Comparative Study between Functional Properties of Different Fabric Structures

Assistant Professor Dr. Nashwa Mostafa Hafez (PhD)
Apparel Department, Faculty of Applied Arts
Helwan University
Cairo, Egypt.

Abstract: *Clothes act as protection from the elements, including rain, snow, wind and other weather conditions, as well as from the sun. Clothes also reduce the level of risk during activity, such as work or sport. The primary function of clothing is to improve the comfort of the wearer. Function has become more and more important, synthetic materials have become more accepted, consequently materials have to fit the purpose to maximize the comfort of the wearer.*
The main objective of this paper is a comparative study between three different knitted structures (single jersey, interlock and rib1/1) to determine the relationship between knitted fabric structures and garments function, as it concerned with the physiological comfort as it is a fundamentally important element of garments.

Key words: *Knitted fabrics, Single Jersey, Rip 1/1, Interlock, Polyamide 6.6, Functional properties.*

1. Introduction

The variety of functional knitted garments depends on end user requirements. They are established in three terms; fabric structure, fiber structure and fabric treatments. (1) This research is concerned with fabric structure.
A basic requirement of clothing is that it must be comfortable for the wearer. Comfort is a neutral sensation and is defined as freedom of pain "wellbeing". (2) In studying the physical factors determining the comfort performance of textiles, it is obvious that comfort involves a complex combination of properties both subjective and physical. (3)

1.1. Properties of functional garments are many bases properties attendant function garments. (4) This research is concerned with 9 functional properties as following.
1.1.1. Abrasion resistance is the ability of a fiber or fabric to withstand surface wear due to rubbing against another surface. Accelerated procedures allow the laboratory technician to determine where performance or durability of a material as experienced in its actual use, so abrasion resistance determines the degree to which a fabric is able to withstand surface against friction forces. (5) The resistance to abrasion is affected by many factors, such as the inherent mechanical properties of the fibers, the structure of the yarns, construction of the fabrics. (6)
1.1.2. Elongation is needed in garments that are exposed to bending and stretched such as knee and buttock areas in trousers or elbows in shirts. Elongation describes the fabrics ability to stretch and recover from the stretched state. It is needed in tight fitting clothing like underwear and sportswear. It is affected by fiber crimp, fiber raw material and fabric construction. (7)

1.1.3. Pilling resistance is the determination of resistance to the formation of pills and surface changes on fabrics. Pilling in garments has always posed major problems, for not only the wearer of the garment, but also for the manufacturer of the fabric. Pilling is a fabric surface fault characterized by little balls of entangled fibers clinging to the surface. These are formed during wearing or washing by the entanglement of the loose fibers, which protrude from the fabric surface. These give a very unsightly look to the garment. (6)

1.1.4. Water repellency is the resistance of fabrics to wetting by water. When the garment becomes damp in rain or snowfall or in sportswear, the moisture diffuses through the clothing and can reach the human skin. As this moisture evaporates, the wearer feels cold and uncomfortable. (4)

1.1.5. Water absorption determines the water absorption percentage and the aptitude of a fabric to absorb and retain water or (sweat) from surfaces such as human skin. (7)

1.1.6. Water absorbency is the ability of a fabric to take in moisture or sweat as it determines the velocity of a fabric to rapidly absorb liquid water from surfaces such as human skin. So it is a very important property, which affects many other characteristics such as skin comfort, static build-up, and water repellency. (5)

1.1.7. Air permeability is an imperative characteristic in the performance; it determines factors such as wind resistance and breath ability. To avoid the condensation of perspiration in a garment breathable fabrics are required. It also influences the warmth or coolness of a garment. (4)

1.1.8. Stiffness is defined as, the ability of a material to resist the deformation under stress. It is concluded that, the fabric stiffness is the key factor in the study of the fabric handle. (6)

1.1.9. Heat insulation is a considerable importance in determining its suitability for use in fabricating cold weather protective clothing. The Heat interchange between man and his environment is an extremely complicated subject which involves many factors in addition to the equilibrium insulation values of fabrics. Therefore, measured Heat insulation coefficients can only indicate relative merit of a particular material. (8)

1.2. Knitted fabric is a textile structure made by the interloping of yarns. This research is concerned with three plain wefts knitted fabric structures as following.

