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An Interdisciplinary Investigation of Silk-Based Garments in Infant Skincare: Effects on Friction and Dermatological Health

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Abstract

Infant skin is particularly sensitive and prone to mechanical irritation due to its delicate dermal structure and undeveloped barrier function. Friction from conventional clothing materials like polyester or cotton is often associated with rashes, redness, and discomfort. This study aims to evaluate how silk-based apparel can improve the cutaneous

health of babies by reducing fabric-to-skin friction and the frequency of skin rashes. A combination clinical and textile-based approach was used to assess the material properties of silk textiles as well as their practical use in baby wear. The hydration-controlling properties, air permeability, interface softness, and frictional ratios of silk, cotton, and polyester fabrics were investigated during the pre-clinical phase. The results showed that silk performed better than other fabrics in terms of friction levels and surface smoothness. Thirty healthy infants between the ages of three and twelve months were divided into three groups and given garments made of silk, polyester, and cotton for fourteen days during the clinical phase. It was a randomized controlled trial. Skin condition was monitored using surface water loss (TEWL), visual rash assessment, and parent survey responses.

The findings demonstrated that newborns wearing silk garments had more pleasant skin and significantly less peeling, with caretakers expressing higher levels of satisfaction. The results of the study indicate that silk-based fabrics greatly enhance the cutaneous safety of babies and lower skin friction, indicating that they might be utilized in both daily and medical infant clothes. This interdisciplinary research establishes links between textile engineering and pediatric healthcare, opening the way for innovations in practical and therapeutic clothing.

Keywords
Silk-based fabrics, Infant skincare, Skin friction, Rash prevention, Dermal irritation, Pediatric dermatology, Textile engineering, Cosmetotextiles, Randomized controlled trial, Moisture management, Surface smoothness.

1.1 Introduction
Due to its anatomical and physiological immaturity, newborn skin is extremely vulnerable to environmental stresses such heat buildup, hydration irregularities, and psychological friction. Compared to adult skin, newborn skin is particularly prone to inflammation, rashes, and discomfort because of its thin epidermis, lower lipid concentration, and increased loss of trans epidermal water (TEWL). Infants' clothing choices are one of the most underappreciated yet significant causes of these cutaneous issues, especially during their initial year after birth when their skin's shield keeps forming (Hon and Leung 2006).

Cotton has long been the preferred material for baby clothes since it is breathable and gentle. Cotton and other common fabrics, such as polyester, can still provide significant scratching, though, to irritate the skin locally, especially in places where there is constant movement or perspiration, such as the neck, armpits and nappies area. A naturally occurring chemical fiber, silk is prized for its moisture-regulating qualities, low sticking index, sensitive nature, and remarkably smooth exterior. These qualities make silk a viable substitute fabric for baby clothes, particularly when it comes to avoiding dermatitis development and technical skin reactions (Engstler and Park and Hwang 2011).

Cosmetotextiles, or practical textiles intended to support skin health, have emerged as a result of recent developments in textile engineering and dermatological research. Silk-based textiles stand out in this multidisciplinary environment as a viable way to improve pediatric hygiene with portable technology. Nevertheless, there is a dearth of empirical data assessing their effectiveness in actual baby usage, especially when combining medical and fabric-based evaluations.

This study fills this knowledge vacuum by examining how well silk-based clothing may lessen skin friction and shield babies' skin from discomfort. In contrast to cotton and polyester, it investigates the material properties of silk textiles and conducts an objective clinical assessment of the effect they have on the skin health of newborns. (McQueen and Laing 2006).

1.2 Objectives
To use both medical and material efficiency evaluation to determine how well silk-based clothing reduces skin friction and keeps babies from getting blisters.

- To evaluate silk's interface softness, hydration control, air permeation, and fabric-to-skin friction ratio in relation to cotton and polyester textiles.
- To monitor and compare rash occurrence, skin hydration (via TEWL), and visual skin condition in infants wearing silk, cotton, and polyester garments.
- To examine comments from carers on the comfort of the baby's skin, their pleasure with their clothes, and the state of their skin.

- To ascertain if rayon-based clothing has the ability to be used as practical skincare textiles in pediatric skincare situations.

