PERFORMANCE OF TEXTILE MATERIALS FOR THE NEEDS OF CHILDREN WITH SKIN PROBLEMS

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Abstract: *This study focuses on the experimental investigation of the efficiency of knitted fabric for the needs of children with skin problems. The aim of this study was to compare the end-use properties of commonly available cotton knitted fabrics with other knitted fabrics from fibres mixtures such as Tencel, Viloft, Micromodal, Crabyon, polypropylene with Ag+ and linen. The physiological and sensory comfort of knitted fabrics was determined by laboratory measurements. The following parameters were tested on selected knitted fabrics: pilling, total hand value, air permeability, thermal effusivity and water vapour permeability. The results suggest that knitted fabrics made from viscose fibre or linen have been shown to be better or comparable as cotton. In addition, some viscose materials (with chitosan) and linen are antibacterial, antistatic and thermoregulatory. Clothes made of mixtures of viscose fibres or linen can substitute for cotton fabrics for clothing intended for children with skin problems.*

Keywords: *Physiological and sensory comfort, skin problems, Tencel, Viloft, Micromodal, Crabyon, polypropylene, linen.*

1 INTRODUCTION

Expertise studies show that for people with skin problems is important option appropriate clothing, especially when the fabric comes into direct contact with the skin [1]. Until now, cotton materials have been used as the most suitable for this purpose. Recent studies have reconsidered this view [2]. Short cotton fibres can irritate the skin and high moisture absorption cotton creates conditions for bacterial growth. Rapid development in the field of materials research offers enormous opportunities to improve the functionality of the clothing and textile products [3]. Conditions can be created that will increase the comfort of children in the event of skin problems and optimize the skin environment [4]. Modern technologies and innovative possibilities are offered by a new generation of chemical fibres. They represent a significant potential for improving health care and preventing the health problems of the population [5].

1.1 Clothing requirements for children with skin problems

When caring for human skin, it is important to:

- keep its basic functions in balance,
- protect it from exposure to adverse environmental influences,
- maintain optimal hydration,
- prevent excessive overheating or drying.

These requirements can be met by appropriate clothing, modification of the external and internal environment, the use of appropriate cosmetic and medical care products [6].

It is necessary to increase the immunity of the skin, keeping the skin supple due to appropriate hydration, prevent inflammatory infections and soothe itching for children with skin diseases [7].

The first step is the choose the right clothes in caring for children's skin. Such clothing does not seal, does not irritate the skin, is breathable, does not lead to overheating or to increased sweating, especially in the skin folds, where the skin touches each other [1].

Children's skin differs from adult skin by morphological and functional peculiarities [8]. The structure of children's skin changes with the age of the child and each stage of childhood requires a specific approach - different is the care of the skin of a newborn, different is the skin of a school-age child [9]. Excessive sweating, unsuitable materials and the wrong size of clothes are not good for children's skin. Child's organism is constantly growing and evolving and is equipped with a less sophisticated system of thermal regulation [10].

Children's skin requires attention and individual care 24 hours a day, 365 days a year [6]. This means a different seasonal approach to her treatment. It is necessary, especially for the youngest children, protection against the sun's rays (photoprotection) in summer. Summer hats and caps protect children from overheating, sunburn and reduce the radiation that falls on the eyes by up to 50%. Moreover, children tolerate very low temperatures less than adults due to the currency of a perfect system of thermoregulation in winter. Proper dressing and prevention of cold sweat are ones of the most