1.2.1. Single jersey fabric has one side consisting only of face stitches, and the opposite side consisting of back stitches. It is also defined as a plain knitted fabric. Single jersey has a simple structure as their stitches are of the same sort and each loop has the same shape. (9)
Fig.(1) Shows the single jersey structure, Fig.(2) Shows the appearance of single jersey fabric.

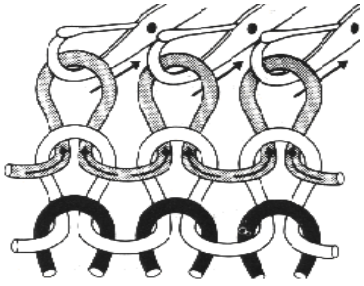

Fig.(1) The single jersey structure (10)

Back Face

Fig.(2) The appearance of single jersey fabric [11]

1.2.2. Rib 1/1 fabric is the simplest rib structure, it stretched widthwise and both sides of the fabric show alternately face and reverse stitches in each course. Once the fabric is released, it shrinks in its width, thus hiding the reverse stitches between the face stitches.[12] Fig.(3) Shows the rib 1/1 structure, Fig.(4) Shows the appearance of rib 1/1fabric.

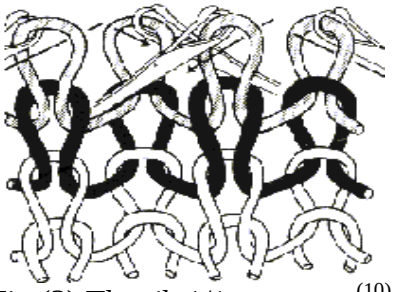

Fig.(3) The rib 1/1 structure [10]

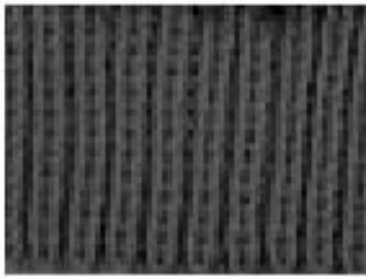

Fig.(4) The appearance of rib 1/1fabric [11]

1.2.3. Interlock fabric could be considered as a combination of two rib knitted structures. The reverse stitches of one rib knitted structure are covered by the face stitches of the second rib knitted structure. On both sides of the fabric, therefore, only face stitches are visible, and it is difficult to detect the reverse stitches even when the fabric is stretched widthwise. [13] Fig.(5) Shows the interlock structure, Fig.(6) Shows the appearance of interlock fabric.

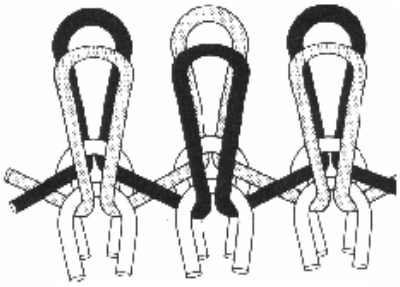

Fig.(5) The interlock structure [10]

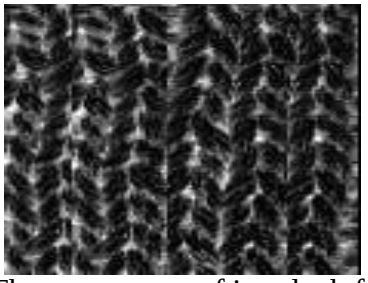

Fig.(6) The appearance of interlock fabric [11]

1.3. Polyamide 6.6 is a manufactured fiber, it is so designated because each of the raw materials, hexamethylene diamine and adipic acid, contains six carbonatoms. In the manufacture of nylon 6.6 fiber, these materials are combined, and the resultant monomer is then polymerized. After polymerization, the material is hardened into a translucent ivory-white solid that is cut or broken into fine chips, flakes, or pellets. This material is melted and extruded through a spinneret while in the molten state to form filaments that solidify quickly as they reach the cooler air. Nylon 66 was developed in the United States. [14]