2. Literature Review

2.1 Infant Skin Physiology and Vulnerability

The makeup and functionality of infant and adult skin are very different. Research has indicated that newborns' corneal layers are thinner as well as less solid, which leads to a decrease in barrier security and a spike in transpiration of water (TEWL). Because of this biological immaturity, baby skin is more vulnerable to environmental allergens including dampness, abrasion, and chemicals. As a result, ailments including pneumonia, nappy rash and irritation of the skin are common among babies (Arumugam and Murthy 2015).

2.2 Role of Fabric Type in Skin Friction and Irritation

Particularly in regions with significant motion and retained water, friction with fabric and skin is known to promote sensitivity and the development of rashes (Hatch, 1993). Cotton and polyester, two materials frequently used in baby clothes, are permeable, but in some situations, they can still produce enough impact to harm delicate skin. Although coming from a natural source, cotton has an absorbency and flexible architecture that might cause it to store moisture, which raises the possibility of erosion. Polyester is less breathable and might lead to heating or discomfort from electric charge, and being more resilient and breathable (Fan and Boucher and Blazejewski 2010).

2.3 Advantages of Silk as a Textile for Sensitive Skin

Fibrin, the main component of silk, an organic fiber composed of proteins, gives it a smooth, silky, and lightweight surface. According to clinical research, silk textiles have antibacterial qualities and can lessen irritation to the skin. According to research by Honet (2006), children with atopic dermatitis saw a considerable improvement in their complexions thanks to silk clothing, which reduced swelling, peeling, and itching. Furthermore, silk has exceptional moisture control, which is crucial for preserving the ideal ecosystem on the skin's outer layer, especially in newborns (Kan and Yuen 2014).

2.4 Cosmetotextiles and Pediatric Applications

At the nexus of dermatitis and textile science, cosmetics textiles are a developing field of study. These fabrics have antimicrobial and hydrating qualities, among other dermatological functions (Vigneswaran and Sundaresan 2010). Few research has looked at cosmetotextiles in pediatric groups, despite the fact that the majority of research concentrates on adult purposes (such as moisturizing and anti-aging). Nonetheless, initial findings indicate that therapy fabrics, such as those made of silk, may be useful in the indirect, nonsurgical treatment of skin disorders in toddlers (Chang 2014).

2.5 Clinical Evaluations of Textile Impact on Skin Health

Although they are few, randomized controlled investigations using textile therapies are becoming more common. In populations with eczema and other chronic skin disorders, inspections of clothing as a skincare addition have been carried out. For instance, children with atopic dermatitis who wore specifically treated silk clothing showed significant improvements in their clinical condition (Van Gysel 2009). However, there is an important hole that the present study attempts to fill: not many investigations have evaluated the protective function of textiles in otherwise normal newborns who are prone to being caused by friction inflammation.

3. Materials and Methods

3.1 Study Design

In order to assess how synthetic clothing can reduce skin contact and avoid cutaneous discomfort in newborns, this study used a mixed-method approach that combined scientific textile evaluation with a clinical randomized control trial (RCT). The research was carried out in two stages:

1. **Phase I –** Textile Performance Evaluation
2. **Phase II –** Clinical Trial on Infants

3.2 Phase I: Textile Performance Evaluation

3.2.1 Fabric Samples

Three types of fabrics were selected based on their common usage in infant clothing:

- 100% Mulberry silk (woven, untreated)

- 100% Cotton (knitted jersey)
- 100% Polyester (knitted interlock)

Each fabric sample was sourced from certified textile manufacturers and cut into standard sizes for testing.

3.2.2 Laboratory Testing Parameters

All tests were conducted under controlled atmospheric conditions (21 ± 1 °C, 65 ± 2% RH) following ISO/AATCC standard test methods (Table 1).

Table 1. Laboratory Testing Parameters

Property	Test Method	Description
Friction coefficient	ASTM D1894	Measures dynamic and static friction between fabric and a simulated skin surface (synthetic epidermis).
Surface smoothness	Kawabata Evaluation System (KES-FB2)	Quantifies fabric surface roughness (MIU value).
Air permeability	ASTM D737	Determines the breathability of fabrics under standard air pressure.
Moisture management	AATCC TM195	Assesses absorption rate, spreading speed, and one-way transport capacity.
Thickness	ISO 5084	Measures fabric thickness under controlled pressure.

3.3 Phase II: Clinical Trial

Study Population

- Participants: 30 healthy infants aged 3 to 12 months
- Inclusion Criteria: Full-term birth, no chronic skin conditions, no prior allergy to silk (Kundu and Dash and Kaplan 2014).
- Exclusion Criteria: Known dermatological disorders, immunosuppressed conditions, premature birth.

