Thermic: A Research-driven Base Layer Developed for Runners

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Functional Clothing, Ready-to-wear, Textile innovation

Bust: 35", Waist: 32", Hip: 36", Pant Inseam: 21"

The objective of this study was to develop and test a base layer concept that aids in thermal comfort while running in cold weather. Cold is defined as being below 0^{o}C (Havenith, 2009). The base layer concept was developed through a participatory design scenario where attributes that are important to runners who run more than 30 miles per week were identified and applied through concepts generated in quasi-experimental controlled design sessions and tested through wear trials in actual use environments. The outcome of this research is *Thermic,* a further refined prototype, based on wear test results. This project followed a Participatory Design (PD) process where runners (a.k.a. users) were active participants in the creation and testing of the base layer. PD methods are grounded in the context of use and involve users as inside and active contributors throughout each step of design and development process (Scariot, Heemann, & Padovani, 2012). This method has been used by apparel researchers, including Uotila, Mattila, & Hanninen (2006) for embedding technologies in clothing and Cramer (2011) to ensure the longevity of apparel products. The key product performance attribute of a cold-weather base layer for runners is its ability to maintain thermal comfort for the moving body in cold environments. Cold-weather runners may experience an evaporative and radiative cooling increase because wet skin (from sweat, rain, or snow) and clothing are exposed to higher wind speed at a time when metabolic heat production decreases (Armstrong et al., 1996). Feeling cold and the onset of mild to full hypothermia is a grave concern to runners in cold weather.

Initially, a pilot survey of user needs was conducted. Of the study participants (N = 20) who ranged in age from 18-54, 81% wear a base layer to aid in thermal management and were identified as a product that could benefit from functional improvements. Base layers available on the market include features such as moisture management, lightweight insulation, and non-bulky base layers. Base layer garments now increasingly look like designs that consumers can wear as an outer garment. Base layers that include both garment -level and fabric-level innovations offer added value for activewear consumers.

In the second phase of the research, the researcher recruited 64 runners, aged 18-75 from Central New York. Participants were eligible to take part in the study if they ran at least 30 miles/week, planned to continue running throughout the research study, and self-reported as being injury free. The researcher organized teams of 3-4 runners and a student facilitator to develop concepts for a cold-weather base layer. Seventeen groups sketched ideas and identified fabrics, and described features. The concepts were rendered into an online survey where each garment was presented in a randomized order to the population of runners from which the design session participants came. 197 people evaluated each garment. Each garment was assessed on three variables: innovativeness, marketability, and the ability of the garment to meet runners' functional needs. The variables were combined to create a garment scale score, assuming equal weight between these variables. The highest ranking concept design, *Thermic*, was evaluated 108 times on a 7-point scale with an overall score of M=5.70, SD =1.27.

The design features of *Thermic* include a polyester/spandex brushed jersey knit used for the back of the garment, sleeves, and hood, a polyester/spandex open knit mesh for the front, and a laminated nylon windproof barrier located over the front layer. All fabrics had a moisture wicking treatment. The windproof layer blocks wind coming at the runners through forward motion. The length of the windproof layer is shorter than the underlying layer so that it can be tucked into tights. When folded down, the hood can be worn as a gator, covering the mouth and nose. The gator is controlled by a drawstring, and the windproof layer has a buttonhole to stash the drawstrings, so they do not bounce. The arms have reflective elements for visibility.

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The researcher produced the *Thermic* prototype and tested it in wear trials. Wear tests enable a subsequent evaluation of the proposed concepts that are not necessarily made salient in sketches. Eight users (four male and four female), who participated in the design sessions, tested the base layer four times, resulting in 32 trials for each garment. Immediately following each trial, the user recorded their perceptions of the performance of the garment in a wear test journal. *Thermic* was the highly rated on 7-point scales with high descriptive mean scores on the variables of mobility *(M =5.63 ; SD =1.20)*, functionality *(M = 5.63; SD =2.26)*, and thermal comfort *(M =4.85 ; SD =1.68)*. The overall performance of the prototype was analyzed using General Linear Mixed Model so that the random effect of the person evaluating the garments could be controlled. In the field trials, *functional* performance became a highly significant variable, ($F(1, 20) = 10.037$, $p = .005$) which influenced the *overall impression* of the garment. Environmental conditions such as length of run in miles or minutes, air temperature, relative humidity, and wind speed, were not significantly correlated with the overall ratings of the garment and not included in the model. Qualitative remarks in the wear trial journal revealed mixed reviews where some participants loved the top, while others were not convinced about the performance. Of the poor reviews, ventilation in the windproof layer was the largest issues as one participant noted, "It did a very good job of keeping me warm in a head wind. However, more ventilation is needed. Towards the end of the workout, it wasn't breathing, causing me to feel very hot." Participants also commented that more ventilation on the back was needed, "Absolute favorite! Love the hood! More ventilation on the back is needed though because it doesn't breathe as well as it could."

These problems and others were addressed in the refined prototype which specifically aimed to improve improving ventilation details that play a crucial role in achieving optimal performance of thermal comfort. The two-layer system of the windproof layer and under layer was successful in this concept because it reduces the amount of separate layers needed to be worn by runners to maintain thermal comfort. The revised garment has a more sophisticated vent system that includes not only mesh under the windproof layer, but also vents that come through the windproof layer to let trapped heat and moisture escape. The vents are laser cut and reinforced with reflective heat-applied Bemis brand tape. Vents were added to the front, and back underarm and neck area optimally placed based on sweat patterns. The fabric for the back was revised to a medium- weight textured fabric to address concerns that the base layer was too hot. The type of material for the windproof layer was changed to address friction between layers, minimize bulk, and reduce weight so that the clothing does not interfere with body movements. A welded pocket was added the back and applied using seam tape, reducing the need for seams that could chafe. Finally, a running tight was also created. The same materials employed in the top were strategically placed on the tight. The windproof fabric was put on the major muscle bellies on the front (e.g. quads, hips, transition area at the waist from the base layer top to tights) to protect the runner and mesh were placed to achieve a thermal balance.

It was the intention of the study to explore and share process-oriented findings that involved users in developing innovative product concepts through participatory design sessions by tapping a community of runners to refine ideas in the development stages. The results of the design session, concept vote, and wear trials show that the participatory design process led to a concrete idea that was grounded in an insightful understanding of user's needs.

References

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