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Exploring the Relationship Between Structural Functionalization and Sensory Attributes of Knitted Polyester Sportswear Fabrics

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Abstract **–** This study investigates the physical and perceptual characteristics of five knitted polyester materials by combining objective measurements and subjective evaluations. The materials were analysed for thickness, surface roughness, and elasticity using precise instruments, while subjective tactile assessments were collected from 40 examiners (20 men and 20 women) who rated three bipolar attributes: thickness, stretchability, and surface roughness. Objective results showed significant variability among the samples, with thickness ranging from 0.36 to 0.59 mm, roughness (Ra) from 7.98 to 16.61 µm, and elasticity from 139% to 212%. Subjective ratings generally corresponded well with the objective data, indicating participants' ability to perceive differences in material properties. Minor discrepancies and gender-based variations were observed but did not substantially affect the overall trends. The findings highlight the value of integrating subjective tactile perception with objective testing to comprehensively characterize textile materials.

Keywords – Material, Fabric, Thickness, Surface Roughness, Elasticity, Subjective Measurement, Objective Measurement.

I. INTRODUCTION

Athletes' clothing plays a crucial role across a wide range of sports, especially in high-speed disciplines such as cycling, skiing, and swimming. The performance of sportswear largely depends on its aerodynamic, hydrodynamic, and thermodynamic properties, including how well it fits the athlete's body. The suitability of materials for sports applications must meet a variety of performance parameters specific to each sport [1].

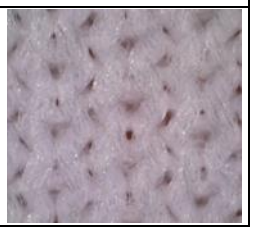
Comfort, functionality, attractive design, and ease of use are key requirements for sportswear. Various properties of sports clothing can be achieved by using new types of fibres, fibre blends, fabric structures, and finishing treatments. Moisture management capabilities—such as sweat absorption, evaporation, and quick drying—are fundamental functions of active sportswear that significantly influence the athlete's comfort during physical activity. Thermal and physiological aspects of clothing also play a vital role in selecting materials for sportswear [2]. Many consumer decisions when buying textiles and apparel are influenced by visual appeal and tactile sensation; therefore, sensory attributes should be regarded as key factors in marketing. Researchers emphasize that the fabric's hand plays a central role in determining the comfort of textiles and clothing [3]. In the study conducted by Xue et al., the fabric samples varied in raw materials as well as in weave types, with fabric mass per unit area ranging from 4.30 to 13.48 mg/cm². The authors concluded that simple sensory methods, specifically free sorting and rating, proved to be effective for evaluating a relatively large number of fabric samples [4]. Researchers have highlighted the importance of including a larger and more representative group of participants to obtain more reliable consumer data. It is also essential to clearly define the age group of evaluators in line with the target population. Previous studies often involved participants aged 20 to 60 within the same group, which may affect the consistency of results. Although both male and female participants were usually included, such group composition limits the ability to draw conclusions about gender-based differences [5-7].

In our previous studies, the goal was to investigate how different materials influence the perception of fabric attributes among evaluators with varying backgrounds. A set of bipolar attributes, such as stiffness–softness and roughness–smoothness, was thoughtfully chosen to capture multiple dimensions of tactile perception relevant to the fabrics assessed by the diverse evaluator groups [8, 9].

II. MATERIALS AND METHOD

For the investigation a set of different knitted materials used. All samples are made of 100% polyester fibre. The description of materials is given in Table 1.

Table 1. Materials used for the assessment

Sample	S1	S2	S3	S4	S5
Mass per unit area g/m^{-2}	152.95	139.56	124.6	184.12	134.51
Microscopic image					

A thickness gauge DM-2000 Wolf Messtechnik was used to measure the thickness of the samples and the average value was given. The tensile strength of the samples was tested on a dynamometer, and the results are shown as the mean value of five obtained results. Surface roughness was measured with a PCE-RT 2000 roughness tester, PCE Instruments UK Ltd. The measurement was made on the front and back of the material and in the direction of the row and row. As a result, the value of Ra is read, where a higher value of Ra indicates a higher roughness of the material.

A total of 40 examiners (20 men and 20 women) aged between 19 and 26 years participated in the subjective part of the tactile test. Before the test began, the examiners were explained the subjective test protocol for all three tested attributes (Table 2). For all three tested bipolar attributes, the examiners gave ratings from 1 to 7. For example, a rating of 1 in the thickness test indicates that the material is the thinnest, and a rating of 7 indicates that the material is the thickest.

Table 2. Bipolar attributes and instructions for manipulation

Bipolar Attributes	**Instruction for manipulation during evaluation**	
Thin - thick	Hold the sample between two fingers and estimate the thickness.	
Smoothness - roughness	The fabric is placed on the flat surface. Move the palm and fingers over the fabric surface.	
Non-stretchable - stretchable	Spread the sample with two hands and assess the elasticity.	