1.3.1. Properties of polyamide 6.6 are excellent strength, flexibility, toughness, elasticity, abrasion resistance, wash ability, easy dry, and resistance to attack by insects and microorganisms, resistance to dirt. [15]

1.3.2. Applications of polyamide 6.6 are used for apparel such as stockings, lingerie, dresses, bathing suits, foundation garments, wash-and-wear linings, active wear, athletic equipment and outdoor garments. [16]

2. Experimental work

2.1. Tested fabrics specifications

Three samples of Polyamide 6.6 knitted fabrics were produced, with different structures (Single Jersey, Rip 1/1 and Interlock), the samples mass was (150 gm/m^2 ± 5 %) and the yarn count was (D78/68/2). Table (1) shows the specifications of the tested fabrics.

Table (1) Specifications of the tested fabrics

Fiber type	Polyamide 6.6		
Structure	Single Jersey	Rib 1/1	Interlock
Stitch Wales/cm	10	12	13
Stitch courses/cm	15	18	20
Machine gauge	18	20	24

2.2. Experimental tests

Some physical factors determining the functional properties of textiles were tested. All tests were done in conditioned atmosphere of 20ºC ± 2 and 65% ± 2 RH. These properties were abrasion resistance, elongation, pilling, water repellency, water absorption, water absorbency, air permeability, stiffness, and heat insulation.

2.2.1. Abrasion resistance test was carried out on Taber 515 Abrasion Tester, according to the (ASTM 3884). [17]

2.2.2. Elongation test was carried out by using Micro-Standard Universal Tester, according to the (ASTM E-4). [18]

2.2.3. Pilling test was carried out by using ICI Pilling Box Tester, according to (BS 5811: 1986). The test specimens were evaluated against the photographic rating standards, which denote following extents of pilling:-

Rating 1: very severe pilling. Rating 2: severe pilling. Rating 3: moderate pilling.
Rating 4: slight pilling. Rating 5: no pilling. [19]

2.2.4. Water repellency test was carried out by using Bundesmann Water Repellency Tester (SDL), according to (BS EN 29865). [20]

2.2.5. Water absorption test was carried out by using Spray Rating Tester, (B.S EN 29865), Standard Method for the determination of the water absorption of fabrics. [21]

2.2.6. Water absorbency test was carried out according to (BS ISO 4920). [22]

2.2.7. Air permeability test was carried out by using Electronic Air Permeability Tester (FX 3300), according to (ASTM D737). [23]

2.2.8. Stiffness test was carried out according to American Standard Specifications of (A.S.T.M. D1388). [24]

2.2.9. Heat insulation test was carried out by using Heat Insulation Tester, according to American Standard specifications of (A.S.T.M. D1518-85). [25]

