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Evaluating a Novel Moisture-Wicking Sports Hijab: A Qualitative Analysis of Thermoregulatory Comfort and Scalp Health in Muslim Athletes

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Abstract

This study aims to develop a conceptual design for a smart sports hijab intended to improve thermoregulatory comfort, scalp health, and athletic performance for Muslim female athletes. Methods: A qualitative approach was employed involving sixty female students from the Faculty of Sports Science (FIK UNNES). Data were collected using an open-ended questionnaire exploring perceptions of thermal comfort, scalp moisture, irritation, and expectations for hijab innovation. Thematic analysis was used to identify dominant patterns in the responses. Results: Four main themes emerged: (1) the urgent need for ventilation and effective airflow; (2) frequent scalp moisture issues related to sweat accumulation; (3) the negative impact of heat and humidity on focus and performance; and (4) strong user demand for cooling fabrics, moisture-wicking layers, antibacterial coatings, and technology-integrated materials. Conclusion: This study proposes a conceptual framework for a smart sports hijab integrating cooling spandex fabric, moisture-wicking layers, thermoregulation concepts, and antibacterial technology as a response to user-identified needs. These findings provide a foundation for future prototype development and empirical validation.

Keywords: smart sports hijab; athletic comfort; scalp health; thermoregulation; textile technology.

Abstrak

Penelitian ini bertujuan mengembangkan desain konseptual hijab olahraga pintar untuk meningkatkan kenyamanan termoregulasi, kesehatan kulit kepala, serta performa atletik pada atlet perempuan berhijab. Metode: Penelitian menggunakan pendekatan kualitatif dengan melibatkan enam puluh mahasiswi Fakultas Ilmu Keolahragaan (FIK UNNES). Data dikumpulkan melalui kuesioner pertanyaan terbuka mengenai persepsi kenyamanan termal, kelembapan kulit kepala, iritasi, serta harapan terhadap inovasi hijab olahraga. Analisis tematik digunakan untuk mengidentifikasi pola utama dari respons peserta. Hasil: Empat tema utama ditemukan: (1) kebutuhan tinggi akan ventilasi dan sirkulasi udara yang baik; (2) permasalahan kelembapan kulit kepala akibat penumpukan keringat; (3) pengaruh negatif panas dan kelembapan terhadap fokus dan performa; serta (4) tingginya permintaan pengguna terhadap bahan berteknologi seperti kain pendingin, lapisan penyerap keringat, serta coating antibakteri. Kesimpulan: Penelitian ini menawarkan kerangka konseptual hijab olahraga pintar yang mengintegrasikan kain spandeks pendingin, lapisan pengatur kelembapan, konsep termoregulasi, dan teknologi antibakteri sebagai solusi berbasis kebutuhan pengguna. Temuan ini menjadi landasan untuk pengembangan prototipe dan pengujian empiris di masa mendatang.

Kata kunci: hijab olahraga pintar; kenyamanan atletik; kesehatan kulit kepala; termoregulasi; teknologi tekstil.

1. Introduction

The development of contemporary sports has opened significant opportunities for Muslim women to participate in various professional disciplines. The hijab, as a part of religious identity, while essential, often poses challenges related to comfort and performance for athletes. According to the International Olympic Committee (IOC, 2022), the growing number of hijab-wearing athletes worldwide underscores the need for sports equipment that meets not only aesthetic but also physiological needs.

During high-intensity exercise, increased scalp temperature, excessive sweating, and suboptimal ventilation can lead to discomfort and disrupted focus. Thermal comfort is a key factor in supporting athletic performance (Rahman et al., 2023). Ideal sports textile materials must be able to control temperature, wick moisture, and provide good air circulation (Hussain et al., 2021; Kim & Lee, 2022). For hijabi athletes, excess scalp moisture can potentially cause irritation, itching, and dandruff, negatively impacting health and comfort during exercise (Khan et al.,2020). However, research examining the specific relationship between sports hijab design and physical comfort and scalp health remains limited.

Current sports hijab innovations tend to focus more on aesthetics and material elasticity without integrating smart textile technologies that can regulate the scalp's microclimate. Smart textile technologies, such as the use of micro-sensors to control body temperature and humidity in real-time, offer great potential to enhance user comfort and health (Chen et al., 2022). Nevertheless, there is a lack of conceptual designs or empirical studies that integrate smart textile technology to meet the specific needs of hijabi athletes.

