Thermal Energy Generating Activewear Designs for Millennials

Yuanting Wang, Washington State University & Chanmi Hwang, NC State University

Background

Applications of smart clothing in sports and fitness sector are providing an impetus to the industry growth (Marci, 2020). Especially, applications of a thermoelectric generator (TEG) with activewear are popular since the development of energy scavengers provides the self-powered and cost-effective to a wearable electronic device (Leonov et al., 2007). Heat flow and infrared radiation are two main energy sources from human body without a stable generator when supplying for a wearable TEG. A key consumer market of self-supporting TEG activewear is Millennials who have higher sense of body image than other generational groups since they are motivated to do physical activities by family background and social conditions around them (Abdullah et al., 2018). The coronavirus 2019 (COVID-19) pandemic has influenced people to engage in low-risk outdoor activities such as jogging and biking compared to indoor physical activities, and these activities have reached record popularity (Tuggle, 2021). Thus, self-sustaining, maintenance-free electronic system is highly recommended in the activewear industry.

Purpose, Significance, and Theoretical Framework

Although studies have focused on the development of TEG, limited studies have been conducted that measure how the direct parts of body transmit the energy effectively to the devices based on the attributes of clothing design. The purpose of the study was to explore and propose a thermal energy generating upper body activewear design for Millennials. Specific objectives of this study included examining thermal energy from the human body to identify the best design placements for TEG integrated activewear, examining Millennials' attitudes towards wearing TEG integrated activewear, and proposing design prototypes that provide wearers with great body management in their self-training while engaging in outdoor activities, running and biking.
A design thinking process framework used by Scataglini et al. (2018) was adopted for this study. The framework highlights the effectiveness of functional wear being based on the integration of physiological, psychological, biomechanical, and ergonomical considerations into the design of a smart clothing system.

Method and Strategies

A total of ten male Millennials were recruited to collect their body heat data and conduct one-to-one interviews including a paper-based survey. Each participant engaged in 30 minutes outdoor activities (15 minutes of running and 15 minutes of biking) at one of the large universities outdoor track. A FLIR T420 thermal camera was used to collect the body heat data throughout 5 minutes intervals during the physical activities. The participants were provided with 100% cotton t-shirts because according to Kinnicutt and Domina (2010), next-to-skin (NTS) tended to impact regular skin temperatures under hot condition and cotton is a good breathable fabric. The retrieved body heats were compared throughout different body parts and movements to examine the placements that generate the most heat. Content analysis was conducted for the qualitative

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data from the interviews after the interviews were transcribed verbatim (Creswell, 2009). The paper-based survey included demographic questions and closed-ended questions with five-point Likert type scale on their attitudes wearing TEG activewear. Based on the participants' body heat analysis and their qualitative and quantitative responses, technical product development using 3D CLO was proposed for TEG integrated activewear for Millennials.

Results and Discussions

The participants' ages ranged from 24 to 32 years old with a mean age of 26 years old. All of the participants exercised at least three times per week and only one participant had prior experience in wearing smart activewear. The results of the heat collection showed that body parts such as neck, chest, back, and shoulder blade disseminated more body heats when the participants engaged in the physical activities. Further, the body heat generated by biking was significantly lower than the body heat generated by running across the participants. All of the participants showed positive attitudes towards wearing TEG activewear and they perceived it as good (M=3.5, SD=0.7), enjoyable (M=3.1, SD=.56), and healthy (M=3.8, SD=0.42). Perceived risks included TEG activewear "*potentially generating radiation*" [P2] and "*causing more heat on specific body positions with different fabric materials*" [P7;P9]. The participants' perceived benefits of wearing TEG included having the function of monitoring their self-training effectively and the convenience of charging device seamlessly. Especially, ability to "*provide self-training opportunity*" [P10], "*organize performance record accurately*" [P4], and "*help detect calories burned and devise strategies to lose weight*" [P9]. The results support previous research (e.g., Abdullah et al., 2018) that Millennials is a key generation that pay more attention to their self-body image and self-training compared to other generations and TEG activewear could be a key resource that aid their functional needs when engaging in outdoor activities.

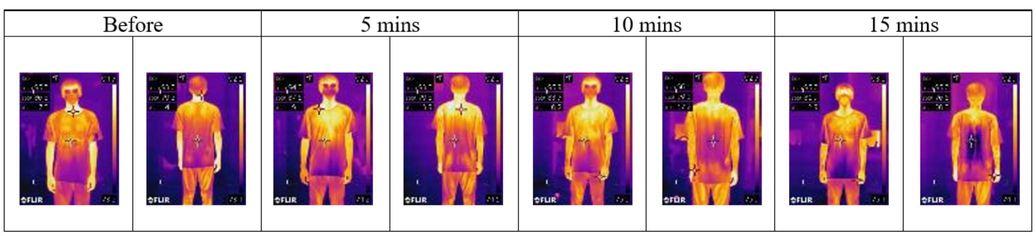

Table 1. Examples of thermal images of running

The presentation of this study includes a complete body heat comparison chart, images of design process that focuses on providing wearers with great body management, and 3D virtualization results of proposed TEG activewear. Future study could include different types of both indoor and outdoor exercises to collect complete human body heat data, both torso and bottom, to devise design strategies for TEG activewear. This study imparts useful implications on body heat placements for the sport industry that can be utilize by apparel retailers, textile manufacturers, and academic researchers.

References

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