important measures that relate not only to the seasons and the activity of the child but also the appropriate choice of clothing size [4]. There are important pleasant fabric handle (the handle characteristics of fabric), non-irritability, good drain of humidity (sweat) and breathable material for clothes for children with skin problems. Used seams should not be hard, sharp or irritating. The issue of easy maintenance needs to be addressed for all products [11]. Clothes are in direct contact with the skin throughout the day, so it is important to carefully select suitable substances that would not damage the skin. Due to their hygienic properties, fabrics made of natural fibres are preferred. Cotton is the most commonly used fabric for patients with atopic dermatitis. It has good folding resistance, better heat conduction, easy dyeing and excellent moisture absorption. Silk fabrics help to keep body temperature by reducing excessive sweating and moisture loss. A new type of silk fabric made from translucent and slightly elastic woven silk is now commercially available (Microair Dermasilk®) and can be used to care for the skin of children with atopic dermatitis. Silver products (textiles/fibres containing silver) have also been shown to offer two benefits in controlling bacterial infections. The fabrics can be used not only on clothing, but also to prevent mite sensitization in atopic patients [12]. Wool fibres that irritate the skin are not suitable, but wearing of Merino wool clothing did not produce any negative cutaneous effects compared with wearing standard clothing [13]. Other studies [14, 15] show that fine-diameter Merino wool clothing should be considered acceptable for people with eczema and seems to be therapeutic to patients with mild to moderate atopic dermatitis. Functional textiles are gaining in importance in medical applications and play a vital role in inflammatory skin conditions. For example, the benefits of two cellulose-based fabrics, Lyocell and SeaCell®, for patients with dermatitis are reported. The use of Lyocell as a nonwoven fabric with biofunctional properties and the ability of SeaCell® to bind and absorb substances, including antimicrobial substances such as silver, are emphasized [16].

1.2 Properties of fibrous knitted fabrics

Modern technologies and innovative possibilities offered by the new generation of fibres represent a significant potential for improving health care and preventing problems. Highly functional fibres give textiles and clothing products made from them specific properties, such as antibacterial, anti-inflammatory, increased absorbency and breathability, thermal insulation or thermoregulatory ability. Rapid development of materials research offers enormous opportunities to improve the functionality of clothing and textiles. The properties of fibrous materials fundamentally determine the properties complexivity of knitted fabrics which are used for AD patients clothing. Therefore properties of special fibres have been investigated to uncover their benefit for AD patient clothing in this article.

Tencel viscose fibre excels in its softness, it is softer than cotton. It is easy to maintain, breathable, helps with temperature control and is suitable for the production of underwear [17].

Polypropylene fibre has low moisture absorbency, low thermal conductivity, high color fastness, and low weight. Polypropylene fibres have a special profile. The cross-section of the fibre is similar to a five-lobed star, and thanks to this profile, moisture wicking is doubled. Thanks to this construction, the fibre is able to absorb a large amount of air, which acts as an insulating layer when the body is unloaded and cools [18].

The special ***Viloft® viscose fibre*** excels in breathability, exceptional moisture transport ability, antistatic properties, softness, thermal insulation properties and easy maintenance [19].

MicroModal® is a fibre made of beech cellulose. The material of these fibres is light, fine and with a regular structure, compared to silk. It is resistant to mechanical stress, resistant to wrinkling, better wicks moisture away from the skin - greater comfort [20].

Crabyon cellulose fibre is completely biodegradable, has an effective antibacterial function for a long time, excellent coloring, prevents the skin from drying out and is therefore suitable for children with skin problems [21].

Linen fibres have high moisture-wicking abilities and low heat retention abilities. Linen products have a stiffer total hand value, good absorbency and are cool. Thanks to the high strength of linen, the products are durable [22].

Cotton fibres have good tensile and abrasion strength. The products have a good total hand value and high absorbency. The products are easy to squeeze, pilling and only provide limited protection against the cold [23].

2 MATERIALS AND METHODS

2.1 Parameters of tested knitted fabrics

The aim of this study is to compare the end-use properties of fabrics made of both functional fibres and classic fibres (cotton). Textiles and clothes with increased comfort properties for the specific needs of children with skin problems have been produced from the above-mentioned fibres. These fabrics appear to be an essential part of complex measures to increase wearing comfort and support the healing process. The knitted fabrics were produced (K1, K2, K3 and K4 are custom made) and selected (K5 and K6 are commercially available) that meet the requirements of sensory and physiological comfort. Based on this requirement, the selection of the following materials (Table 1) for children's clothing was recommended.

Table 1 Parameters of tested knitted fabric for the production of children's clothing

Sample	Fibre content/commercial name	Structure of knitted fabric	Weight [g/m^2]	Thickness [mm]	Stitch density [cm^{-2}]
K1	Viscose (Tencel) 50% / Polypropylene with Ag+ 50%	jersey fabric	161	0.64	240
K2	Viscose (Viloft) 60% / Viscose (Micromodal) 40%	jersey fabric	116	0.45	234
K3	Viscose (Micromodal) 48% / Cotton 40% / Viscose with chitosan(Crabyon) 12%	double jersey	143	0.93	374
K4	Linen 100%	jersey fabric	149	0.53	224
K5	Cotton 100%	interlock	210	0.90	330
K6	Organic cotton 100%	jersey fabric	154	0.64	323

Note: Organic cotton refers to naturally cultivated cotton without the use of any synthetic agricultural chemicals such as fertilizers or pesticides or transgenic technology [24].