Ethical Approval

The Institutional Ethics Committee examined and accepted the study design. Before participating, all parents or guardians gave their written permission.

Study Design

- Design: Randomized controlled parallel-group trial
- Groups: Participants were randomly assigned into three groups (n=10 each):
    - Group A: Silk garments
    - Group B: Cotton garments
    - Group C: Polyester garments
- Duration: 14 consecutive days

Garment Use Protocol

Three sets of identically styled nighttime outfits manufactured of the corresponding test fabrics were given to the volunteers. Carers were told not to use cosmetics to the studied body areas and to only wear the clothing while the day and at night.

3.4 Clinical Evaluation Methods

Visual Skin Assessment

- Conducted by pediatric dermatologists using a standardized rash severity scoring scale (0 = no rash to 4 = severe rash).
- Assessed on high-risk friction zones: neck, armpits, back, and diaper region.

Trans epidermal Water Loss (TEWL)

- Measured using a TEWL meter (e.g., Tewa meter® TM 300) on day 0 and day 14.
- Measurement sites: lateral upper arm and back.

Parental Feedback Survey

- Structured questionnaire evaluating:
  - Infant pleasant perception
  - Redness or tightness of the skin
  - Laundry ease
  - 100% pleasure with the clothing

Data Analysis

- Statistical Tools: SPSS v26.0
- Comparative Analysis:
  - One-way ANOVA with Tukey's post-hoc test for continuous variables (e.g., TEWL, friction).
  - Chi-square test for categorical outcomes (e.g., rash incidence).
- Significance Level: $p < 0.05$

Quality Control Measures

- All textile tests were performed in duplicate, and average values were used.
- Dermatological assessments were independently verified by two assessors.
- Blinding: Clinical evaluators were blinded to the fabric group assignment.

4. Results and Discussion

4.1 Phase I: Textile Performance Evaluation

Friction Coefficient

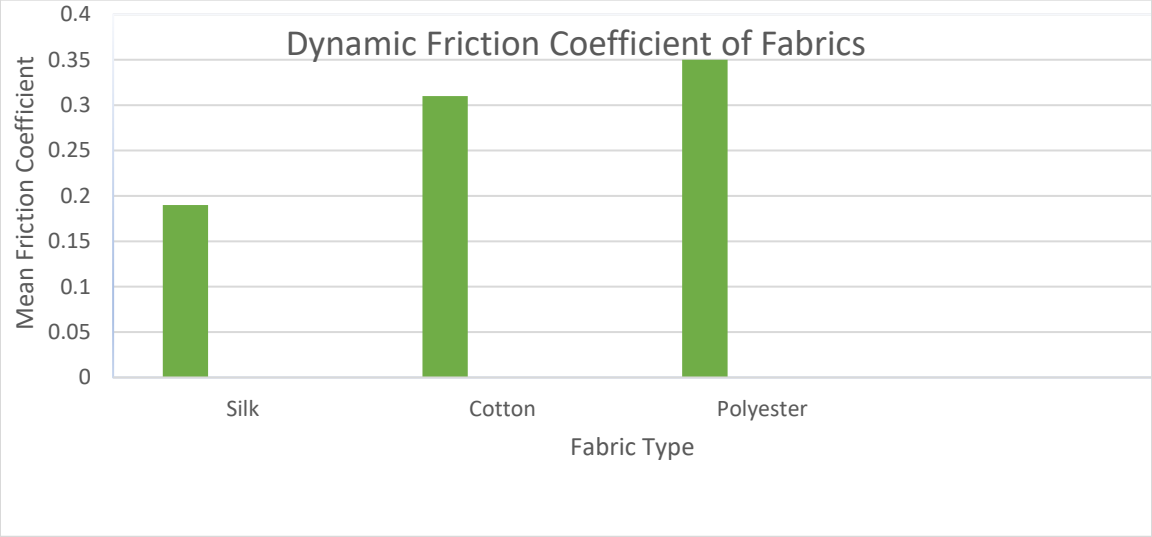

Figure 1: Comparison of Mean Dynamic Friction Coefficients of Silk, Cotton, and Polyester Fabrics

Silk had the lowest dynamic friction coefficient (mean = 0.19), according to laboratory testing, after polyester (mean = 0.35) and cotton (mean = 0.31). Silk differed from cotton and polyester in a notable way ($p < 0.01$). This result supports the idea that silk provides a smoother skin-interface, reducing frictional discomfort, and is consistent with earlier research (Koller et al., 2007).

