(REFEREED RESEARCH)

A STUDY ON ANALYSIS AND IMPROVEMENT OF TROUSER FABRICS USED FOR PRIMARY SCHOOL UNIFORMS

İLKÖĞRETİMDE KULLANILAN PANTOLONLUK KUMAŞ ÖZELLİKLERİNİN İNCELENMESİ VE İYİLEŞTİRİLMESİ ÜZERİNE BİR ARAŞTIRMA

Zümrüt BAHADIR ÜNAL[1], Esra Zeynep YILDIZ[2], Nilgün ÖZDİL [1]

[1] Ege University, Engineering Faculty, Textile Engineering Department, Izmir, Türkiye

[2]Ege University, Emel Akın Technical Vocational School of Higher Education, Izmir, Türkiye

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ABSTRACT

The basic requirement for garments is, not to cause discomfort for the consumer. In order to produce a garment from fabric, fabric should provide body movement, sensorial and thermophysiological comfort. As well as user expectations from a garment varies in a wide range, appearance, handle, performance and price criteria can never be disregarded. In many cases, compliance with the terms of use and feeling comfortable are more important than physical appearance.

Primary school students spend half of their days, according to the education state of school, by wearing school uniforms. Therefore school uniform should be comfortable in both physical and psychological areas and also they should be worn fondly. In most of the schools, male students wear gray classic trousers.

This paper presents an experimental study about physical properties of trouser fabrics used for/in school uniforms. By evaluating the results of tests, ideal trouser fabric for primary school students was decided.

Key Words: School uniform, Trousers, Physical properties, Thermal properties, Clothing comfort.

ÖZET

Giysilerden temel gereksinim, kullanıcı açısından rahatsızlığa neden olmamasıdır. Bir kumaştan giysi üretilebilmesi için o kumaşın, vücut hareketi konforu, duyusal ve termofizyolojik konforu sağlaması gerekir. Kullanıcıların giysilerden beklentileri çok çeşitli olmakla birlikte görünüş, dokununca verdiği his, performans ve fiyat kriterleri hiçbir zaman göz ardı edilemez. Pek çok durumda, giyside kullanım şartlarına uygunluk ve rahatsızlık vermemesi dış görünüşten daha çok ön plana çıkmaktadır.

Okulların öğretim durumuna göre ilköğretim öğrencileri, günlerinin yaklaşık yarısını okul giysisi içinde geçirmektedirler. Bu nedenle, okul giysisi fiziksel ve psikolojik bakımdan çocukların rahat kullanabileceği ve severek giyebileceği bir giysi olmalıdır. Okulların birçoğunda erkek öğrenciler, gri renkli, klasik pantolon giymektedirler.

Bu çalışmada ilköğretim öğrencilerine yönelik üretilen pantolonluk kumaşlar, bazı fiziksel testlerle analiz edilmiştir. Bu testlerin sonuçları değerlendirilerek ilköğretim öğrencilerine yönelik ideal kumaş tipine karar verilmiştir.

Anahtar Kelimeler: Okul giysisi, Pantolon, Fiziksel özellikler, Isıl özellikler, Giyim konforu.

Corresponding author: Zümrüt Bahadır Ünal, zumrut.bahadir.unal@ege.edu.tr, Tel: + 90 232 311 27 94 Fax: + 90 232 339 92 22

1. INTRODUCTION

As well as body proportion, movement abilities and skin properties of children who have a tendency to continuous growth and development differ from adults (1).

Children usually become more involved in social experiences outside the family during the school-age period (2). Therefore, school uniforms should be comfortable for children in both physical and psychological areas and they should be worn fondly (3). The school uniforms should be easy to clean, breathable and aesthetic. Also they should provide body movement comfort and heat-moisture balance (4). In addition to these properties, high tensile strength, abrasion resistance and also good fastness to washing are essential.

According to the experts, children don't like to wear tight clothes, necked sweaters and clothes with zippers. Besides the model of children clothes, the suitability of the fabric, freedom of movement, good handle and ease of use are very important (5).

According to the literature research, school uniforms were first designed for orphans and low income families' children in the 16th century. School uniforms have many social, physical and psychological purposes. However, the most important aim of wearing a school uniform is to make person and her/his neighborhood feel the privilege of being a member of a particular group and provide the responsibility of being a member of it.

In Turkey, school uniforms for primary schools were used to be black colored until 1990s, and then changed as blue. Later, due to the climatic differences in our country, the school uniforms in primary schools were released on with the condition that certain rules were followed. Today primary schools can choose their uniforms as apron or uniform in accordance with the regulations of the Ministry of National Education (3). Boys' school uniforms are designed as aprons or shirts with trousers.