3. Results and Discussions

3.1. Abrasion resistance test results

Table (2) Abrasion resistance test results

Abrasion resistance (cycles)		
Single Jersey	Rib 1/1	Interlock
2660	3400	5970

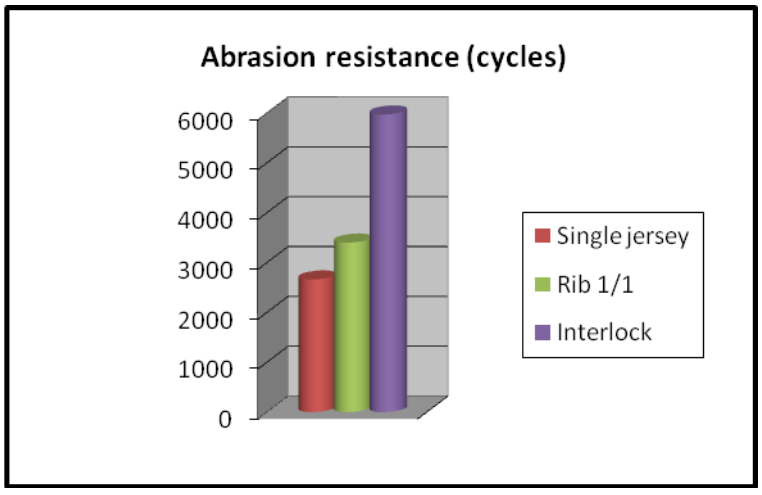

Fig. (7) Abrasion resistance test results

The combination of two rib knitted structures in the interlock structure gives very little space at all for the wales or courses so the tightness of interlock structure and its stitch density are greater than that of the other tested structures, this basics gives to interlock fabrics the highest abrasion resistance property. While the open structure of single jersey, gives it the lowest abrasion resistance. Knitted structure type has a significant effect on abrasion resistance.

3.2. Elongation test results

Table (3) Elongation test results

Elongation (%) L=length, W=width		
Single Jersey	Rib 1/1	Interlock
79/L, 168/W	80/L, 216/W	57/L, 96/W

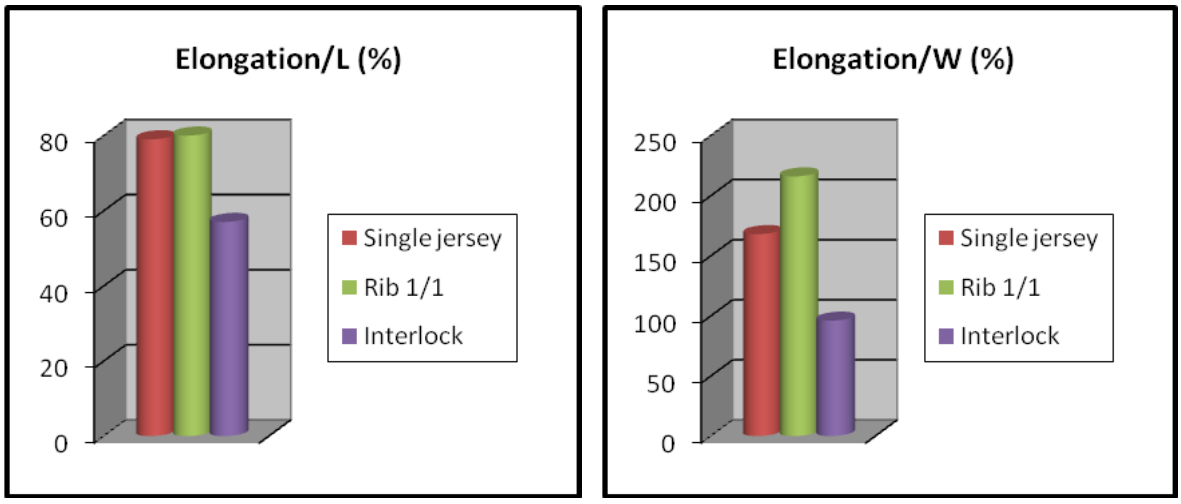

Fig. (8) Elongation test results

The geometry of the yarn path influences the elastic behavior of the knitted structures. The extensibility in length direction of the rib structure is nearly the same of the single jersey structure. The change of direction of the interloping wales stitches in rib structure gives it the best elastic properties widthwise than the other knitted structures. Interlock has the lowest elongation due to the tightness of interlock structure which decrease the stitches elongation, as the composition of two rib knitted structures in the interlock structure gives very little or no room at all for the wales or courses to close up, and therefore the interlock fabrics show very poor elastic properties in both directions.