2.2 Methods of testing

Selected end-use properties and their evaluation methods that are associated with physiological comfort will now be presented. It is important to testing of pilling, total hand value, air permeability, thermal effusivity and water vapour permeability for the physiological and sensory properties of knitted fabrics for children with skin problems. The measurement was applied on brand-new samples (without maintenance).

Pilling / Abrasion resistance - appearance change - determination of the pilling / abrasion resistance of tested samples was carried out by the Martindale method EN ISO 12945-1 / EN ISO 12947-4. The degree of appearance change AP [-] of tested samples was determined in range 1-5. The degree 1 means the biggest appearance change and the degree 5 the smallest one.

Total Hand Value - determination of the total hand value of tested samples was being executed by Kawabata system by Internal regulation IP KOD 01_2004 [25]. Properties that allow objective evaluation of total hand value are measured. The measuring system is able to test the tensile, shear, bending and surface properties in a standard load. The measurement of the fabric is called the Total Hand Value and takes values from 1 to 5 (excellent THV has a value of 5).

Air permeability - the rate of air flow passing perpendicularly through a known area of fabric is adjusted to obtain a prescribed air pressure differential between the two fabric surfaces [26]. From this rate of air flow, the permeability of the fabric is determined by the standard EN ISO 9237 “Determination of the permeability of fabrics to air”.

Heat transport - thermal transport properties were measured using C-Therm Thermal Conductivity Analyzer TCi. The TCi employs the Modified Transient Plane Source (MTPS) technique in characterizing the thermal conductivity TC [W/m.K] and thermal effusivity TE [W.s^{½}/m^{2}K] of materials. The standard test method EN 61326-2-4:2006 was used for this testing by TCi.

Water vapour permeability - the FX 3180 Cup Master was used for measurement of water vapour permeability. This equipment determines parameter the Water Vapour Transmission Rate WVTR [g/m²/24 h] using the gravimetric measuring principle. The measurement was carried out according to standard JIS L 1099 (2012).

3 RESULTS AND DISCUSSION

As shown in Figure 1, the samples K1, K2 and K4 achieve very good resistance to pilling. This is due to the structure of knitted fabric and stitch density. Cotton samples K5, K6 have a lower resistance to pilling because of the character of used fibres.

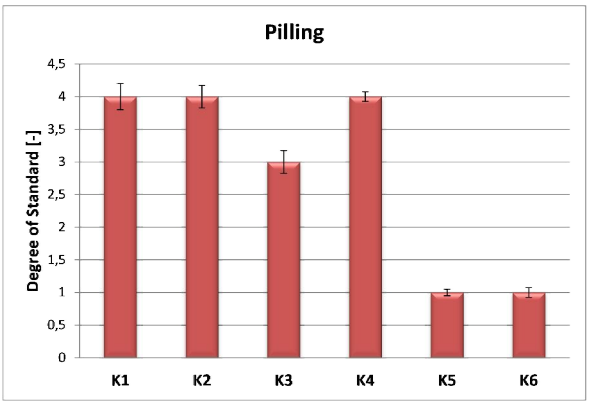

Figure 1 Test results of pilling

On the contrary to the pilling results, samples containing cotton K3, K5 and K6 achieve excellent total hand value. These samples have below-average stiffness, above-average smoothness, fullness of hand value and softness as measured. These properties are given mainly by fabric structure (pattern, density, thickness, etc.) in combination with material raw of tested samples. In the above-average total hand value of the samples are K1 and K4. Below-average stiffness, good smoothness and softness were found here. Surprisingly, the sample K2 (Viloft/Micromodal) has been shown the lowest total hand value, because of a limited low stiffness, above-average smoothness and fullness of the hand value. What is interesting about this fact is that sample K2 has the lowest thickness, weight and density from all tested samples and there is a positive structure condition to pleasant to touch.