In this study, the fabrics which are present in the school trousers manufacturing market and the ones can be alternative to them were determined. Each of fabric was subjected to physical and chemical tests for determining their properties. By evaluating the results of tests, ideal trousers' fabric for primary school students was decided.

2. MATERIAL AND METHOD

2.1. Material

In this study, 4 different fabrics which are usually used for manufacturing of school uniform trousers were examined. Plain and twill fabrics that have same weft and warp counts (Nm 42/2) but different compositions were analyzed. The properties of fabrics are given in Table 1.

Fabric 1 and 2 are commonly used for manufacturing of the school uniform trousers. Fabric 3 includes elastane content incorporated into core spun yarns in the warp direction. Fabric 4 consists of polyester and wool fibers. The fabrics 3 and 4 were chosen as an alternative to other fabrics.

2.2. Method

Fabric unit weight, tensile and tear strength in warp and weft directions, breaking elongation value, pilling properties, abrasion resistance, air permeability, thermal properties and washing fastness were tested and the results were analyzed. All the measurements managed after conditioning of the fabrics for 24 hours under the standard atmosphere conditions (20±2°C temperature and 65±4% relative humidity).

Fabric unit weight was measured according to TS EN 12127 standard. Tensile strength properties were measured on Zwick Z010 according to TS EN ISO 13934-1. Five samples for each specimen were tested, and averages of the test results were calculated. Pilling was measured on Martindale according to TS EN ISO 12945-2 standard for 2000 cycle. The pilled fabric specimens were then compared with standard pilling test images to determine the pilling grade on a scale from 1 (most severe pilling) to 5 (no pilling). Air permeability was measured on FX3300-Tester according to TS 391 EN ISO 9237 standard. The abrasion resistances of the fabrics were tested according to ISO 12947-2 standard. In order to evaluate the abrasion resistance of the fabrics Martindale Abrasion Tester device under 9kPa pressure was used. All the fabrics rubbed till 50000 turns to observe breakage any of the fabric yarn. Handle properties of fabric specimens was carried out in circular bending rigidity tester, developed according to ASTM 4032. In this method, the force which is generated while pushing a fabric specimen through a ring is measured. So, the higher the value, the stiffer is the fabric.

Washing fastness tests were made to determine the change in colors of a dyed or printed textile product, when exposed to various washing conditions. Washing fastness depends on product type and its intended usage. Washing tests were made in Linitest according to ISO 105 C06 standard and the changes of color in samples were assessed in the grey scale.

Thermal conductivity, thermal resistance and thermal absorptivity properties were measured by computer controlled instrument called Alambeta. Also this device calculates all the statistical parameters of the measurement (6, 7). The contact pressure was 200 Pa in all cases, and the CV values of all the samples were lower than 3%. The parameters obtained from Alambeta;

- Thermal conductivity (λ) - W/mK
- Thermal resistance (R) - m^2K/W
- Thermal absorptivity (b) - $Ws^{1/2}/m^2K$
- Thickness (h) - mm (8).

Thermal resistance is the strength of the fabric to the heat flow and it depends on thickness and thermal conductivity. And this relationship can be expressed by the following equation;

$R = h/\lambda$ (m^2K/W),

h: thickness,

λ: thermal conductivity.

It is an important comfort parameter for protecting human body especially from cold environmental conditions. In fabrics with a low thermal resistance value, heat energy decreases rapidly and human body perceives the cold feeling in various environmental conditions. For that reason, to protect the body from cold, clothes with higher thermal resistance value should be preferred.

Thermal absorptivity is a sudden flow of heat that occurs when the two pieces with different temperatures touch each other (9).

It can be expressed as:

$b = (\lambda \rho c)^{1/2}$ $Ws^{1/2}/m^2K$ (9)

λ: thermal conductivity,

ρ: fabric density,

c: specific heat of fabric.

Thermal absorptivity is the objective measurement of the warm-cool feeling of fabrics. A warm-cool feeling is the first sensation experienced when a human touches a fabric. When a human touches a garment that has a different temperature than the skin, heat exchange occurs between the hand and the fabric (10). Fabrics with a low value of thermal absorption give a "warm" feeling, whereas fabrics with a high value of the thermal absorption give a "cool" feeling (11).

Heat flow increases with the thermal conductivity of the material. This is a good or bad feeling according to the human's choice because in hot summer days a cold feeling is preferred whereas warm clothing is required in cold environments (12, 13).

3. EXPERIMENTAL RESULTS

The test results of fabric unit weight, tensile strength in warp and weft directions, breaking elongation, tearing strength, pilling properties and air permeability are given in Table 2.

