

**Research Article***Copyright © All rights are reserved by Sertaç Güney*

Investigation of Fabric Behaviours in Compression Sportswear Under Extended Condition

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Compression sports garments in usage stretch up to 10% length and 60% in width, depending on the circumference variations of body. This stretch also changes the loop density, loop shape, porosity and thickness of fabrics. Especially for heat and water vapor transfer, it is expected to play a very important role. Compression sportswear are generally produced from knitted stretch fabrics, which get extended on wearing and remain under extended condition. Since they are worn next to skin and are direct contact with the body surface, their comfort properties are more effective on overall clothing comfort. As Permeability and porosity are strongly related to each other, we compared air permeability of fabrics in extended condition considering the fabric extension results taken from 3D simulation. The aim of this study was to investigate the effect of fabric extension on fabric Behaviours (air permeability, loop density and thickness of fabric) of eleven stretch knitted fabrics used largely in compression sportswear. Revised patterns in virtual garment simulation can help to use the air permeability property more effectively to improve the overall clothing comfort. The results of study show that air permeability and loop density which are strongly related, change significantly when the fabric is posed under an extended condition, especially it is more visible in warp knitted structures. Investigations on fabric Behaviours under extended condition could be the key for solution in ventilation of appropriate zones on garment.

Keywords: Air permeability; Loop density; Clothing comfort; Fabric extension; Virtual garment simulation**Introduction**

High-tech sportswear has been widely applied in special sports and has played an important role in improving athlete's performance in speed, body control, stamina and strength [1]. Every fabric property should be analyzed in detail for better performance. Compression garments elongates up to 10% in length and 60% in width when worn, depending on the variations in body circumference. This stretch also changes the loop shape, density, thickness of fabric and also porosity. All these changes are expected to affect significantly the comfort behavior of fabrics [2].

Air permeability is often used in evaluating and comparing the "breathability" of fabrics due to their porous structure. Air permeability is an important factor in the comfort of a fabric as it plays a role in transporting moisture vapor from the skin to the outside [3] and also in heat transfer; containing open structure pores, airflow carrying heat energy transfers from one side to another side by conduction and convection [4].

Elastane are used mostly in sportswear for compression garments which are used to improve blood circulation, reduce lactic acid and DOMS and it can also be used to help hold a

garment up. Elastane content effects on the air permeability. Air permeability is much better for the knits with no elastane than for the knits with incorporated elastane due to their porosity. The air permeability of knitted fabrics is generally investigated in relaxed condition [5-6]. The researches on air permeability of knitted fabric in extended condition are very limited so that this study could be useful for further researches. In this research field, Virtual garment simulations can be useful to see the fabric poses on body zones.

3D CAD systems for garment simulation has been extensively developed by a transformation into a high technology industry. Researchers focused on the research of computer simulation of garments based on the physical-mechanical properties of fabrics and the intention to achieve the most accurate and realistic simulations of garments [7-8]. Not only advanced computational models are responsible for precise virtual garment simulations but also exact input parameters play an important role for a correct reproduction of the fabric's mechanical behavior [9]. Some researchers have investigated the accuracy of virtual simulations by inputting the fabric properties [10-11].

Materials and Method

Materials

Table 1: Physical and structural parameters of fabric specimens.

Fabric Code	Fibre Composition	Fabric Structure	Fabric Mass (g/m ²)	Fabric Density (kg/m ³)	Air Permeability (l/ m ² /s)	Fabric Thickness (mm)	Loop Shape Factor
1	82% PES 18% Elastane	weft knitted	155	378.05	372.4	0.41	2
2	80% PES 20% Elastane	warp knitted	250	543.48	122.2	0.46	1.3
3	80% PA 20% Elastane	warp knitted	210	328.12	617.4	0.64	1.15
4	85% PA 15% Elastane	warp knitted	240	180.45	745	1.33	1.13
5	83% PES 17% Elastane	warp knitted	280	227.64	424.6	1.23	1.13
6	75% Cot 25% Elastane	weft knitted	200	408.16	119.2	0.49	1.5
7	80% PES 20% Elastane	weft knitted	300	508.47	76	0.59	1.8
8	82% PA 18% Elastane	warp knitted	180	315.79	1326	0.57	1.09
9	84% PA 16% Elastane	warp knitted	180	367.35	776.4	0.49	1.15
10	80% PA 20% Elastane	warp knitted	240	369.23	375.8	0.65	0.86
11	85% PES 15% Elastane	warp knitted	230	479.17	422.6	0.48	0.76

Eleven stretch knitted fabrics (having the same warp and weft knit structure) made of polyamide, polyester and cotton including different amounts of elastane fibers were provided from sports garment producer. Their physical and structural parameters of fabric specimens were given in Table 1.