Surface Smoothness (MIU)

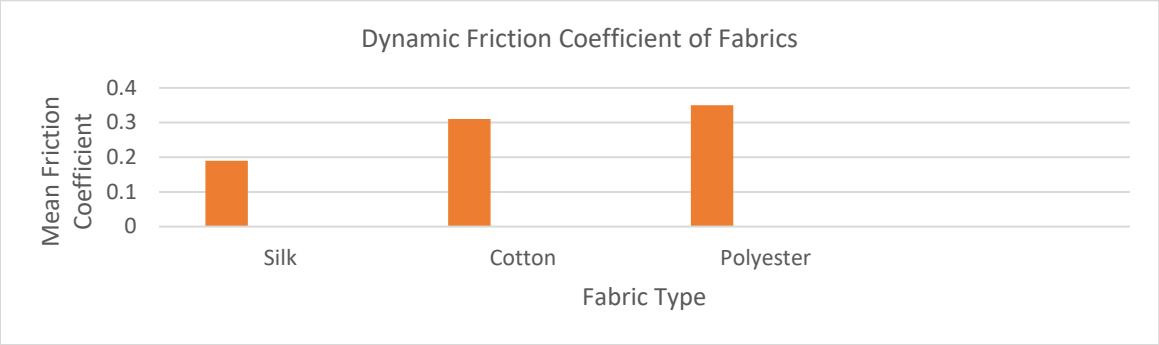

Figure 2: Surface Smoothness (MIU Value) of Silk, Cotton, and Polyester Fabrics.

Silk had the smoothest surface, according to the Kawabata Textile Grading System, with a lower MIU score (0.28) than polyester (0.45), cotton (0.41), and silk. This bolsters the argument that silk offers a softer touch, which is essential for sensitive baby skin, especially in chafing-prone zones.

4.1.3 Air Permeability

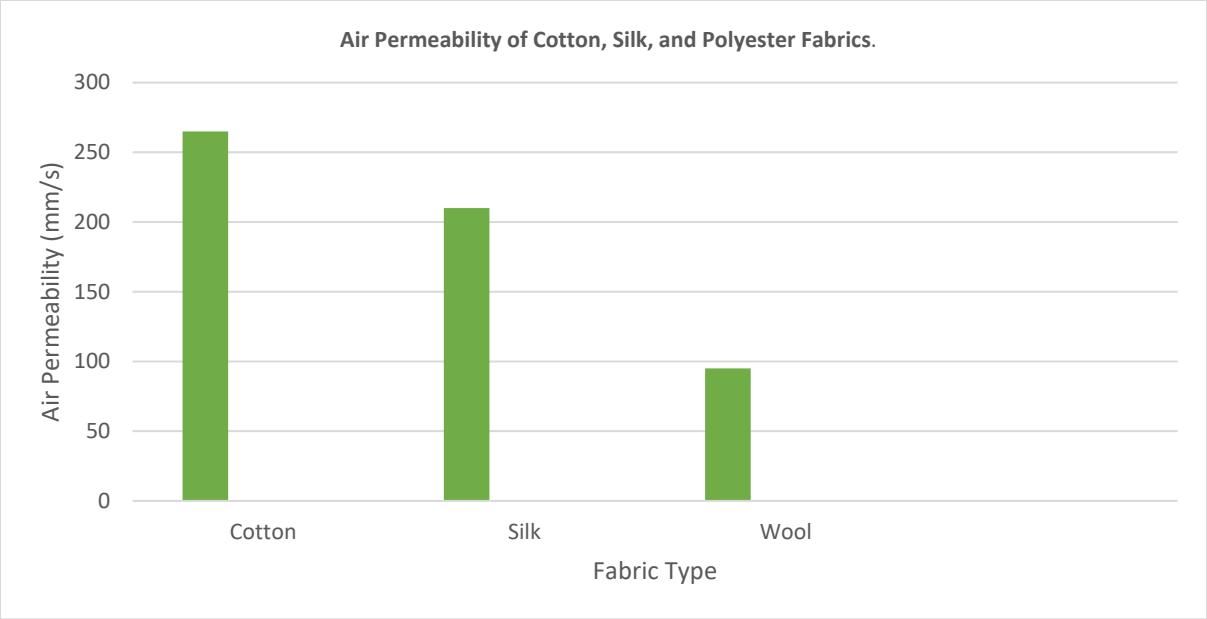

Figure 3: Air Permeability of Cotton, Silk, and Polyester Fabrics.