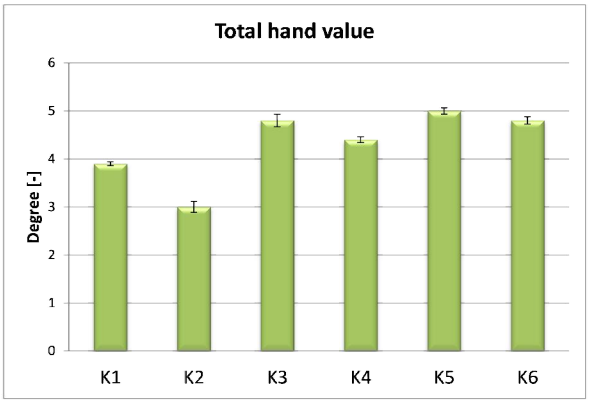

Figure 2 Test results of Total Hand Value

Figure 2 provides the test results of the total hand value.

Air permeability is significantly influenced by a fabric´s material and structural properties too. The results of the air permeability test are presented in Figure 3. Very good air permeability is achieved by samples K1, K2 and K4, which have a lower stitch density and a smaller thickness. In contrast, samples containing cotton K3, K5 and K6 have lower air permeability values due to higher stitch density and higher thickness.

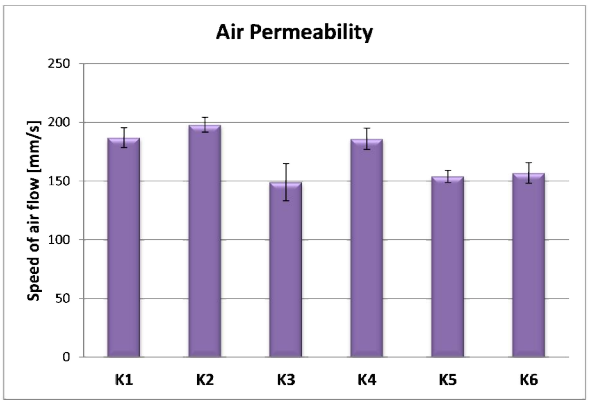

Figure 3 Test results of air permeability

When determining the water vapour permeability, the tested samples are compared with a reference water sample, where Water Vapour Transmission Rate WVTR = 17.000 g/m^2/24 h. Figure 4 presents the value of testing water vapour permeability. The samples K1, K2 and K4 with a smaller thickness and a smaller stitch density have very good water vapour permeability. The samples K3, K5 and K6 containing cotton fibres show lower values of water vapour permeability due to a higher thickness and higher stitch density.

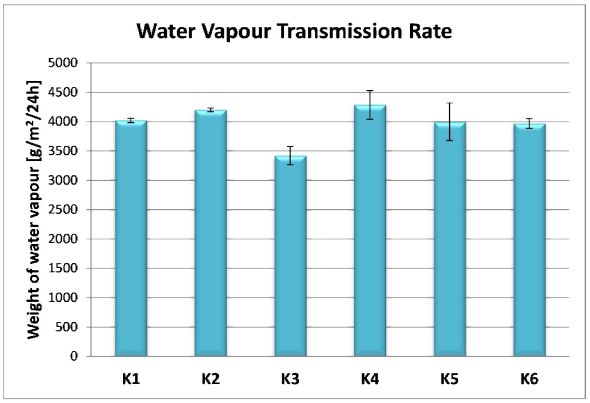

Figure 4 Test results of WVTR

Thermal effusivity is a parameter that characterises the transient thermal feeling during the first contact of the body skin with clothes. From the point of view of thermal effusivity, the samples K1, K2 and K4 have lower values, which is related to the high thermal conductivity and it represents the cold character of the knitted fabric. In contrast, samples K3, K5 and K6 containing cotton show a warm feeling, as shown in Figure 5.