3.3. Pilling resistance test results

Table (4) Pilling resistance test results

Pilling resistance (rate)		
Single Jersey	Rib 1/1	Interlock
4	5	5

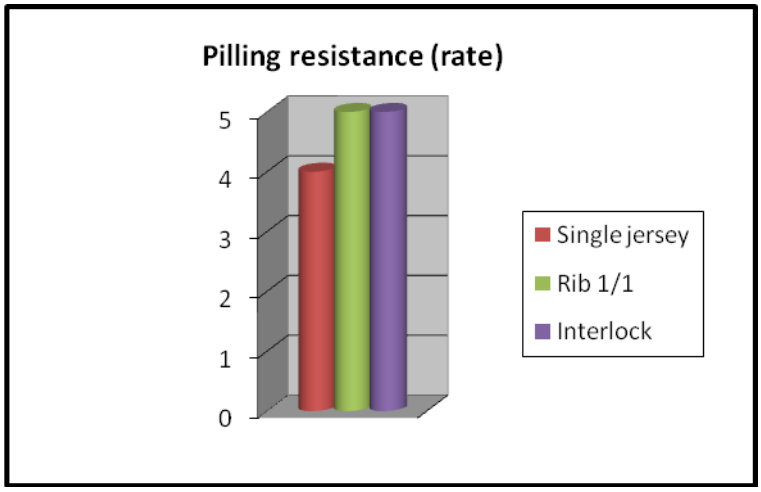

Fig. (9) Pilling resistance test results

The tested fabrics rib1/1 and interlock had no-pill that can be attributed to their more compacted structures, whereas single jersey had low-pill. It is clear that pilling resistance rate dependent also on the kind of fiber which is an effective factor on pilling resistance.

3.4. Water repellency test results

Table (5) Water repellency test results

Water repellency (cm^3)		
Single Jersey	Rib 1/1	Interlock
134	103	145

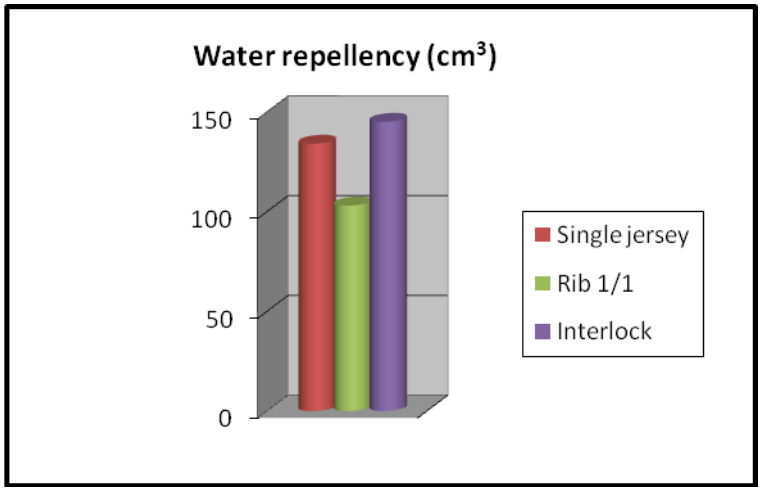

Fig. (10) Water repellency test results

Interlock fabric is more water repellency than the other tested fabrics, because the tightness of the interlock structure gives very little spaces at all for the wales or courses to close up, these little spaces restrict the pass of water drops through the fabric and let it on the surface, in addition the smooth surface of interlock structure skids the water drops so

that repellent water increases. Despite rib1/1 has more compacted structure than single jersey it scored lower water repellency which could be explained as the existence of crinkles in the structure which makes buses allow water permeability.

