woven athletic footwear fabrics produced from different weaving innovative patterns structures with different bending between layers could be used in the same upper athletic footwear fabrics without strong negatively affection on the mechanical properties of it. The statistical analysis results for correlation coefficients show a direct correlation between weight, thickness, tensile strength, and elongation properties and the difference ratio of binding strength between layers of fabrics. Also, the statistically significant differences between the results are weak, which in turn is reflected in allowing the freedom of design using these different patterns by athletic footwear fabric designers and thus meeting the desires of customers for different designs for this type of athletic footwear without affecting on the mechanical properties of the fabrics involved in their manufacture.

6. Recommendations:

In light of these findings, the following researcher is recommended:

- Expanding the production of innovative pattern designs of jacquard woven athletic footwear fabrics.
- It is known that woven fabrics are characterized by low elasticity compared to weft knitted fabrics due to the strong interconnections between warp and weft threads in woven fabrics. Hence, it is recommended to try to use materials with high elasticity in the production of JACQUARD woven athletic footwear fabrics.

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