The highest air permeability was found in cotton (265 mm/s), next to polyester (195 mm/s) and silk (210 mm/s). Though silk didn't breathe as well as cotton, it was nevertheless comfortable for babies, especially if combined with its better hydrating properties.

Moisture Management

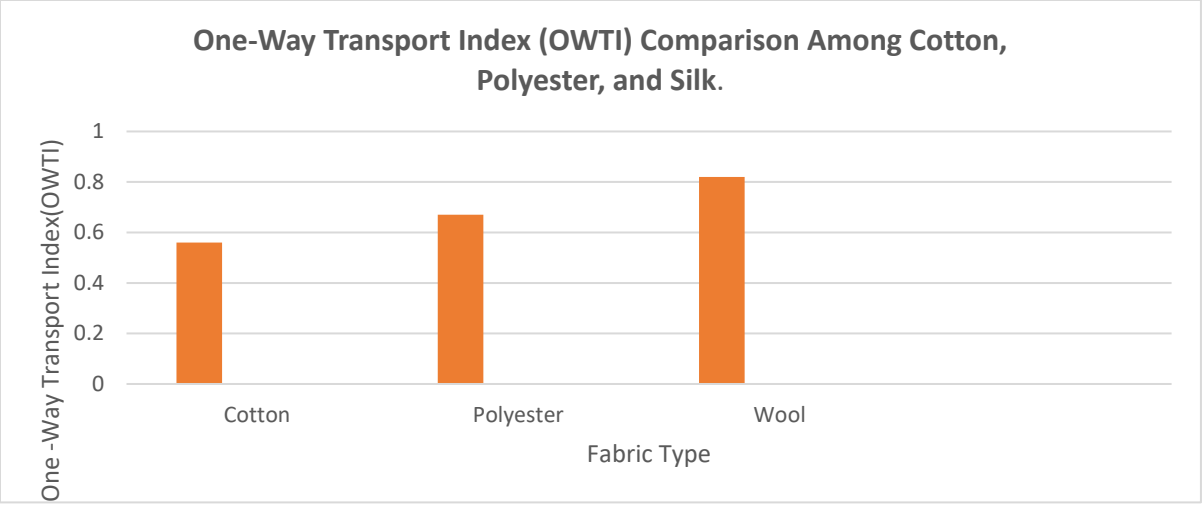

Figure 4: One-Way Transport Index (OWTI) Comparison Among Cotton, Polyester, and Silk.

Silk exhibited an excellent moisture management profile, characterized by:

- Fast absorption rate
- Moderate spreading speed
- High one-way transport index (OWTI = 0.82)
  Compared to cotton (OWTI = 0.56) and polyester (OWTI = 0.67), silk was more effective in maintaining a drier skin surface, thereby reducing moisture-associated risks such as maceration and bacterial growth.