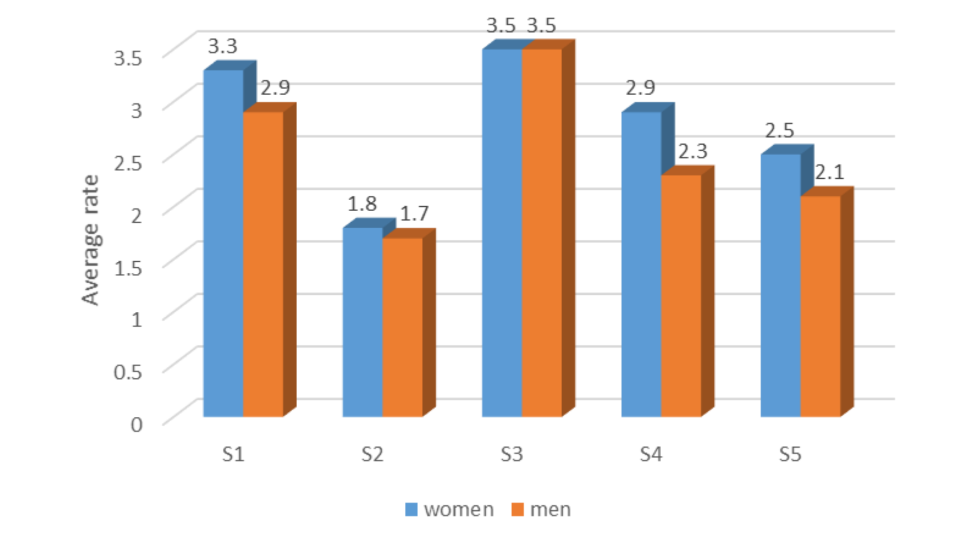
III. RESULTS

The results of objective measurement for materials thickness, roughness and elasticity are given in table 3. The results of average rates given by examiners for three bipolar attributes are given in the figure 1.

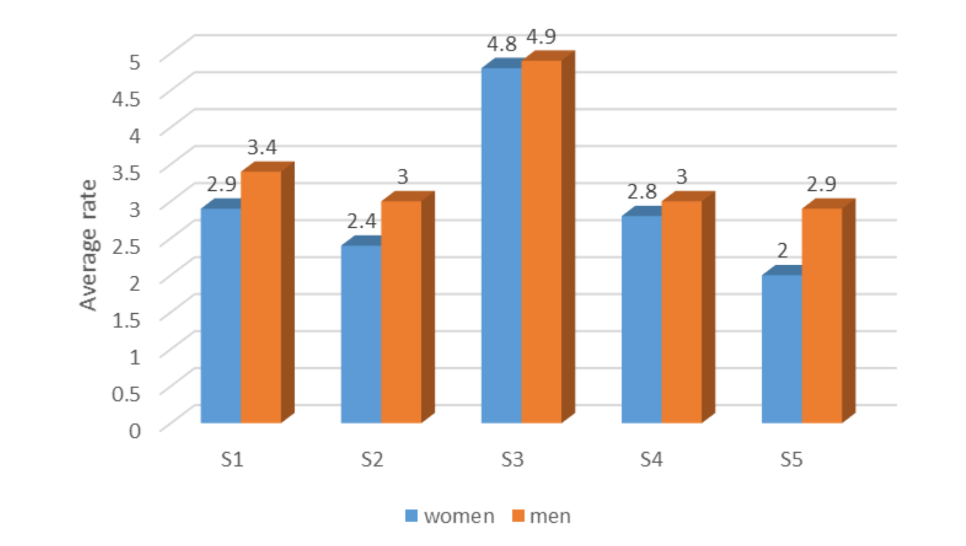
Table 3. The results of objective measurements

Sample	**Material thickness (mm)**	**Roughness (μm)**	**Elasticity (%)**
S1	0.59	7.9774	138.96
S2	0.36	9.5645	212.23
S3	0.49	16.6130	153.20
S4	0.43	13.0674	157.29
S5	0.51	9.2931	151.34

Table 2. Bipolar attributes and instructions for manipulation



a



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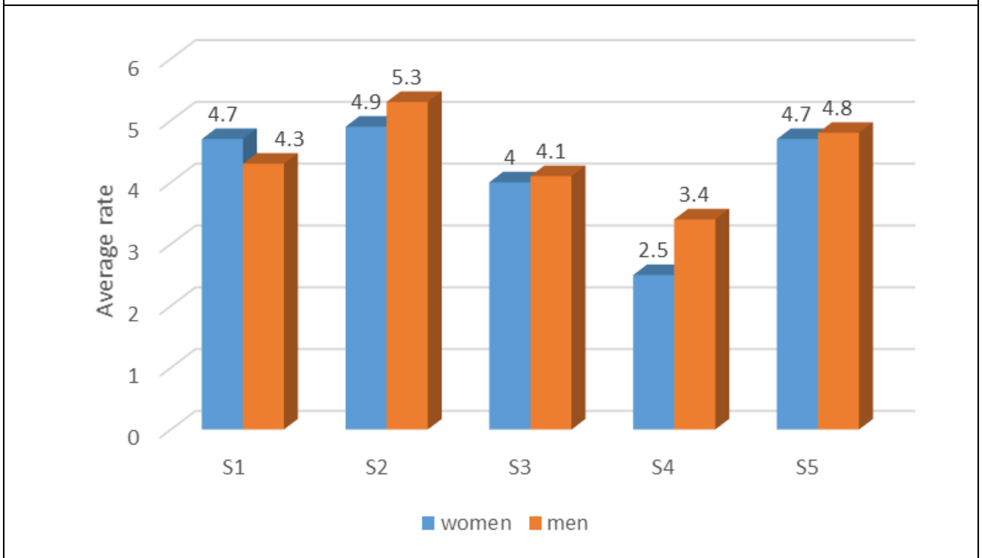