Methods

As a compression garment extends in width as well as length when worn, the structural and air permeability properties were measured at relaxed condition and also in different extended conditions. For measuring the extended fabric samples, a 16x16 cm² frame was prepared. 10cm x 10cm square was marked on the relaxed fabric mounted on the frame at a given extension (10-20-30-40%). Air permeability were measured by extending the fabric on the frame. Air permeability of relaxed and extended fabric samples were tested according to EN ISO 9237 standard using FX 3300. Average of at least 10 readings was taken.

Number of stitches in courses and wales per cm in the fabric counted by a pick glass in relaxed and also extended condition. Stitch density and loop shape factor were calculated form Equations

1 and 2 respectively.

$$\text{Stitch / cm}^2 = \text{Wales / cm} * \text{Course / cm} \quad (1)$$

$$\text{Loop shape factor} = \frac{\text{Courses / cm}}{\text{Wales / cm}} \quad (2)$$

Thickness of relaxed and extended fabric samples were measured according to TS 7128 EN ISO 5084 using Louis Schopper Test Device.

KES-F (Kawabata evaluation system for fabrics) measurements derived from objective fabric measurements were input into the simulation (Optitex) and the fabric extension maps were obtained. The results can give important predictions about fabric behaviours in extended condition.

Findings

The fabric parameters (tensile, bending rigidity, shear rigidity, weight, thickness) were inputted into the simulation database to simulate the fabric behaviors properly. We adjusted the same mannequin measurements (in Medium body size) and used the same t-shirt pattern for all simulation results (Figure 1).

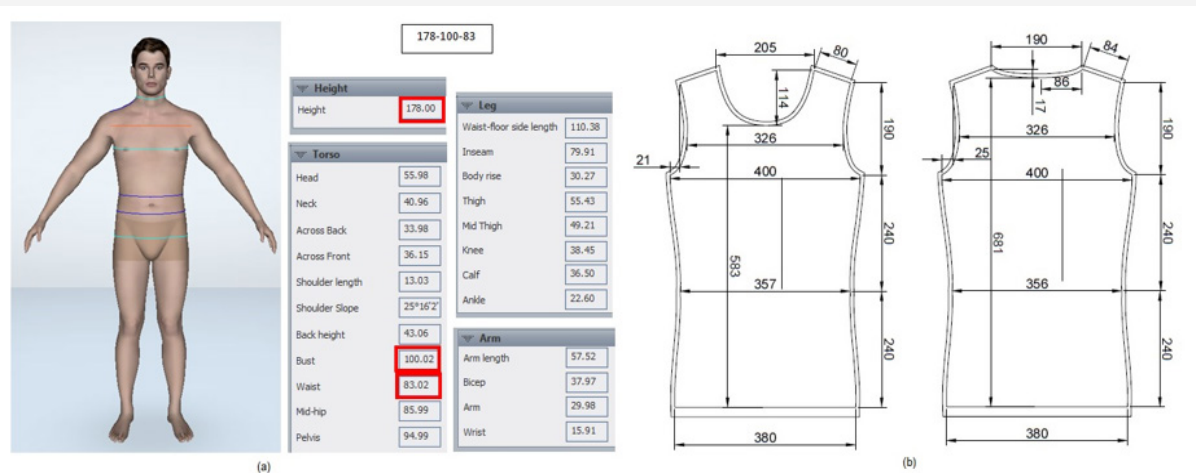



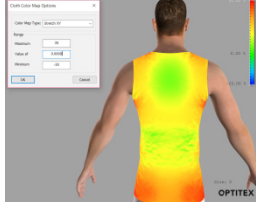

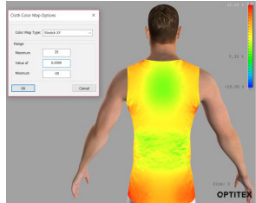

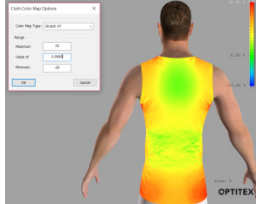
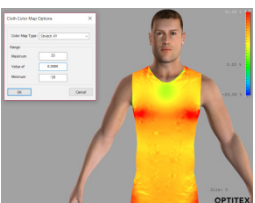
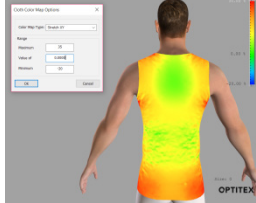
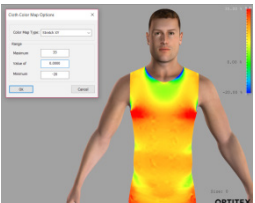
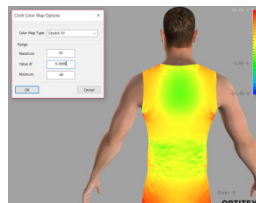