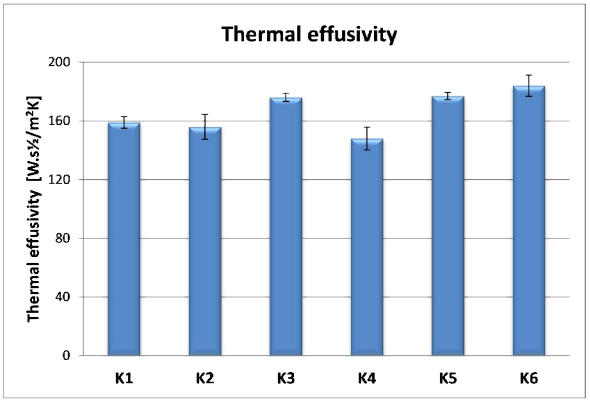

Figure 5 Test results of thermal effusivity

The Figure 6 presents parameter TLWC [%] (Total Level of Wearing Comfort) that is given by sum of percentage contributions (PC) of each tested properties to total performance of tested samples. These percentage contributions were calculated for each tested parameter on the basis of the measured value of the best sample (e.g., value PC of WVTR for sample K4 was considered such as 100%). PC values of WVTR for rest of samples were proportionally related to this "the best" value. The same procedure was applied for each measured parameter. Tested samples can achieve maximum value of TLWC equals 500%.

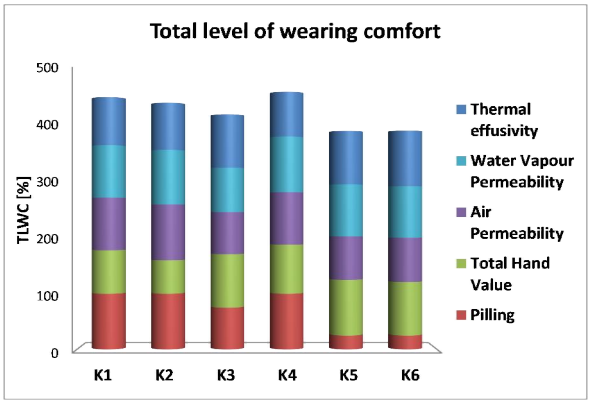

Figure 6 Comparison tested samples from point of view of TLWC

Parameter TLWC can be considered to simplified and moreover rough tool for appraisal of tested samples performance. Nevertheless, the Figure 6 shows clear differences between efficiency of tested samples. The most obvious finding to emerge from this analysis is that sample K4 (linen) achieved the best value of TLWC, moreover the distribution of PC for individual tested parameters of sample K4 are nearly uniform. In the present study, comparing cotton fabrics with others functional samples including linen showed that is possible to substitute commonly used cotton material for these special materials in order to support heath for AD illness. It is question, if this fact is acceptable by customer manners.

4 CONCLUSIONS

The aim of this study was to test the end-use properties of selected knitted fabrics intended for clothing of children with skin problems. Methods for evaluating the performance of knitted fabrics from mixtures of viscose, polypropylene and linen yarns and their comparison with knitted fabrics containing cotton were selected and described. The following the end-use properties were tested - pilling, total hand value, air permeability, water vapour permeability and thermal effusivity. The purpose of this study was to select a suitable material with better both physiological and sensorial properties for clothing for children with skin problems. This research has shown that all selected knitted fabrics achieve good value in terms of performance, but some knitted fabrics are more suitable for children with skin problems. In the evaluated parameters, sample K1 from a mixture of viscose and polypropylene fibres with silver performed best and K4 from 100% linen yarns. The problem with linen material is the difficult workability and durability of the material due to the brittleness of the fibres in use. Sample K2, which is composed of a mixture of Viloft and Micromodal viscose fibres, also shows very good values of the tested parameters.

The research has shown that, from the point of view of the evaluation of thermal effusivity, these knitted fabrics can be divided into use for summer and winter periods. Samples K1, K2 and K4 have a cooling character and are suitable for summer. On the contrary, samples K3, K5 and K6 show a warm feeling and are suitable for cold conditions. Taken together, these results suggest that fabrics made from mixtures with viscose fiber or made from linen can fully substitute cotton fabric to support and even increase in health for AD patients.

A natural progression of this work is to complete the objective laboratory evaluation of end-use properties of knitted fabrics by subjective practical test. The selected set of probands will record the course and conditions of using clothes made from samples K1 and K2. The evaluation will be performed using standards and questionnaires. Clothes made of tested materials for children with skin problems will significantly contribute to increased comfort in case of skin diseases, support the healing process and help optimize the skin environment.

Several questions still remain to be answered. Therefore future research should be focus on determining of effect of fabric maintenance (namely by washing) to clothing comfort performance of tested samples.

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