As shown in Table 2, polyester-viscose blended twill fabric was found to have highest fabric unit weight due to its high warp and weft densities. On the other hand plain fabric with same composition had the lowest fabric unit weight due to its low weft and warp densities.

When the tensile strength in warp and weft directions of fabrics was examined, the results revealed that the fabric 1 with higher densities had the highest tensile strength in both directions.

Table 1. The structural properties of the fabric specimens

Fabric codes	Composition	Weave type	Thread per cm	
			Warp	Weft
1	Polyester:Viscose (67/33)	2/2 Twill	36	24
2	Polyester:Viscose (67/33)	Plain	22	18
3	Polyester:Viscose:Elastane (66/32:2)	Plain	22	24
4	Polyester:Wool (50/50)	2/2 Twill	26	24

Table 2. Test results of the fabric specimens

		Fabric 1	Fabric 2	Fabric 3	Fabric 4
Fabric unit weight (g/m^2)	-	257	196	243.5	255.5
Tensile strength (N)	Warp	1853.94	1333.69	678.91	730.15
	Weft	1237.92	938.28	892.96	680.04
Breaking elongation (%)	Warp	27.60	20.80	47.18	27.44
	Weft	23.08	27.49	31.72	26.83
Tearing strength (N)	Warp	104.3	109.6	63.4	49.1
	Weft	97.9	94.6	63.7	47.8
Pilling (degree)	-	2	2-3	3-4	4-5
Bending rigidity (N)	-	2.07	1.35	1.27	2.17
Air permeability (l/m²/s)	-	83.9	341.2	180.4	58.9

The tensile strength in warp directions is greater than that in the weft directions except the 3rd fabric which contains warp yarn with 2% elastane. The results of previous studies confirm that the core spun yarn structures, which have an elastomeric filament in the core and around it, where staple fibers are located, causes difficulties holding the fibres together and because of that strength of these yarns are lower than the yarn without elastane. The core spun yarns have a lower tenacity compared to the PES/viscose staple yarn. (14). The outcomes clearly revealed that the tensile strength of fabric that contains elastane is lower than fabric with no elastane. Therefore, as the elastane amount in the fabric increased, the tensile strength values decreased (15). In this study it was found that the tensile strength in warp direction was lower than weft direction in fabric 3 due to the elastane content in warp direction.

The tensile strength of the fabric 3 is considerably lower than the fabric 2 with same construction. This may be explained by the low warp density and elastane content of fabric 3. Fabric 4 gives a low tensile strength due to the low tensile strength of wool fiber.

As it can be seen from Table 2, the breaking elongation values of the fabric 3 with core-spun yarns are high. The fabric 1 with twill weave has higher elongation value in warp direction than fabric 2 with plain weave. It can be explained by the fewer warp and filling yarn intersections per unit area and high-long float length in twill weaves than a plain weave. Fabric 4 had high elongation values in both directions due to the high elongation property of the wool fiber.

When the tearing strength of the fabrics were analyzed, the tearing strength values obtained in weft directions of the fabrics 1 and 2 were almost same but the tearing strength in warp direction of the fabric 2 was higher because of loose constructions, yarns are more free to move and group and thus provides a better tearing resistance. The tearing strength in weft and warp directions of the fabric that contains elastane was low. The fabric sample that contains 50% wool had lowest tearing strength values like as tensile strength due to the low strength of wool fiber.

Tendency to increase pilling for fabrics with twill weave is significantly more than fabrics with plain weave due to the long floats on the twill fabric surface. Tendency to increase pilling for fabrics which do not include elastane fibers is significantly more than fabrics that include elastane. Wool-Polyester blend fabric had a high degree of pilling so tendency to increase pilling was lower. The fibers used in this fabric is spun in long staple spinning system and they are longer than other fibers used in other fabrics, so it becomes more difficult to emerge to the surface hence better values are obtained in pilling tests.

When the fabric specimens were evaluated according to their handle properties, the fabric consists of elastane exhibited the lowest bending rigidity value whereas the fabric 4 had the highest. Although the density of fabric 1 is the highest it can be said that due to the structure of wool fibers, fabric 4 showed the hardest structure.

When the specimens were evaluated according to their air permeability properties, it had seen that the fabric 2 with the lowest warp and weft densities had the highest air permeability values and the fabric 4 that consists of wool fiber had the lowest air permeability due to its cuticle layer that causes higher fabric cover. It was observed that with the increment in the warp and weft densities, the resistance of the fabric to air permeability also increased. Loose fabrics exhibited higher air permeability than dense fabrics (16). The air permeability of fabric 3 was lower than fabric 2 with same construction, due to the high weft density of fabric 3.

