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COMPREHENSIVE ASSESSMENT OF FRICTION AND MOISTURE-MANAGEMENT PROPERTIES OF SKIN-CONTACT TEXTILES

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Abstract: This article addresses the selection of textiles that come into direct contact with the skin for therapeutic and functional garments. The literature indicates that friction, contact pressure, moisture transport, and air permeability are interrelated characteristics of the skin–fabric interface. A comparative experimental protocol is proposed for cotton, modal, lyocell, and blended fabrics. The protocol includes measurements of fabric thickness and areal density, air permeability in accordance with ISO 9237, liquid moisture management using AATCC TM195 or an equivalent validated method, drying time, and repeated friction measurements against a standardized skin-simulating surface. Measurements before and after laundering are included to assess the durability of functional properties. The methodological contribution lies in integrating these indicators within a multi-criteria selection framework rather than assessing fabric composition alone. No original laboratory measurements by the author were provided for this manuscript; therefore, the article presents a testing protocol and a framework for analysing results rather than fabricated empirical findings. The proposed approach may support the preliminary screening of textiles for sensitive-skin garments, but it does not establish clinical efficacy.

Keywords: therapeutic garments, textile materials, skin–fabric interface, coefficient of friction, moisture management, air permeability, functional textiles, multi-criteria assessment.

INTRODUCTION

Continuous contact between clothing and the skin is an important factor affecting comfort and garment performance. In people with sensitive or dryness-prone skin, particular importance attaches to fabric surface structure, frictional forces, moisture absorption and release, and effects on air exchange. However, whether a fabric is made from natural or synthetic fibres does not fully determine how it interacts with the skin. Yarn parameters, textile structure, finishing methods, and garment construction may also influence the outcome.

Gerhardt and colleagues experimentally investigated the effect of skin hydration on friction against textiles and demonstrated the importance of controlling friction and contact conditions when evaluating the skin–fabric interface [1, 2]. These findings support the need to measure physical properties when selecting materials for sensitive skin rather than relying solely on fibre type.

The aim of this article is to develop a methodology for the comprehensive assessment of skin-contact textiles in terms of friction, moisture management, and air permeability, and to substantiate preliminary criteria for screening materials intended for therapeutic garments. The objectives are: (1) to identify the principal physical indicators; (2) to select appropriate testing

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methods; (3) to develop a procedure for assessing performance stability before and after laundering; and (4) to propose a multi-criteria comparison approach. The scope of the study does not include the evaluation of clinical treatment efficacy.

LITERATURE REVIEW

Research on the skin–textile interface identifies frictional and shear forces, contact pressure, and surface moisture as important physical factors. Gerhardt and colleagues measured friction between human skin and fabric under different moisture conditions [1]. In another study, Gerhardt and co-authors demonstrated that a skin-like test surface can be used to objectively determine differences in static and dynamic friction among fabrics [2]. These studies highlight the need to compare textiles under controlled loading, movement, and surface conditions.

Moisture exchange cannot be described by water absorption alone. The spreading of liquid across a fabric surface, capillary transport along fibres, and subsequent drying depend on fabric geometry and yarn and fibre characteristics. AATCC TM195 is intended for the objective measurement and classification of liquid moisture-management properties in knitted, woven, and nonwoven fabrics [4]. AATCC TM199 describes a method for assessing drying time using a moisture analyser [5].

For measuring air permeability, ISO 9237 specifies a method applicable to a range of textile fabrics [3]. Nevertheless, a high air-permeability or moisture-management value does not automatically indicate a material that is clinically superior. The appropriate choice for a garment depends on the balance among several indicators, user needs, and garment construction.

Existing studies examine individual physical factors in detail. The practical approach proposed in this article seeks to integrate them into a single testing protocol and multi-criteria selection matrix. Its novelty does not lie in claiming a universal or clinically validated ranking, but in proposing a reproducible procedure for jointly analysing indicators obtained under consistent conditions.

MATERIALS AND METHODS

The proposed initial sample set comprises four to six fabric types: 100% cotton, modal, lyocell, and one or two types of blended fabric. For each sample, the manufacturer's information on fibre composition, fabric structure, areal density, thickness, dyeing, and finishing should be recorded. Sample dimensions, conditioning temperature, and relative humidity should be kept as consistent as possible and aligned with the requirements of the relevant standards. At least five independent specimens or laboratory-appropriate replicates are recommended for each material; the final number should be determined according to the test method and statistical power.

Thickness and areal density are recorded to characterise fabric construction. Air permeability is measured in accordance with ISO 9237 or an equivalent method validated by the laboratory [3]. Liquid moisture management may be assessed using a standard method such as AATCC TM195 [4], while AATCC TM199 or another validated method may be considered for drying time [5]. For each measurement, the calibration status of the equipment, test surface, pressure, specimen orientation, and ambient conditions should be documented.

