Introduction
In order to gather information to allow the optimization of clothing systems, a numerical study was developed on the coupled heat and mass transport phenomena through multi-layer textile assemblies made wool and polyester.

Question
- How does the layers relative position affect the heat and mass loss from the body?
- What is the influence of sorption and vaporization/condensation enthalpies on the heat loss from the body?
- How does the sweat rate affect the clothing thermal performance?

Approach
- FEM-based approach for 1D geometry
- 2 layers of equal thicknesses (wool and polyester)
- Multi-layer in equilibrium with ambient conditions prior to skin contact onset
- Ideal contact assumed on the skin-textile boundary
- Convective heat transport (natural convection) assumed on the external boundary

Computational methods and boundary conditions
Following the approach suggested by Gibson and Charmchi, the coupled heat and mass transfer through textiles was described considering: diffusion of water vapour through porous, heat conduction through solid phase, sorption/desorption of water vapour into fibre and water phase change.

Energy and mass balance equations were solved using PDE module for the following boundary conditions,

Table 1. Boundary conditions and initial conditions when the fabrics are in contact with the skin

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<td><strong>Initial conditions</strong></td>
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<td><strong>Exposure conditions</strong></td>
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Conclusions:
- The relevancy of sorption and vaporization/condensation enthalpies escalates for increasing sweat rate
- The influence of layers’ relative position escalates with increasing sweat rate

Main results:

Effect of sweat rate level

**Figure 3.** Body heat loss versus time for different sweat rates; wool facing skin

**Figure 4.** Body heat loss versus time for different sweat rates; wool facing skin

**Figure 5.** Humidity versus time for different sweat rates; wool facing skin

**Figure 6.** Water rate absorption versus time for different sweat rates; wool facing skin

Effect of sorption and vaporization/condensation enthalpies

**Figure 7.** Body heat loss versus time for wool facing skin, with and without enthalpies (sweat rate set 9 g m^{-2} h^{-1})

**Figure 8.** Body heat loss versus time for wool facing skin, with and without enthalpies (sweat rate set 240 g m^{-2} h^{-1})

**Figure 9.** Body heat loss versus time for wool facing skin, with and without enthalpies (sweat rate set 240 g m^{-2} h^{-1})

**Figure 10.** Body heat flux versus time for wool facing skin and polyester facing skin (sweat rate set 240 g m^{-2} h^{-1})

**Figure 11.** Body heat flux versus time for wool facing skin, with and without enthalpies (sweat rate set 240 g m^{-2} h^{-1})

Layers relative position

**Figure 12.** Body heat flux versus time for wool facing skin and polyester facing skin (sweat rate set 240 g m^{-2} h^{-1})

**Figure 13.** Body heat flux versus time for wool facing skin, with and without enthalpies (sweat rate set 240 g m^{-2} h^{-1})

Influence of layers relative position escalates with increasing sweat rates.

Maximum heat loss is highly dependent on skin-facing layer thermal inertia.

References: