Assessment of Ventilated Athletic Uniforms for Improved Thermal Comfort and Human Performance

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Keywords: Comfort, ventilation, uniforms, human performance

The collegiate football uniform is designed for the safety of football athletes when competing in physical activity. The National Collegiate Athletic Association (NCAA) provides rules regarding the required game uniform for football; however, there is flexibility in the design configuration (McCullough & Kenney, 2003). Football uniforms serve as the protective, portable clothing environment for the athlete against the elements of the external environment and physical impact. Each component of the uniform functions to protect, while also providing increased mobility, breathability, and flexibility.

Performing physical activity in a hot environment is more stressful to the worker than in a neutral environment. The need to wear protective clothing in such conditions may exacerbate this issue, leading to heat strain, as clothing can have a detrimental effect on the ability to lose heat from the body (Havenith, 1999). The production of sweat helps maintain internal core body temperature and prevent heat strain by releasing moisture with the intent it will evaporate into the environment, cooling the body. For such evaporative heat loss to be effective, sweat must fully evaporate from the skin into the surrounding environment. Therefore, it is important that ventilated clothing design features are incorporated into athletic uniform applications in order for successful sweat evaporation to occur (McQuerry et al, 2015).

The purpose of this research was to assess multiple material ventilation design techniques for their breathability and thermal comfort performance in football uniforms. This research is necessary as, to the investigators' knowledge, there is no current literature that investigates the subjective thermal comfort differences of material ventilation designs in football uniform applications. One such novel ventilation design technique recently adopted on the market is micro-perforated laser ventilation. Laser perforation is the creation of small, uniform holes in the fabric material to help increase air and moisture vapor permeability. The application of the laser-cut holes should enhance the transport of vapor through the clothing barrier. Other material ventilation design techniques include larger, chain-maille mesh inspired openings and traditional mesh ventilation which has a different geometrical opening, compared to the laser-perforated design (Figure 1). Placement of the vented materials within the uniform design is also important. Smith & Havenith (2011) found that for male athletes the highest sweating rates are observed in the central and lower posterior torso; thus supporting the placement of ventilated material in the torso and lower back regions of the football uniforms. Figure 1 illustrates three different types of mesh vent designs incorporated into athletic football uniforms.

The experimental design used in this study included a human wear trial to assess the subjective thermal comfort of football uniforms with various material ventilation designs. The aim of the experimental procedure was to investigate the vented uniforms to determine if open

material ventilation designs allow for sufficient thermoregulation and the ability for heat to transfer from the skin to the environment.

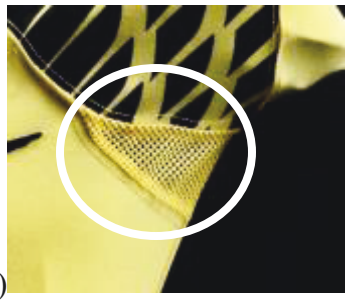
(a)  (b)  (c) 

Figure 1. Three types of vent designs in athletic football uniforms: (a) chain-maille mesh, (b) laser perforated mesh, and (c) traditional mesh

Ten healthy, male, university students were recruited to participate in the wear trial. Each participant completed three test sessions, one for each of the three football uniform. Test sessions consisted of three consecutive walk/run cycles: walking at 3.5 mph for 2 minutes followed by jogging at 5 mph for 8 minutes for a total of 30 minutes. Each subject rated their perceived exertion, perceived comfort, and thermal temperature sensation before, during, and after the physical activity when wearing each football uniform.

Results analyzed subjective thermal comfort ratings at various time intervals for significant differences using two-sample t-tests. The addition of the ventilated materials in the uniforms significantly improved the subjective thermal comfort of the wearer. Further testing is needed on the garment and fabric levels to measure thermal insulation, evaporative resistance, and total heat loss of each ventilated material. This study provided justification for the adoption of laser perforated material technologies in multiple athletic uniform types, as well as, protective and military garment applications.

Acknowledgements: This work was partially supported by a student research support grant funded by the American Society for Testing and Materials (ASTM).

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