The coefficient of friction is determined using a tribometer or a specialised device suitable for the fabric–test-surface system. Unless clinical safety requirements and ethical approval permit

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the use of human skin, a characterised and standardised synthetic skin model should be used instead. Normal load, sliding speed, travel distance, specimen orientation, and whether the surface is dry or moist must be specified consistently for all samples. If friction force is measured, the coefficient may be calculated using the simple Coulomb model, $\mu = F/N$, where F is the tangential friction force and N is the normal load. This model does not capture every complexity of actual skin–fabric contact; therefore, results must be reported together with the testing conditions.

Some specimens are tested in their initial state, while further measurements are repeated after a predetermined number of laundering cycles. For example, five and ten cycles may be selected as preliminary observation points. However, the washing programme, detergent, water temperature, drying method, and number of cycles must be specified in the protocol. These cycle counts are proposed for experimental design and are not presented as requirements of a standard.

For each indicator, the mean, standard deviation, and sample size should be reported. Depending on the data distribution and experimental design, an appropriate parametric or non-parametric test should be selected to compare two or more groups. Results before and after laundering should be analysed as paired measurements. Alongside statistical significance, reporting effect sizes and confidence intervals is recommended. In multi-criteria assessment, the direction of each criterion must be specified in advance: for example, lower friction and shorter drying time may be preferable, whereas air permeability should be interpreted in conjunction with the garment's intended function and other properties.

RESULTS AND FRAMEWORK FOR ANALYSIS

The proposed methodology reduces the limitations of assessing a fabric on the basis of a single property. For example, good moisture absorption does not necessarily imply rapid moisture release, and high air permeability alone does not prove clinical benefit. Consequently, all indicators and garment construction should be considered together when selecting a material.

A synthetic skin or standardised test surface may improve the reproducibility of results, but it cannot represent all the biological and mechanical properties of human skin. Separate ethically approved clinical studies would be required to establish the clinical efficacy of therapeutic garments.

Indicator	Unit	Recording procedure	Interpretation
Thickness	mm	Repeated measurements for each specimen	Describes fabric geometry
Areal density	g/m²	Standardised specimen area and mass	Material quantity and construction
Air permeability	Unit specified by the standard/method	According to ISO 9237	Potential for air exchange
Moisture management	Method-specific indices	AATCC TM195 or an equivalent method	Liquid spreading and transport
Drying time	min	From a defined initial	Moisture-release

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		moisture level to the specified endpoint	dynamics
Coefficient of friction	Dimensionless	μ = F/N; record test conditions	Mechanical interaction with the test surface
Change after laundering	%	(X_after − X_before) / X_before × 100	Functional stability

Table 1. Recommended test indicators and their interpretation.

To select a material, the function of each indicator in the intended therapeutic garment should first be defined. Measurements should then be normalised so that they can be interpreted on a consistent scale. If weighting coefficients are used, their sum should equal 1, and the weights should be justified by expert judgement or a predefined method. A notional overall score can be expressed as:

$$S_i = \Sigma_j \, w_j \, z_{ij}$$

Here, S_i is the overall score for material i; w_j is the weight assigned to criterion j; and z_{ij} is the normalised value for the relevant criterion. For indicators where lower values are preferable, such as friction and drying time, the direction of normalisation should be reversed.

DISCUSSION

The principal advantage of the proposed protocol is that it does not evaluate a material using only one characteristic, such as fibre composition or water absorption capacity. Air permeability, liquid-moisture spreading, drying time, and friction are complementary but not interchangeable criteria. For instance, a fabric that absorbs a large amount of moisture may release it slowly; surface smoothness is also not the sole determinant of friction. Material selection therefore requires a multi-criteria approach.

Because previous research has demonstrated that moisture conditions affect friction, testing fabrics only in a dry state may lead to an incomplete or misleading interpretation of the results [1]. However, when comparing moisture conditions, the amount of water, conditioning procedure, and test sequence must be standardised precisely. A synthetic skin model may improve reproducibility, but it may not fully reproduce the biological and mechanical characteristics of human skin.

The proposed approach also has limitations. First, laboratory results do not directly establish real-world garment comfort or dermatological outcomes. Second, surface treatments, dyes and finishing chemicals, seams, garment fit, and individual user characteristics require separate consideration. Third, the proposed multi-criteria score is not a clinically validated indicator and should be treated only as an auxiliary tool for preliminary material screening.

At the next stage, it is recommended that fabrics from the same production batch be tested, the laundering protocol be standardised, an adequate number of replicates be obtained, and the results be verified by an independent laboratory. Any clinical claims would require a separate, appropriately designed clinical study with ethical approval.

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CONCLUSION

When evaluating textiles that come into contact with the skin, friction, moisture management, air permeability, and post-laundering stability should be considered together. ISO 9237 provides a methodological basis for measuring air permeability, while AATCC TM195 can be used to assess liquid moisture-management properties. Friction testing should be conducted under clearly defined loading conditions and against a specified test surface. The next stage of research should involve testing fabric specimens under standardised conditions, conducting repeated measurements and statistical analyses, and comparing the resulting data with independent scientific studies.

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