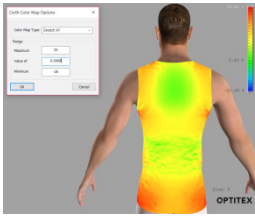

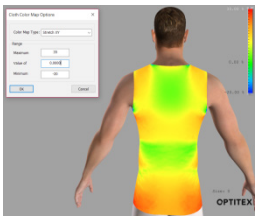
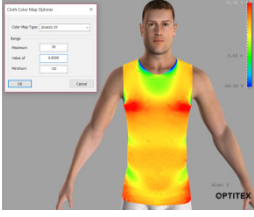
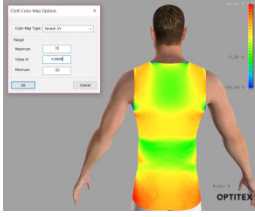

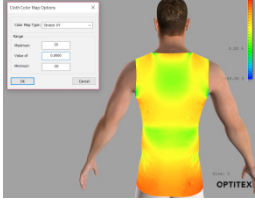
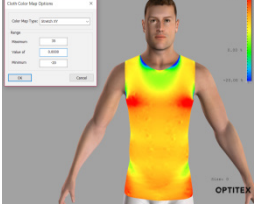
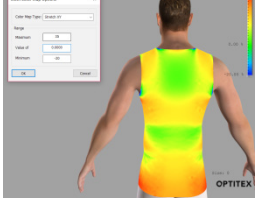


Figure 1: (a) Mannequin view and measurements (b) T-shirt measurements.

The fabric parameters and stretch maps for all fabrics taken from simulation were shown in Table 2. Results show that fabrics on virtual mannequin stretch up to max. 35%. So, it is enough to investigate the extensions up to 40%.

Table 2: Fabric parameters and Fabric stretch maps in Optitex 3D.

Fabric Code	Tensile (N)	Tensile Strain (%)			Shear Rigidity (N/m)	Bending Rigidity (µN.m)		Fabric Stretch Maps in Optitex 3D	
		Wale	Course	Bias		Wale	Course	Front View	Back View
1	0,245	3,05	2,85	4,45	27,64	2,02	1,76		
	0,98	16,15	12,15	18,50					
	4,905	73,30	57,20	67,55					
2	0,245	1,05	1,85	1,35	91,11	2,45	6,03		
	0,98	3,95	6,75	5,30					
	4,905	29,75	33,55	29,75					
3	0,245	1,45	3,20	2,45	50,20	1,05	4,52		
	0,98	8,25	14,35	12,85					
	4,905	54,10	58,95	62,40					
4	0,245	2,16	4,6	3,3	37,27	3,13	5,79		
	0,98	12,09	14,8	13,2					
	4,905	58,23	51,6	56,3					
5	0,245	1,9	1,15	2,4	51,25	6,75	12,33		
	0,98	7,3	6,2	8,05					
	4,905	44,5	28,85	39,5					
6	0,245	3,1	2,8	3,8	32,37	0,13	0,42		
	0,98	12,3	12,1	15,1					
	4,905	59,4	51,6	61,3					

7	0,245	1,9	1,4	3,5	35,14	0,64	3,91	 
	0,98	12,3	9	16,8				
	4,905	67	47,8	72,6				
8	0,245	3,3	7,2	4,2	29,29	0,71	0,29	 
	0,98	14,8	32,4	23,4				
	4,905	85	93,1	85				
9	0,245	6,3	2,4	4,8	25,63	2,04	0,74	 
	0,98	24	10,2	19,5				
	4,905	72,1	46,9	69,4				
10	0,245	1,2	3,9	2,7	45,56	5,17	0,99	 
	0,98	5,7	23,4	15,3				
	4,905	34,2	95,9	71,5				
11	0,245	2,7	7,2	5,7	21,58	1,15	0,95	 
	0,98	10,8	23,1	21				
	4,905	52,9	64,9	60,4				