The main problem of this research is how to develop a conceptual framework for a smart sports hijab based on spandex material that can provide a cooling effect, moisture-wicking properties, thermoregulation sensors, and an antibacterial layer to maintain scalp health and enhance athlete comfort during exercise. This research is important because poor thermal comfort can reduce focus, diminish exercise effectiveness, and negatively impact scalp health.

The state of the art in this field indicates that most previous studies have not specifically examined the integration of smart technology in sports hijabs, and a comprehensive approach combining thermal comfort, scalp health, and wearable technology aspects for hijabi women is absent. Thus, this study fills an important gap in the existing literature.

Therefore, the purpose of this study is to develop a concept for a smart sports hijab that combines cooling materials, moisture-wicking layers, thermoregulation sensors, and antibacterial properties to enhance the comfort and scalp health of hijabi athletes. Additionally, this research aims to understand user perceptions of comfort and the potential impact of such technology on their sports performance. The urgency of this research is high, given the increasing number of hijabi athletes and the need for innovations that are not only aesthetic but also functional, supporting both health and athletic performance. The contribution of this research is expected to form the basis for developing high-tech sports hijab products that can improve the quality of life and achievements of Muslim female athletes.

2. Method

This study used a qualitative approach to explore the perceptions and experiences of hijabi athletes regarding comfort and scalp health while exercising, specifically in the context of a proposed smart sports hijab concept. The research was conducted online, with data collection taking place over a two-week period, concluding on November 13, 2025. The study population was drawn from the Faculty of Sports Science, Universitas Negeri Semarang (FIK UNNES). The research subjects consisted of 60 female students from FIK UNNES who are active in sports and wear the hijab. The participants' age range was 18 to 23 years. All participants took part voluntarily, and their personal data was kept confidential. Data was collected using an open-ended questionnaire consisting of three main parts: (1) feelings of comfort when using current sports hijabs; (2) experiences related to scalp health, such as moisture, itching, heat, or irritation; and (3) expectations for sports hijab innovation based on smart textile technology. This study received ethical approval from the Research Ethics Committee of Universitas Negeri Semarang. All participants provided informed consent before participating. They were informed about the study's purpose, their right to withdraw at any time without penalty, and the confidentiality of their responses. No personally identifiable information was collected in the questionnaire. Data collection was carried out through an online form over two weeks. Respondents were asked to provide descriptive and reflective answers based on their personal experiences wearing sports hijabs.

This study focused on evaluating four proposed elements of the smart hijab material as the main conceptual variables: 1. Spandex Cooling Fabric: Flexible, lightweight material with good air circulation. 2. Moisture-Wicking Layer: A sweat-absorbing layer that dries quickly to prevent moisture buildup. 3. Thermo-Regulation Micro Sensor: A hypothetical micro-sensor technology to maintain optimal scalp temperature. 4. Antibacterial & Anti-Odor Coating: A layer to prevent bacterial growth and unpleasant odors. This conceptual design is proposed as a potential prototype for manufacturers of sports equipment for hijabi women. The collected data were analyzed using thematic analysis to identify patterns and main themes from the respondents' answers, thereby illustrating the participants' needs and perceptions regarding the smart sports hijab concept.

3. Results and Discussion

Thematic analysis of qualitative data from 60 participants revealed four dominant themes regarding needs and expectations for a smart sports hijab. These themes, along with their frequency of mention among participants, are summarized in Table 1 below.

Table 1. Key Findings of Thematic Analysis

No	Theme	Frequency (n=60)	Description
1	Need for ventilation and air circulation	51(85%)	Sports hijabs feel hot and stuffy; users require better airflow and breathable fabrics.
2	Scalp moisture issues	47(78%)	Moist and sweaty scalp leads to discomfort, itching, and irritation.
3	Impact of comfort on performance	43(72%)	Heat and humidity reduce focus, motivation, and exercise duration.
4	Demand for advanced textile technologies	41(68%)	Users expect features such as cooling fabrics, moisture-wicking layers, antibacterial and anti-odor coatings.