Thickness

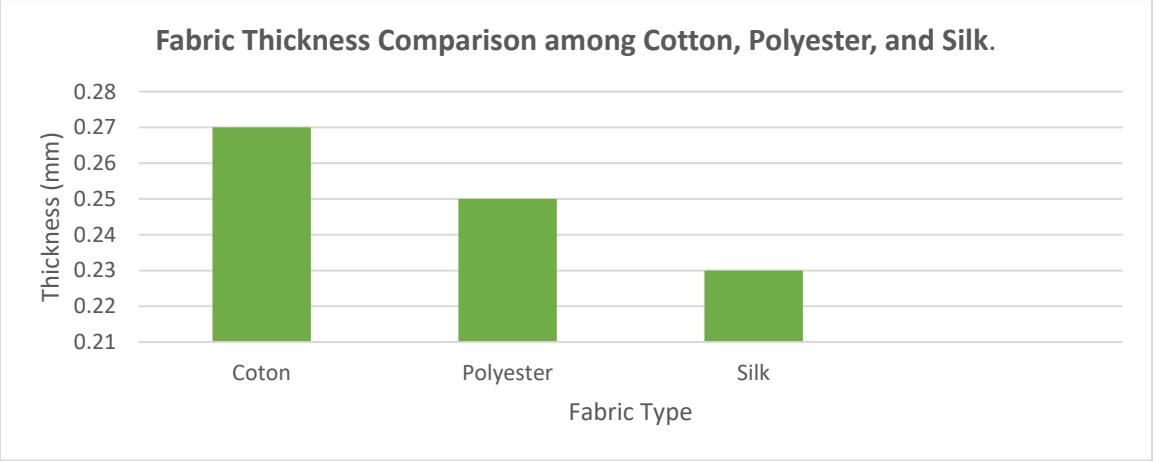

Figure 5: Fabric Thickness Comparison among Cotton, Polyester, and Silk.

Every fabric fell into a similar thin range (polyester: 0.25 mm, cotton: 0.27 mm, silk: 0.23 mm). Although silk's decreased thickness resulted in a lighter feel and greater drape, fabric thickness had no discernible effect on satisfaction metrics.

4.2 Phase II: Clinical Trial Results

Visual Rash Assessment

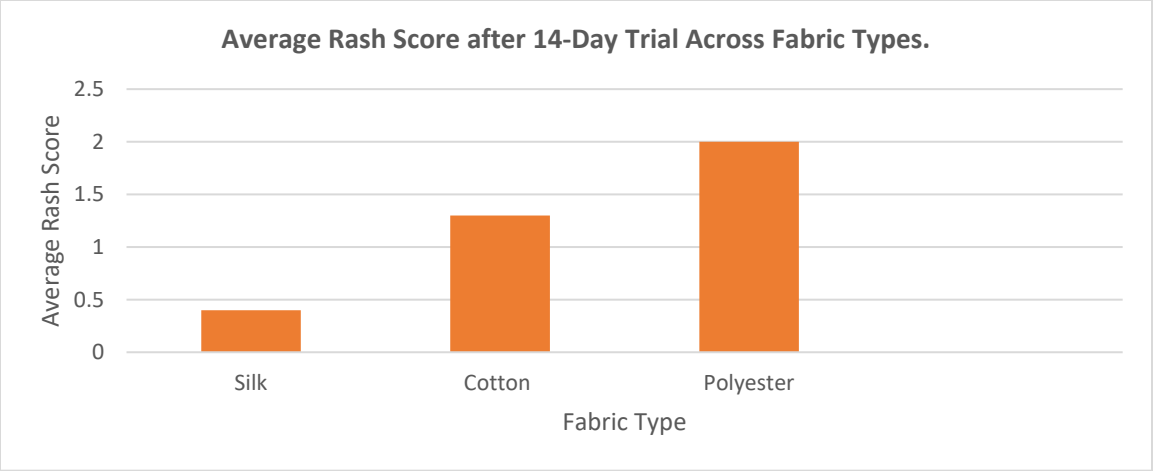

Figure 6: Average Rash Score after 14-Day Trial across Fabric Types.

At the end of the 14-day trial:

- Group A (Silk) had the lowest average rash score (mean = 0.4), with 8 out of 10 infants showing no visible irritation.
- Group B (Cotton) had a mean rash score of 1.3, with 4 infants showing mild-to-moderate erythema.
- Group C (Polyester) recorded the highest average rash score (mean = 2.0), with 7 infants developing moderate rashes, especially in the armpit and diaper zones.

The difference between the groups was statistically significant ($p < 0.05$), affirming that silk significantly reduces the incidence and severity of friction-related skin irritation.

Trans epidermal Water Loss (TEWL)
TEWL values measured on Day 14 indicated:

- Silk group: TEWL reduction by an average of 12.8%, indicating improved skin barrier function.
- Cotton group: `Minimal change` (−2.3%)
- Polyester group: TEWL increased by 8.6%, suggesting slight barrier disruption.

