

## Role of Textiles in Diabetes Management

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Received: July 03, 2026; Accepted: July 09, 2026; Published: July 17, 2026

Textiles play a pivotal and evolving role in diabetes management, moving beyond traditional clothing to become "smart" wearable systems that aid in monitoring, therapeutic support, and complication prevention. These advanced textiles, often integrated with sensors, provide a non-invasive, continuous, and comfortable method for managing chronic conditions.

### Non-Invasive Continuous Glucose Monitoring (CGM)

- **Sweat Sensors:** Textile-based sweat sensors use conductive materials (e.g., silver nanoparticles, graphene) embedded in fabrics to detect glucose levels in perspiration, offering an alternative to finger-prick testing.
- **Janus Textiles:** These materials feature a dual-sided structure—hydrophobic (water-repelling) on one side and hydrophilic (water-attracting) on the other—to efficiently collect and transport sweat to sensing areas for rapid, real-time analysis.
- **Optical Fiber Sensors:** Embedded in garments, these can measure pulse waves, from which blood glucose levels can be estimated using neural network analysis.
- **Smart Patches & Garments:** Flexible patches, armbands, or shirts can track glucose levels and transmit data to smartphone apps, aiding in lifestyle management for Type 2 diabetes and providing continuous feedback for Type 1 diabetes.

### Diabetic Foot Care and Complication Monitoring

- **Smart Socks & Insoles:** Specialized socks, such as Siren Diabetic Socks, feature "Neuro fabric" which uses integrated sensors to continuously monitor foot temperature, which is critical for early detection of inflammation or ulcers.
- **Pressure Monitoring:** Textile pressure sensors embedded in socks can monitor plantar pressure in real-time, helping to reduce the risk of diabetic foot ulcers (DFUs).
- **Improved Circulation:** Garments embedded with far-infrared (FIR) emitting particles are used as a complementary therapy to improve peripheral microcirculation, as measured by transcutaneous oximetry (TcPO2).

### Advanced Wound Healing (Diabetic Ulcers)

- **Drug-Delivering Bandages:** Electro spun nanofiber dressings, often loaded with zinc oxide nanoparticles, act as smart, antibacterial wound dressings that promote healing.
- **Biomimetic Dressings:** Janus-structured dressings with asymmetric wettability (hydrophilic side for blood coagulation, hydrophobic for protection) are used to treat diabetic foot ulcers, reducing healing time.

### Key Benefits and Future Directions

- **Reduction of Diabetes Burnout:** Smart garments provide "seamless" monitoring, reducing the stress associated with daily, manual glucose measurement.
- **Material Advancements:** Use of natural materials like cellulose, silk, and chitosan ensures comfort, breathability, and sustainability in wearable health trackers.
- **Challenges:** Current research focuses on enhancing the precision of textile-based sensors to match standard CGMs and ensuring the scalability and FDA approval of these wearable technologies.

### Textiles for Diabetic Footwear Recommendation

Professionals generally recommend that patients with insensitive feet (due to neuropathy) wear dense, padded socks made of synthetic/acrylic blends to wick away moisture and reduce vertical pressure, which prevents Callus formation and ulcers.

Textiles are evolving from basic protective clothing into active therapeutic and diagnostic platforms that play a vital role in managing diabetes, particularly in glucose monitoring and foot care.

- **Continuous Glucose Monitoring (CGM):** Smart textiles integrate electronic components and biosensors directly into fabrics to monitor glucose levels non-invasively.
- **Sweat-Based Sensing:** Conductive textiles (e.g., Adafruit 1364) can be embedded with enzymes like glucose oxidase to detect glucose in sweat. This data can be transmitted wirelessly to a smartphone, potentially reducing the need for traditional blood-based fingerstick tests.
- **Seamless Integration:** Devices like smart shirts, armbands, or socks provide a continuous feedback loop. They can alert users to high or low blood sugar and may eventually integrate with insulin pumps for automated delivery.
- **Optical Fiber Sensors:** Optical fibers woven into garments can detect variations in pulse waves to estimate blood glucose levels.

### Diabetic Foot Care and Prevention

For patients with diabetic neuropathy, smart textiles help prevent complications like Diabetic Foot Ulcers (DFUs) through continuous monitoring.

- **Temperature Monitoring:** Products like Siren Diabetic Socks use integrated sensors to track foot temperature at multiple points. Significant temperature differences between feet can alert users to inflammation or infection before an ulcer forms.

- **Pressure Sensing:** Textile-based strain sensors, such as Smart Sox measure plantar pressure and joint angles in real-time to identify high-risk areas prone to ulceration.
- **Fabric Choice:** Specialized "diabetic socks" are often seamless and non-binding to avoid restricting blood flow or creating pressure points. Moisture-wicking synthetic blends (like acrylic) are often recommended during exercise to keep feet dry and prevent fungal growth.

#### **Therapeutic Applications**

Textiles are also being used as active treatment delivery systems.

- **Wound Healing:** Advanced dressings use electro spun nanofibers that mimic the skin's extracellular matrix to promote faster tissue regeneration and provide antimicrobial protection.
- **Circulation Support:** Textiles embedded with far infrared (FIR) emitting particles (e.g., Circufiber®) have been shown to improve peripheral microcirculation and tissue oxygenation in distal extremities.
- **Electrical Stimulation:** Smart textiles can facilitate low-level electrical stimulation to speed up the healing of diabetic foot wounds and improve patient mobility.

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