3.5. Water absorption test results

Table (6) Water absorption test results

Water absorption (%)		
Single Jersey	Rib 1/1	Interlock
103	105	102

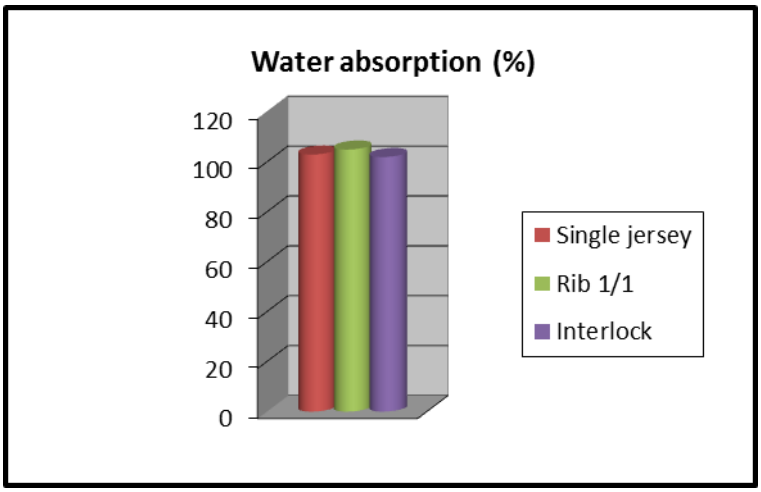

Fig. (11) Water absorption test results

Due to the tightness of interlock structure, it scored the lowest water absorption. Single jersey scored higher water absorption due to its low compacted structure. Rib 1/1 scored the highest water absorption that could be explained as the existence of crinkles in its structure which makes its layers enclose the water through the yarn bundles of the structure.

3.6. Water absorbency test results

Table (7) Water absorbency test results

Water absorbency (cm/2min.)		
Single Jersey	Rib 1/1	Interlock
24	32	20

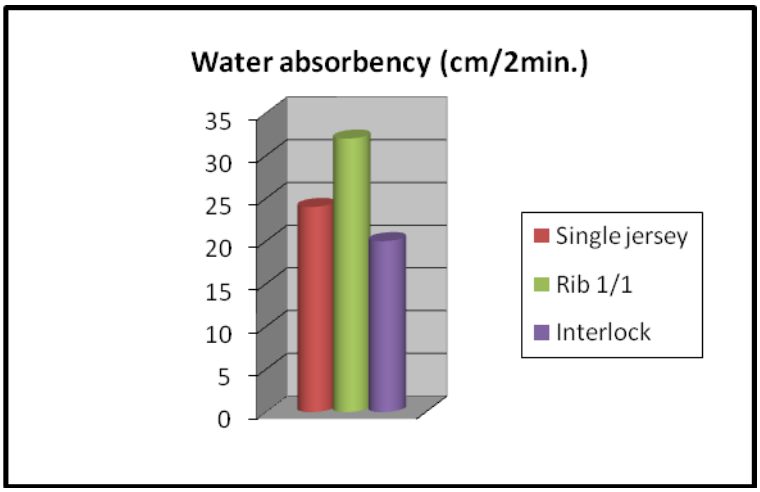

Fig. (12) Water absorbency test results

Rib 1/1 scored the highest water absorbency that could be explained as the existence of crinkles in its structure which makes buses allow increasing water raise. On the other hand the decreasing of water absorbency for interlock structure returns to its tightness and stitch density on which the water raise deter.
Single jersey open structure increases the void ratio inside the fabric which makes the water flow more quickly.

3.7. Air permeability test results

Table (8) Air permeability test results

Air permeability ($cm^3/cm^2/sec.$)		
Single Jersey	Rib 1/1	Interlock
802	490	273

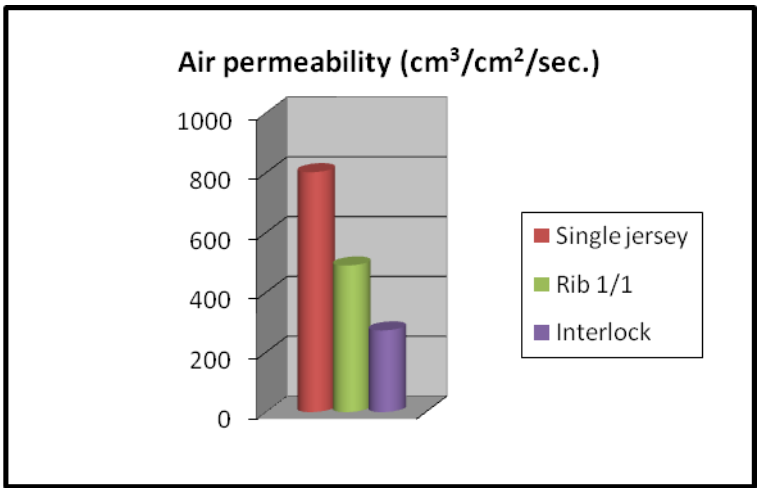

Fig. (13) Air permeability test results

It can be noticed that single jersey has the highest air permeability that could be probable due to the less compact structure of single jersey fabric. While rib structure is more air permeable than interlock structure because the spaces of rib structure are more than that of interlock structure and due to the tightness of interlock structure which decreases the spaces and deters the air flow. Knitted structure type has a significant effect on air permeability.

