

## THE ROLE OF KNIT STRUCTURE IN UNDERWEAR ON THERMOREGULATORY RESPONSES TO INTERMITTENT EXERCISE.

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After-exercise chill is a common cause of thermal discomfort in clothed people exercising in cold environments. It has been demonstrated that use of different fiber type material in the underwear of a multi-layer clothing ensemble influences the thermoregulatory responses during intermittent exercise in a cold environment. The purpose of this study was to evaluate the role of knit structure in underwear on thermoregulatory responses.

Underwear manufactured 100% from polypropylene fibers in five different knit structures (1-by-1 rib, fleece, fishnet, interlock, double-layer rib) were evaluated. Thermal resistance,  $R_c$ , of the five materials measured on a flat plate skin model were as follows: 0.156, 0.193, 0.139, 0.148 and 0.147  $m^2 \cdot K \cdot W^{-1}$  (includes a  $R_a = 0.065 m^2 \cdot K \cdot W^{-1}$ ). All five underwear prototypes were tested as a part of a typical, standardized clothing system. Measured on a thermal manikin these clothing systems had total thermal resistances,  $I_{tot}$ , of 0.243, 0.268, 0.256, 0.248 and 0.250  $m^2 \cdot K \cdot W^{-2}$ , respectively (includes  $I_a = 0.104 m^2 \cdot K \cdot W^{-1}$ ). Testing was done on eight male subjects and took place in a climatic chamber at  $T_a = 5^\circ C$ ,  $T_{dp} = -3.5^\circ C$  and with a  $V_a = 0.32 m \cdot s^{-1}$  directed toward the front of the subject. The test was repeated twice, and consisted of a 40 min cycle exercise bout ( $315 W \cdot m^{-2}$ ;  $52 \pm 4.9\% VO_2max$ ) followed by 20 min of rest ( $62 W \cdot m^{-2}$ ) on the ergometer.  $VO_2$  and heart rate were measured periodically during the test. Esophageal temperature, nine local skin temperatures, ambient air temperature, dew point temperature at three skin sites and in the ambient air were monitored every minute. Onset of sweating was evaluated from the dew point sensor recordings. Non-evaporated sweat accumulated in the clothing was determined by weighing each individual piece of clothing on a balance. Changes in the subject's evaporation rate during the test and total evaporative weight loss were obtained with a Potter platform balance upon which the cycle was placed. Total sweat loss was calculated as the sum of non-evaporated and evaporated sweat. Skin wettedness was calculated from the measured dew points and temperatures.

The differences in knit structure of the underwear in the clothing systems resulted in significant differences in mean skin temperature, local and average skin wettedness, non-evaporated and evaporated sweat during the course of the intermittent exercise test. No differences were observed in the course of the core temperature. The fleece construction produced the warmest responses with highest skin temperature, increased sweating and greater skin wettedness. The fishnet structure gave the coldest thermoregulatory responses. The decrease in mean skin temperature during the course of the rest periods were 0.8% with the fishnet underwear and 1.5% with the fleece underwear. However, even after 20 min of rest mean skin temperature was still significantly higher in the condition with the fleece underwear ( $30.1$  vs.  $29.4^\circ C$  and  $29.8$  vs.  $29.1^\circ C$ ).

In conclusion, knit structure of underwear in a multi-layer clothing system has a significant influence on thermoregulatory responses during intermittent exercise in a cold environment. When polypropylene underwear was evaluated a fleece construction decreased the development of after-exercise chill during rest in spite of more sweating during exercise.

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