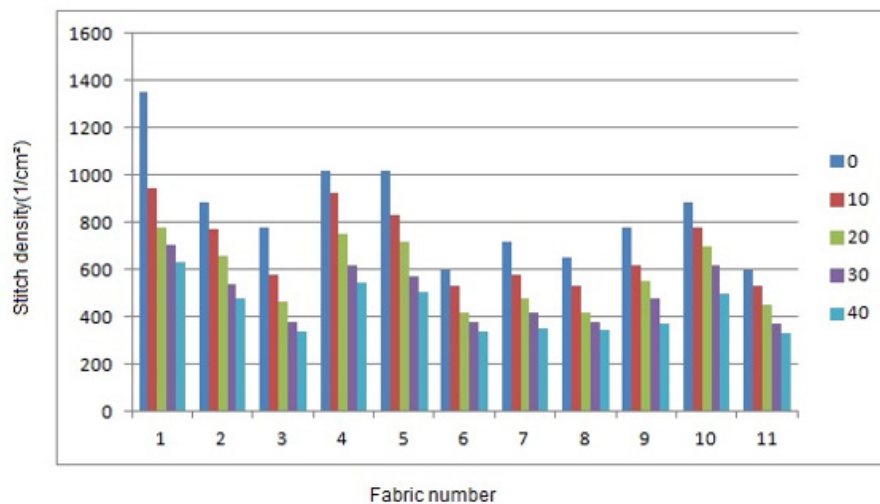


Figure 2: Stitch density values at various extension levels (10-20-30-40%).

Stitch densities of the fabrics at various extension levels in both wale and course directions were shown in Figure 2. As extension increases up to 40%, the stitch density decreases by range of 44-56%. As the percentage of elastane increases in warp knitting, the variations in the stitch density decrease under extended condition. Among warp and weft knitted fabrics with the same elastane content, the warp knitted loop shows a more stable structure and lower variation in stitch density.

Air permeability values of the fabrics at various extension levels were shown in Figure 3. The results show that Air permeability and fabric density are significantly related to each other and also increasing of elastane in structure makes the air permeability decrease. The value variations up to 40% in weft knitted fabrics are higher than the ones in warp knitted fabrics. Because the warp knits have more stable loop structures.

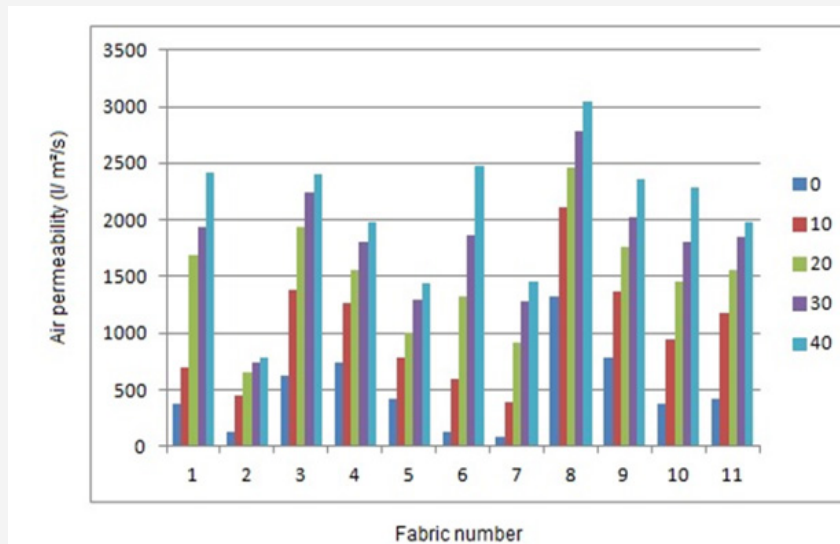


Figure 3: Air permeability values at various extension levels (10-20-30-40%).