3.8. Stiffness test results

Table (9) Stiffness test results

Stiffness (mg.cm.) L=length, W=width		
Single Jersey	Rib 1/1	Interlock
98/L, 32/W	128/L, 35/W	66/L, 21/W

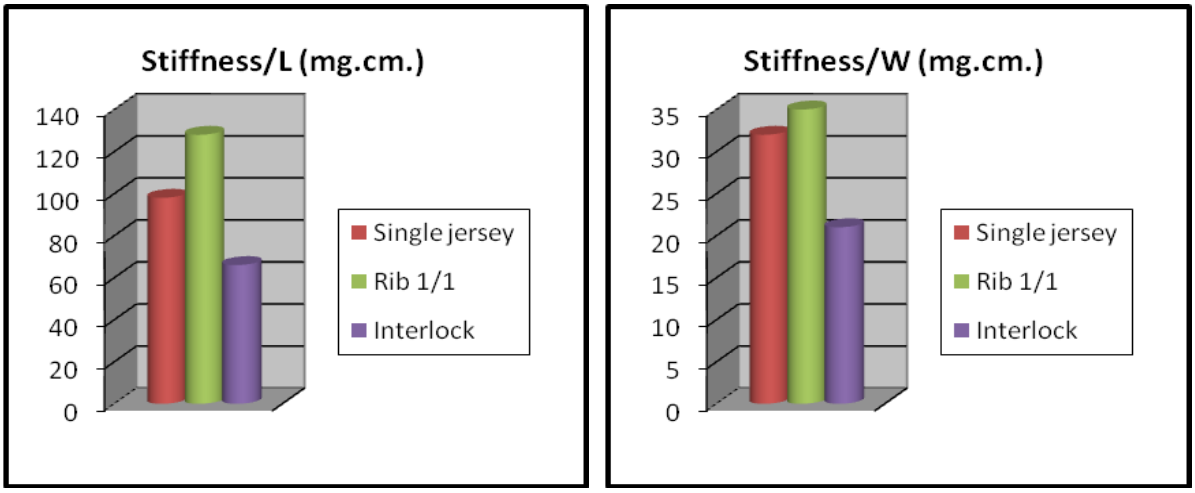

Fig. (14) Stiffness test results

Fabrics made from rib 1/1 structure are stiffer than other tested structures because the existence of crinkles in the rib structure makes it more stiffness while interlock structure has a smooth surface that gives it the lowest stiffness.

3.9. Heat insulation test results

Table (10) Heat insulation test results

Heat insulation (clo)		
Single Jersey	Rib 1/1	Interlock
0.16	1.17	2.27

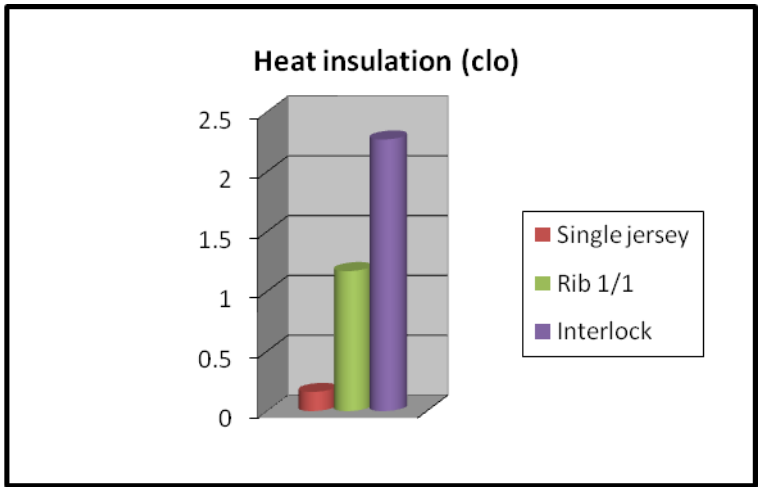

Fig. (15) Heat insulation test results

Interlock structure has the highest heat insulation due to its more compacted structure than the other tested fabrics. Single jersey structure has the lowest heat insulation due to its highest air permeability. The heat insulation increases in rib structure, due to the increase in air entrapped between face wales and back wales. Knitted structure type has a significant effect on heat insulation.