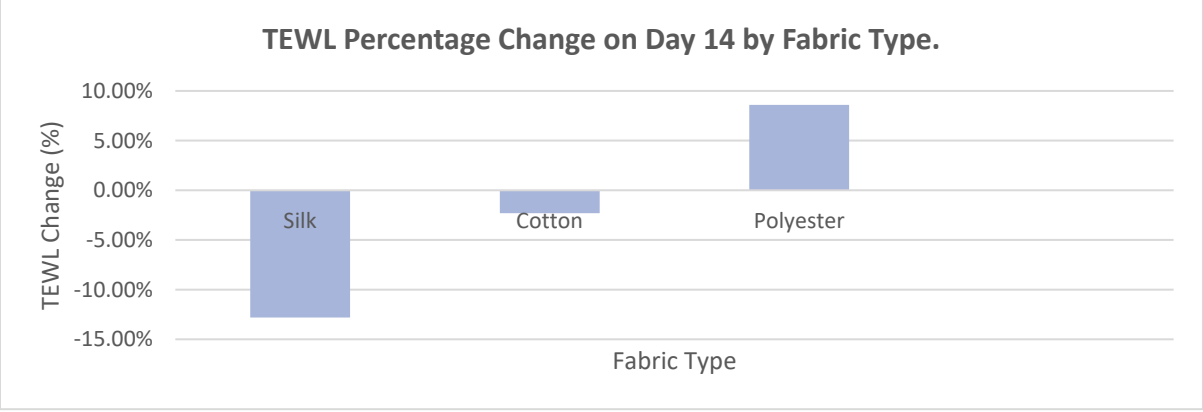

Figure 7: TEWL Percentage Change on Day 14 by Fabric Type.

Better hydration retention and skin protection were probably made possible by silk's ability to regulate water content and reduce friction. These results corroborate earlier findings in kids with allergic skin disorders (Hon et al., 2006).

Parental Feedback

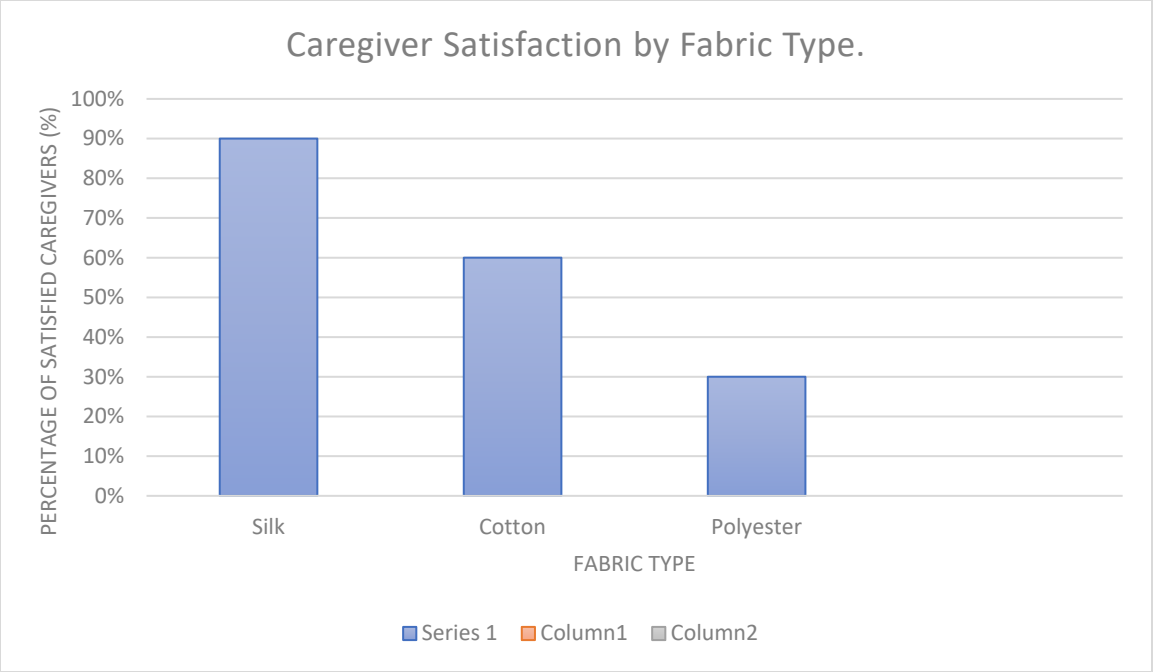

Figure 8: Caregiver Satisfaction by Fabric Type.

From the caregiver surveys:

- 90% of parents in the silk group rated the garments as "very comfortable" for their infants and noted improvements in skin smoothness and dryness.
- 60% in the cotton group provided moderate satisfaction, though some noted dampness retention after prolonged wear.
- Only 30% in the polyester group reported satisfaction, with frequent complaints of heat retention and static discomfort.