c

Fig. 1 Average rating for bipolar attributes for women and men: a) thin-thick, b) smoothness- roughness and c) non-stretchable – stretchable.

The results of both objective and subjective evaluations provide insight into the perceptual and physical characteristics of the five tested materials. Material thickness, roughness, and elasticity were measured using precise instruments, while subjective assessments were gathered from 40 participants (20 male and 20 female) for three bipolar attributes: thickness, stretchability, and surface roughness.

Based on the objective results shown in Table 3, the thickest material was Sample S1 (0.59 mm), while the thinnest was Sample S2 (0.36 mm). Examiners' subjective ratings generally followed the trend of the objective measurements, indicating that both men and women were able to detect differences in thickness with a reasonable level of consistency. For instance, Sample S1, which had the highest thickness (0.59 mm), received high subjective ratings from both women (3.3) and men (2.9), suggesting that it was perceived as relatively thick (Figure 1a). Similarly, Sample S2, with the lowest thickness (0.36 mm), received the lowest subjective scores (1.8 from women, 1.7 from men), aligning well with the objective data. It is worth noting that women tended to give higher ratings than men across most samples, possibly indicating greater sensitivity to small changes in thickness or a tendency to use a broader rating scale. Nonetheless, gender differences in perception were minimal overall.

Regarding surface roughness, objective Ra values ranged from 7.9774 µm for S1 to 16.6130 µm for S3. Subjective ratings by evaluators generally followed the trend of the objective measurements. Sample S3, which had the highest roughness, was rated as the roughest by both women (4.8) and men (4.9), suggesting that participants were able to perceive differences in texture accurately (Table 1b). Similarly, Sample S5, with one of the lower roughness values (9.2931 µm), was also subjectively rated as the smoothest, receiving average ratings of 2.0 (women) and 2.9 (men). Although Sample S1 had the lowest objective roughness, the subjective ratings did not fully reflect this — women rated it at 2.9, while men gave it a slightly higher score of 3.4. This discrepancy may indicate gender differences in the perception of tactile properties, although the difference is relatively small. Additionally, Sample S2, which had a relatively low roughness (9.5645 µm), received slightly lower subjective ratings than S1, suggesting that perception is not always strictly proportional to objective values.

With regard to elasticity, the highest value was recorded for Sample S2 (212.23%), and the lowest for S1 (138.96%), indicating notable variability among the samples. Subjective ratings generally followed the pattern of the objective elasticity data, particularly for samples with extreme values. For instance, Sample S2, which had the highest measured elasticity (212.23%), received the highest perceived elasticity scores from both women (4.9) and men (5.3), suggesting that participants were able to recognize its superior stretchability (Table 1c). Conversely, Sample S1, with the lowest elasticity (138.96%), also received among the lower subjective ratings (4.7 from women and 4.3 from men), though not the lowest overall. Interestingly, Sample S4, with a moderate elasticity of 157.29%, was rated significantly lower by participants (2.5 by women and 3.4 by men) than might be expected based on its objective measurement. Notably, men generally gave slightly higher elasticity ratings than women for most samples, particularly for S2 and S4. This could suggest that men are either more sensitive to differences in stretchability or apply a different internal scale when judging elastic properties. However, the gender-based differences in perception are relatively small and do not appear to significantly alter the overall trend.

IV. CONCLUSION

This study successfully evaluated the physical and perceptual properties of five different knitted polyester materials through a combination of objective measurements and subjective assessments. Objective data on thickness, surface roughness, and elasticity revealed distinct differences among the samples, which were largely reflected in the subjective ratings provided by 40 participants of both genders. Participants demonstrated a consistent ability to perceive variations in material thickness and surface texture, with subjective evaluations aligning closely with the measured values. Although some minor discrepancies were observed—particularly in the perception of roughness and elasticity—these did not significantly affect the overall correlation between objective and subjective results. Gender differences in subjective perception were present but minimal, with women tending to be slightly more sensitive to thickness differences and men generally assigning marginally higher ratings for elasticity. The findings indicate that subjective tactile assessments can reliably complement objective testing in characterizing material properties, providing a comprehensive understanding of the tactile experience of knitted fabrics.

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