Conclusion

As a result of this research we proof that changing on knitted fabrics structure has a significant effect on function properties for the fabrics which can add value for these fabrics and as all these are the results:

- Knitted structure type has a significant effect on functional properties.
- Interlock structure has the highest abrasion resistance then rib 1/1 then single jersey.
- Rib 1/1 structure has the highest elongation then single jersey then interlock.
- Rib1/1 and interlock structure had no-pill while single jersey had low-pill.
- The kind of fiber is a more effective factor on pilling resistance than the fabric structure.
- Interlock structure is more water repellency then single jersey then rib 1/1.
- Rib 1/1 structure scored the highest water absorption and water absorbency then single jersey then interlocks.
- Single jersey structure has the highest air permeability then rib 1/1 then interlock.
- Rib 1/1 structure has the highest stiffness then single jersey then interlock.
- Interlock structure has the highest heat insulation then rib 1/1 then single jersey.

From all the above results the author thinks there was useful information can help the sports wear designer to select the correct fabric structure which are effecting on functional properties of these products.

References:

1-Li.,Y., The Science of clothing comfort, Textile Progress, Vol.31, No.1/2, 2001.
2-Smith, J.E., The comfort of clothing, Textiles, No.1, 1993.
3-J.E. Ruckman and R. Murray, Engineering of clothing systems for improve thermo physiological comfort, International Journal of Clothing Science and Technology, Vol.11, No.1, 1999.
4-Jenkins, G. The clothes in question. London: Royal College of Nursing/Disabled Living Foundation, 1990.
5-Comfort factors for active sport fabrics, http://www.torayentrant.com/comfort. html(2/9/2012)
6-Fiber Characteristics, www. Fabric Link.com(2/9/2012)
7-Active Sport Fabrics, Comfort factor, understanding the function of fabrics, http://www.torayentrant.com/faq/faq.html(2/9/2012)
8-Webb, L. H. & Parsons, K. C. Thermal comfort requirements for people with physical disabilities. Human Thermal Environments Laboratory, Department of Human Sciences, Loughborough University, Loughborough Leicestershire. UK. 1997.
9-Textile Inst. report, Principles of Knitted Structures, Manchester, 1990.
10-Knitted structures http://www.comstock1700k.com/en/company/licensing(2/9/2012)
11-Spencer, D.J., Knitting Technology, Second Edition Textile Institute, Manchester, 1989.
12-Brackenbury, T. Knitted Clothing Technology, Blackwell scientific publication, London,1992.
13-Kamal,M.S. Knitting Technology:, faculty of applied arts, Helwan university 1998.
14-Textiles material, http://msucares.com/pubs/infosheets/is1250.htm(2/9/2012)
15-Complete textile glossary, Celanese Acetate, 2001, New York.
16-Polyamide, Nylon Filament Yarns and fibers, http://www.swicofil.com(2/9/2012)
17- ASTM 3884: Method of test for determination of abrasion resistance.
18- ASTM E-4: Method of test for determination of elongation.
19- BS 5811- 1986: Method of test for determination of pilling resistance.
20- BS EN 29865: Method of test for determination of water repellency.
21 B.S EN 29865: Method of test for determination of water absorption.
22- ISO 4920:1981: Method of test for determination of water absorbency.
23- ASTM D737: Method of test for determination of air permeability.
24- A.S.T.M. D1388: Method of test for determination of stiffness.
25- A.S.T.M. D1518-85: Method of test for determination of heat insulation.