It is observed that all fabrics withstood 50000 rubs without breaking a thread in abrasion resistance test.

The test results of thermal properties measured with Alambeta tester are given in Table 3.

When the test results of thermal properties were evaluated for fabrics 1 and 2, we can state that due to the twill weave and denser structure, fabric 1 had the lowest thermal conductivity and highest thermal resistance. Due to the low thickness of fabric 2, thermal resistance was found significantly lower. As mentioned by Frydrych et al, due to high thickness values of twill and canvas weaves according to the plain weaves, we observed the increase of thermal insulation and in the same way the decrease of heat loses (17). The weft density and the thickness values of the fabric 3 were higher than fabric 2, so thermal resistance was higher in fabric 3. When the thermal properties of fabric 4 that contains wool were analyzed, it is observed that due to the low conductivity values of wool fiber, fabric 4 had the lowest thermal conductivity value. It was observed that fabric 4 had higher thermal resistance values than other fabrics except fabric 1 which is thicker.

Table 3. Thermal properties of the fabric specimens

	Fabric 1	Fabric 2	Fabric 3	Fabric 4
Thermal conductivity (10^{-3}W/mK)	50,36	53,5	57,48	48,27
Thermal absorptivity ($Ws^{1/2}/m^2K$)	180,3	190,5	193,36	196
Thermal resistance ($10^{-3}m^2K/W$)	13,9	9,7	11,77	12,11
Thickness (mm)	0,69	0,51	0,67	0,56

The experimental results of thermal properties of the fabrics were analyzed at 95% level significant by using ANOVA statistical test. The results of ANOVA analysis is given in Table 4.

Table 4. p values of variance analysis for thermal comfort parameters

	Thermal conductivity	Thermal absorptivity	Thermal resistance	Thickness
p value	0.000*	0.044*	0.000*	0.000*

*significant for $\alpha = 0.05$

Table 5. Washing fastness results of fabric specimens.

Fabric	Colour change	ACET	Co	PA	PES	PAC	Wo
Fabric 1	4-5	5	3-4	4-5	5	5	5
Fabric 2	4-5	5	3-4	4-5	5	5	5
Fabric 3	4-5	4	3-4	4-5	5	5	5
Fabric 4	4-5	4-5	3-4	5	5	5	5

When the thermal absorptivity results were analyzed, fabrics that contains elastane had a higher value of thermal absorptivity, so they give us cooler feeling in the first moment of contact. This conclusion is compatible with the results that Marmaralı et al. have obtained with knitted fabrics that contain elastane and no elastane (18). Comparing the values of thermal conductivity in relation to the weave type, we can state that the fabric 2 made of plain weave had higher thermal absorptivity than fabric 1 due to its untight structure that cause more area of contact. So fabric 1, gives warmer feeling. Contrary to expectations, wool-polyester blended fabric had high thermal absorptivity value, so it is interesting that in first contact it gives a cool feeling.

The test results of color fastness to washing are shown in Table 5.

As the fastness test results were examined it was found that the color change values of the all fabrics were acceptable. Staining properties of the fabrics were evaluated with gray scale. Staining of the all fabrics over adjacent fibers was found were well except cotton. The cotton fiber results were evaluated slightly lower than the others.

RESULT AND DISCUSSION

Most of the school trousers in the market are manufactured from twill or plain fabrics made of polyester-viscose blend, as given in Table 1 with codes 1 and 2. Trousers offered for sale are thought to be used in whole academic year, so they are not separated for winter and summer. In this study, fabrics 3 and 4 were chosen as an alternative to other fabrics and they will be a choice for summer-winter separation. In good weather conditions, students become more active, so a fabric that consists of elastane was chosen and for cold weather a fabric that contains wool was chosen. Then 4 different type of fabrics were analyzed comparatively.

Among the examined fabrics, due to the low density values, fabric 2 with plain weave that contains 67% PES-33% CV had the lowest weight. Depending on this, the air permeability value that obtained from fabric 2 was higher than other fabrics. It had high tensile and tear strength, low bending rigidity.

Fabric 3 that was chosen as an alternative due to their high stretch abilities, but the low values in mechanical properties is an important negativity for the severe requirements in elementary school students clothing. If the thermal properties are analyzed, high conductivity and air permeability, low thermal resistance obtained from fabric 3 makes the fabric especially suitable for use in the summer days.

The last fabric that contains wool had the high weight, low thermal conductivity and high thermal resistance, although the mechanical properties of this fabric were slightly lower than other fabrics, it will be more appropriate for winter use.

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