Property Evaluation of Diabetic Socks used to prevent Diabetic Foot Syndrome

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STATEMENT OF PURPOSE

Diabetes is a chronic disease which is increasing during the past years. Studies state that in 2025 the number of patients around the world will approximately be the double. Due to the complications promoted by diabetes, the patient looses sensitivity, but at the same time injuries are more complicated to be healed.

Special care must take place with diabetic feet, namely by using proper shoes and socks, in order to avoid exceeding friction, sudation, high temperature, among other relevant factors.

One of the most serious problems for diabetic patients is called diabetic foot syndrome, that when neglected, can become dramatic, because in extreme cases, amputation of the foot may occur. In this research we studied several socks, made with new and advanced materials and diversified knitted structures, focusing on socks commercially available and specially designed for diabetic patients, in order to understand what would be the most adequate combination of structure and fibres that would give the adequate results in terms of l properties using different equipment and to foreseen the possibility of indicating the most appropriate material/sock for the different existing diabetic foot syndromes.

INTRODUCTION

Diabetes is a problem that affects millions of people worldwide. In Portugal, Diabetes affects near 10% of the Portuguese population and about 15% more are in danger of developing this disease. Consequences of diabetes are problems associated with the feet of these patients. Known as diabetic foot syndrome, the typical symptoms can be lack or excess of sensitivity, poor blood circulation, bad tolerance to compression and difficulty to control hemorrhagic wounds [1,2].

There exist two types of diabetic foot syndrome: neuropathic and angiopathic syndrome. The first exists when the diabetic patient is non sensitive against high pressure points, lesions and temperatures. In the case of angiopathic foot syndrome, lack of oxygen and nutrients to the foot tissue exist [3], which can promote fat and blood clots to build up in the large blood vessels, stick to vessel walls, and block the flow of blood (Figure 1).

Patients with diabetes mellitus and peripheral neuropathy are at high risk for skin breakdown and subsequent lower-extremity amputation due to unnoticed repeated trauma to the foot's skin surface during walk [4].

FIGURE 1. Example for the diabetic foot syndrome[3]

Special care must take place with diabetic feet, by using proper shoes and socks. The available solutions for socks include new raw materials with antimicrobial activity, regenerating activity, temperature management, among other characteristics. These socks can combine different knitted structures, especially in the heel, toes, instep and bottom of the foot, contributing for an improved comfort and promoting a better heat exchange [1,2].

The textile sector can and should contribute to a better quality of life of diabetic patients, particularly with diabetic foot syndrome, applying their knowledge in terms of raw materials and combination of different knitted structures.

EXPERIMENTAL APPROACH

Tested Material

At the beginning seven different commercially available socks for diabetic patients were studied, composed by functional fibres with antimicrobial activity, moisture management and increasing the wound healing process combined with several types of knitting structures.

The Table 1 shows the composition for each one of the seven socks, the knitting structure and the mass per unit area.

It should be noted that sock #2 is considered the reference sock for this study, since health professionals usually recommend socks based on cotton.

The objectives of this particular study were to understand the effect or influence of raw material and structure in properties like thickness, water vapour permeability, air permeability, thermal resistance and thermal conductivity. Moreover, understand underlying relationships between these properties for this particular kind of sock. As stated before, diabetic socks should take into account that diabetic foot requires improved protection for good temperature and moisture management.

TABLE I. Fibre Composition and Basic Characteristics for the studied Diabetic Socks.

Sock Code	Composition	Knitting Structure	Mass/Area (g/m^2)
1	67%PA/15%PU/19%X-STATIC®	Jersey	188
2	97%CO/3%PU	Jersey	218
3	80%CO/12%PP/6%PA/2%PU	Plush	475
4	75%CO/19%CRABYON®/4%PA/ 2%PU	Jersey	227
5	82%CO/9%X-STATIC®/6%PA/ 3%PU	Jersey	213
6	97%COOLMAX®/3%PU	Jersey	432
7	86% ACRILICS/10%PA/3%PU	Plush	647

As it can be seen in Table 1, most of the socks present a jersey structure. Only socks #3 and #7 have a plush structure. So, it was decided to eliminate these socks in the statistical treatment.

Tested Properties

Table 2 show the applied test methods and units in the study to ascertain the properties of the knitting structures used for the diabetic socks.

TABLE II. Studied Properties, Test Methods and Units.

Property	Test Method	Units
Thickness	Manufacturer (KES-FB3)	[mm]
Water Vapour Permeability	BS 7209	[g/m^2/day]
Air Permeability	NP EN ISO 9273	[$l/m^2/s$]
Thermal Properties: **Thermal Conductivity** **Thermal Resistance**	Manufacturer (Alambeta)	[W/m°K] [m^2°K/W]

RESULTS AND DISCUSSION

An objective analysis of the five selected socks was conducted in order to determine which materials and structures were the most important for a patient with diabetic foot, using SPSS for data analysis and statistical tests.

The table 3 summarizes the ANOVA and post-hoc tests conducted for the properties under study. ANOVA tests showed that there exists a statistically significant difference between the socks.

TABLE III. Similarities between socks for each property, sorted from lower to higher values.

			Sock code and group by similarities		
Thickness	2,5	1	4,6	-	-
Water Vapour Permeability	1,2,4,5	6	-	-	-
Air Permeability	6	1	2	4	5
Thermal Resistance	1,5	6	4	2	-
Thermal Conductivity	1,2,4	5	6	-	-

The post-hoc tests were used to quantify which were the socks that could be considered as having the same value on a particular property. For example, for thickness, post-hoc tests showed that there are three groups that can be considered statistically different for a significance of 0,05. Under this analysis, sock #2 and #5 would have similar thickness, while sock #1 presents an average value which is different from the other socks. Socks #4 and #6 can also be considered as presenting similar results, being also the highest ones. Similar analysis can be performed for the remaining properties.

CONCLUSIONS

The main findings of this study was that the 100% cotton jersey sock, referred throughout this study as the standard sock, didn´t performed as expected for the studied properties. This sock has the highest thermal resistance and lowest conductivity, although it´s the thinnest one. This discovery is rather important, because this sock is referred as the most recommended sock for a diabetic patient with diabetic foot syndrome. However, its lower price makes this sock a strong competitor to all the other studied socks, including the ones with advanced or high performance fibres. These results reinforce the idea that actually there are other alternatives in terms of new fibres with high performance for this type of product. Considering the same structure, a thick sock may not be a synonym of a hot sock, with high thermal resistance, as well as a light sock might not necessary mean that is very thin or present very high air permeability, since functional fibres and yarn properties may influence this behaviour. Beyond the observations and conclusions obtained during this research, an interesting suggestion resulted, that is the need for a classification of diabetic socks in two types: Socks recommended for the spring-summer; and socks recommended for the autumn-winter. This kind of classification should be included on the diabetic sock labels in order to elucidate “consumers” - diabetic patients and prevent improper use of these socks.

KEYWORDS

Diabetic foot Syndrome, Advanced Materials, Properties, Comfort

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