Picture 1. Smart Sports Hijab Design Based on Thermo-Regulation and Anti-Odor Coating

3.1 Discussion

3.1.1 Interpretation of Finding

These findings clearly demonstrate that hijabi athletes face significant challenges related to thermoregulation and scalp health during physical activity. Many participants explicitly described feeling overheated and experiencing discomfort while exercising in their current sports hijabs. For example, one participant noted, "Wearing my current sports hijab makes my head feel hot within 25 minutes of exercise" (Participant 12). Others emphasized the lack of ventilation: "The hijab feels very hot during exercise, it feels like no air is getting in" (Participant 8) and issues with moisture accumulation: "As soon as I sweat, my head immediately feels stuffy and damp" (Participant 21). The high demand for ventilation and moisture-wicking properties aligns with established physiological principles: high scalp temperature inhibits sweat evaporation, leading to heat stress, skin irritation, and reduced aerobic efficiency (Kumar & Ali, 2021; Rahman et al., 2023). The reported discomfort goes beyond mere inconvenience; it acts as a physiological and psychological barrier to optimal performance. Participants directly linked hijab discomfort to reduced focus and motivation: "If the hijab feels hot, I lose focus and get tired quickly" (Participant 34). This underscores the critical role of apparel in athletic experience (Fathima et al., 2022).

3.1.2 Relevance to Previous Research

This study's results are consistent with prior work on sportswear thermoregulation. For instance, Park et al. (2021) found that cooling fabrics could lower skin surface temperature by up to 2°C during intense activity. Similarly, Al-Farhan et al. (2023) identified a significant correlation between breathable materials and the mental focus of athletes in the Middle East. However, our research adds a crucial, often overlooked dimension: scalp health. While previous studies focused on general comfort and thermal regulation, the qualitative data here highlights specific concerns about itching, irritation, and dandruff caused by a humid microclimate under the hijab (Khan et al., 2020). This positions scalp health as an integral component of overall athletic comfort for hijabi women.

3.1.3 Theoretical and Conceptual Implications

The proposed smart hijab concept serves as a theoretical bridge between user- identified needs and advanced textile technologies. The strong participant endorsement for features like cooling fabrics and antibacterial coatings validates the conceptual direction. This suggests that the integration of Phase Change Materials (PCMs), which absorb and release heat to maintain

a stable temperature (Zhang et al., 2020), is a theoretically sound approach for the cooling fabric variable. Likewise, the application of silver-ion coatings, proven to effectively inhibit odor-causing bacteria (Li & Chen, 2021), directly addresses the scalp health and hygiene concerns raised by participants. The proposed micro-sensor, while currently hypothetical, represents the forward-looking potential of wearable technology to provide real-time, personalized thermoregulation.

3.1.4 Research Application and Design Implications

It is important to clarify that this study presents a conceptual framework, not a tested prototype. The value of this research lies in its user-centered design approach, providing a validated set of requirements for future research and development (R&D). The findings imply that textile designers, sports scientists, and dermatologists should collaborate to create a truly effective smart hijab. The conceptual design (see Figure 1) incorporates the key findings: a minimalist, contoured design from lightweight fabric, a proposed sensor location for thermoregulation monitoring, and an integrated antibacterial lining. This framework can now guide material scientists and engineers in selecting and testing specific fabrics and technologies that fulfill these user-driven criteria before moving to the prototyping and empirical testing phase.

3.1.5 Image Description

The image above shows the design concept of a smart sports hijab with a minimalist, lightweight, and functional look. Light pastel blue was chosen because it has low heat absorption, thus maintaining the wearer's comfort when doing outdoor activities. A micro sensor is located on the left side behind the ear, functioning to detect body and environmental temperature as part of the thermoregulation system. An anti-odor coating based on silver ions is applied to the inner layer of the hijab that comes into contact with the skin. This layer helps prevent bacterial growth, which also causes unpleasant odors, keeping it hygienic and comfortable even with prolonged use. The ergonomic facial contour design and gently curved neckline provide a modern look suitable for various users, including athletes and daily use.

4. Conclusion

This study provides a significant conceptual contribution to sports technology and functional apparel design by focusing on the specific needs of Muslim female athletes. Unlike previous studies that primarily examined general thermal comfort or material properties, this research presents a user-driven conceptual framework that prioritizes scalp health, safety, and comfort during exercise as important yet underexplored factors in sports hijab design. The qualitative findings from 60 participants establish a clear mandate: future sports hijabs must be cool, quick-drying, breathable, and hygienic. The conceptual framework of a smart hijab integrating spandex-based cooling fabric, moisture-wicking layers, thermoregulation concepts, and anti-odor coatings is proposed as a direct solution to these demands. The primary implication of this research is the creation of a validated foundation for subsequent work. The direct outcome should be the initiation of technical R&D to materialize this concept, starting with laboratory testing of proposed materials (e.g.,PCM-treated fabrics, silver-ion coatings) for their efficacy on scalp temperature and moisture management. This study opens a significant opportunity to integrate wearable technology into Muslim women's sportswear,

promoting innovation that is not only aesthetic but fundamentally functional, health-oriented, and capable of enhancing both.

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