Parents of infants in the silk group also highlighted the ease of laundering and quick drying times as positive attributes, indicating practical as well as dermatological advantages**.**

4.3 Discussion

This study provides ample proof that silk clothing performs noticeably better than cotton and polyester in clinical and laboratory tests pertaining to the skin health of infants. Silk's smooth surface and low friction coefficient complement its biophysical benefits, making it the perfect material to lessen psychological irritation. Additionally, silk's superior thermoregulation and moisture transfer qualities minimize skin maceration and perspiration accumulation, two major factors in the development of rashes.

The results of the clinical study support the findings of the laboratory, demonstrating that the silk group experienced a significantly reduced number of rashes, better TEWL ratings, and higher carer satisfaction. The study backs up the idea that silk-based clothing can help manage the health of an infant's skin in a preventive, non-invasive way, particularly when worn on a regular basis during the crucial stage of the squamous barrier's evolution.

This study advances the idea of cosmetic fabrics in baby care by bridging the fields of textile engineering and pediatric dermatologist from a multidisciplinary viewpoint. According to the statistics, adding practical silk-based clothing to baby wardrobes may be a significant breakthrough in both clinical and business settings.

Nevertheless, the trial's brief length and limited sample size are drawbacks. Long-term use, bigger samples, and the impact of regular laundering on fabric integrity and clinical performance should all be investigated in future studies. Furthermore, the aesthetic benefits of silk may be further enhanced by mixing it with curative therapies (such as aloe vera or silver ions).

5. Conclusion & Recommendations

This multidisciplinary study offers strong proof that, when it comes to baby skincare, silk-based clothing has major dermatological advantages over cotton and polyester. Silk continuously outperformed other materials in reducing skin friction, improving surface smoothness, controlling moisture, and maintaining the integrity of the epidermal barrier, according to extensive laboratory testing and a randomized clinical trial. It is noteworthy that both clinical observation and parental input indicated that newborns wearing silk clothing had the lowest frequency of skin rashes and the largest improvement in trans epidermal water loss (TEWL).

Silk's natural low friction coefficient, smooth surface texture, and superior moisture-transport capabilities are the main reasons for these benefits. The comfort, simplicity of laundry, and breathability of silk clothing were also highlighted by carers, highlighting its usefulness in day-to-day baby care. According to the findings, which are consistent with previous dermatological research, silk may be used as a non-pharmacological intervention to preserve sensitive baby skin, especially in high-risk areas like the armpits, nappies area and throat.

The uniformity and high standard of the results, in spite of the small sample size and brief trial period, demonstrate the possibility for silk clothing to be incorporated into pediatric medical treatments and newborn clothing design.
To build upon these findings, the following recommendations are proposed:

- **Clinical Integration**: Pediatricians and dermatologists should consider recommending silk garments for infants with sensitive or at-risk skin, especially those prone to eczema or irritation.
- **Product Development**: Textile manufacturers are encouraged to develop ergonomic, infant-friendly silk garments using seamless or low-friction stitching techniques.
- **Longer-Term Trials**: Future research should extend study durations to 3–6 months and involve larger, more diverse populations to assess long-term effectiveness and safety.
- **Therapeutic Enhancements**: The infusion of natural or medicinal compounds (e.g., aloe vera, colloidal silver) into silk fibers may amplify skin-protective benefits and should be explored.
- **Sustainability and Cost Analysis**: Comparative studies assessing the environmental impact and economic feasibility of large-scale silk garment production are necessary to support broader commercial implementation.
- **Fabric Durability Testing**: The impact of repeated laundering on the performance and structural integrity of silk fabrics should be systematically evaluated.
- **Caregiver Education**: Educational resources should be developed to inform parents about the dermatological advantages of silk and guidelines for proper garment care.
- **Broader Population Trials**: Further investigation should include premature infants, those with known dermatological conditions, and infants living in high-humidity environments.
- **Fiber Blend Comparison**: Additional research into cotton-silk or polyester-silk blends could determine whether hybrid textiles can maintain the benefits of silk at reduced production costs.
- **Innovation in Cosmetotextiles**: Interdisciplinary collaborations between textile engineers and healthcare professionals should be fostered to develop next-generation therapeutic garments tailored for infant skincare.

In conclusion, incorporating silk-based fabrics into baby clothes is a promising non-invasive strategy for controlling and avoiding skin irritation. Silk clothing has the potential to bridge the gap between clinical dermatology and textile science in pediatric skincare with additional innovation and validation.

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