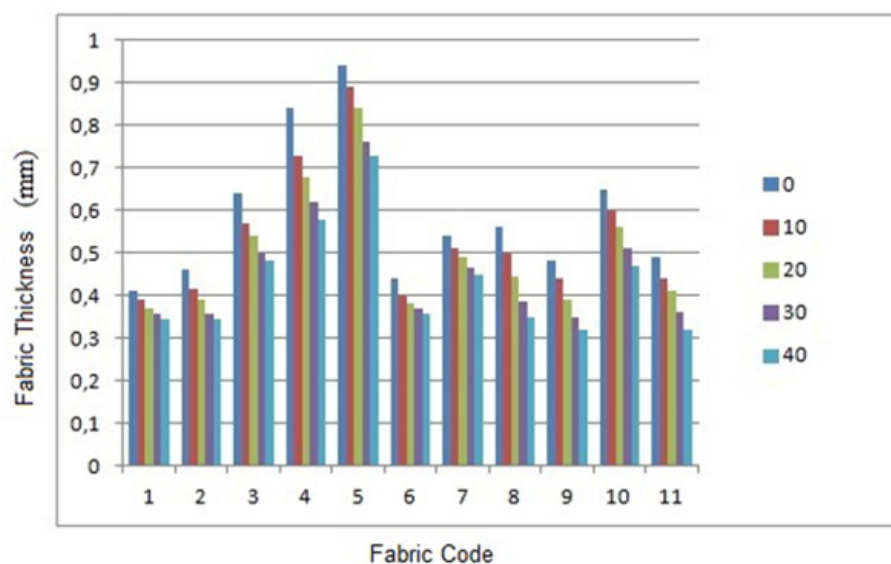


Figure 4: Fabric thickness values at various extension levels (10-20-30-40%).

Fabric thickness values at various extension levels were shown in Figure 4. Because the fabric thickness is related to the thermal resistance, decreasing of this parameter may cause the thermal comfort to change.

The reduction percentages of the fabric thicknesses depending on the elongation rates were shown in Figure 5. Fabric weight, fabric thickness, elastane ratio and density affect the reduction

percentages of fabric thickness. The fabric 8 showed the highest fabric thickness decrease (37.5%) under 40% extension level because it is warp knitting and has lower values in weight and thickness. While the reduction percentage change of weft knitted structures under 40% elongation did not exceed 20%, the reduction percentage in warp knitted structures exceeded 20% even under 30% elongation.

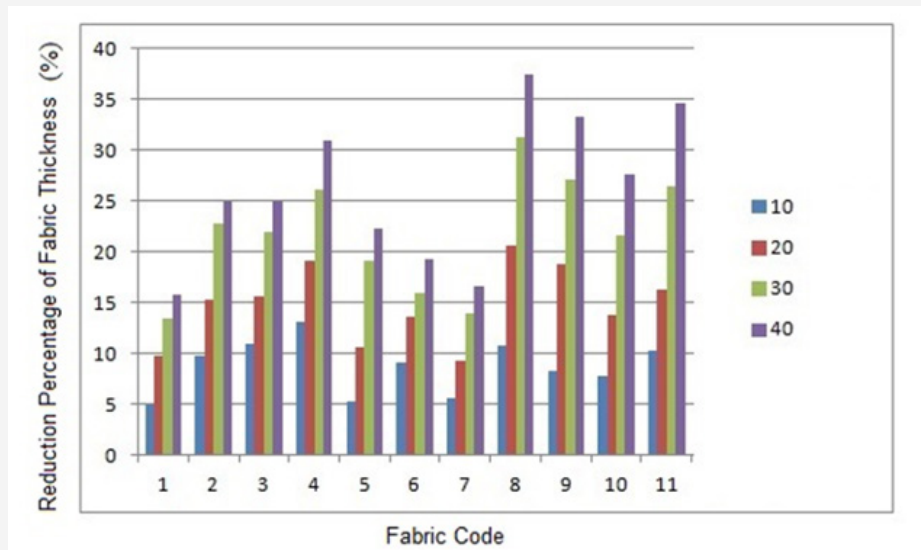


Figure 5: The reduction percentage of fabric thickness values at various extension levels (10-20-30-40%).

Result and Discussion

In this study, the air permeability of elastic weft and warp knitted fabrics used for compression sportswear has been evaluated in relaxed as well as extended conditions. The loop shape changes and fabric structure open up in extended condition so that the structure gets more permeable. It improves the fabric breathability significantly. This case can be important for designing the sports garment for especially performance sportswear. Revised patterns in virtual garment simulation can help to see the fabric poses and use the air permeability property more effectively to improve the overall clothing comfort. Investigations on fabric behaviours under extended condition could be the key for solution in ventilation of appropriate zones and thermal transfer on garment. Adjusting the extension level on appropriate body zones may increase the thermal transfer performance of fabrics and it may help the body to regulate the core temperatures. In further studies, we will investigate on the thermal transfer performance of fabrics under extended condition.

Acknowledgement

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Conflict of Interest

No conflict of interest.

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