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# The Influence of Backpack-Design on Thermophysiological Parameters during Simulated Hiking Activities

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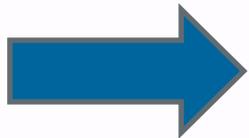


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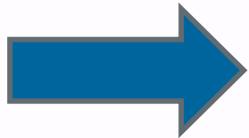


"The importance of heat balance is still totally underestimated in sports. Optimal thermoregulation is more important for performance than the amount of red blood cells".

In: Wissen, Swiss Sunday newspaper, 23.9.2007



Importance of investigation in thermoregulation



Optimization of outdoor clothing, backpacks

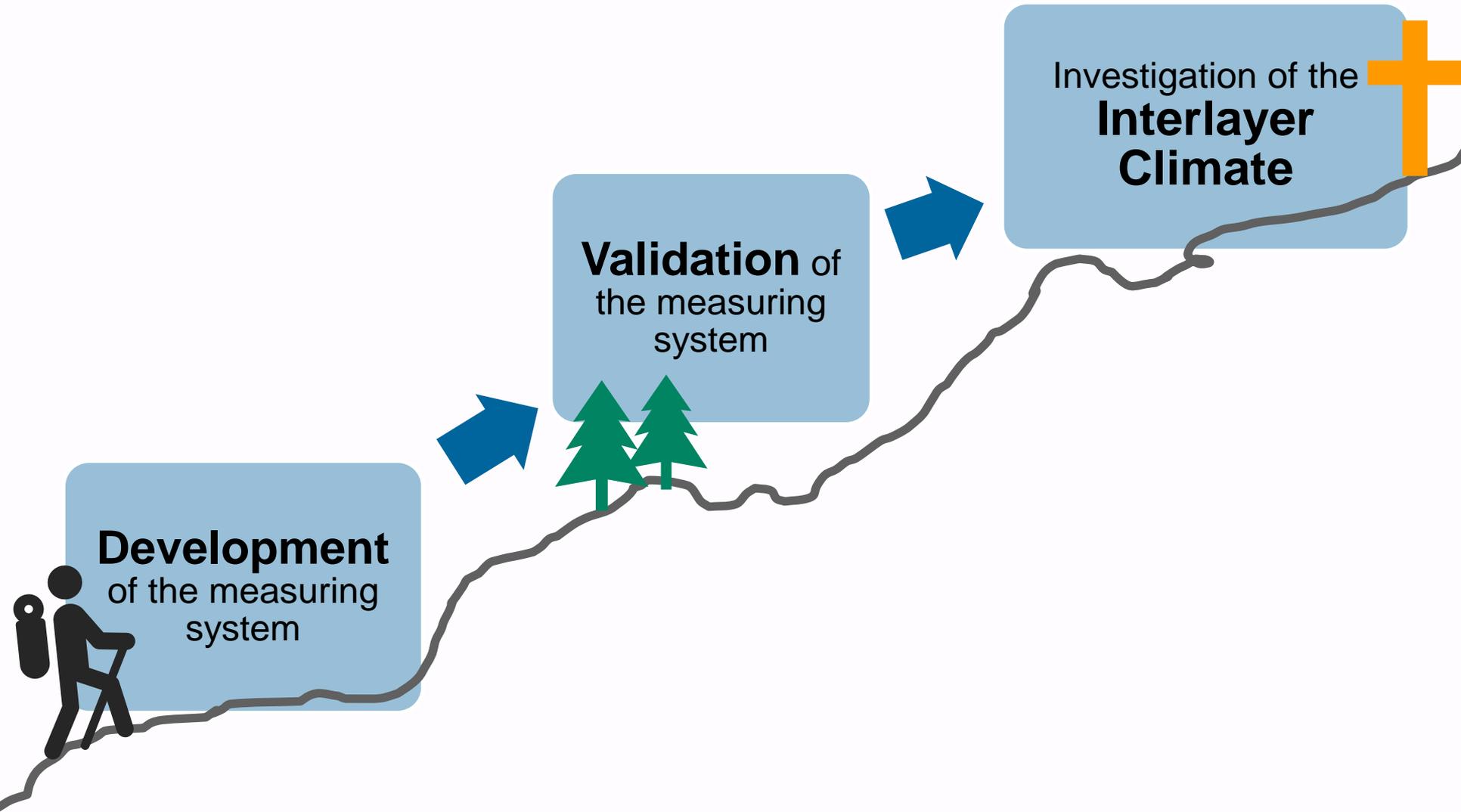


# Interlayer Climate = Climate in the typical **layer system of clothing**



- 1 Base Layer  
→ Moisture management
- 2 Mid Layer  
→ Insulation
- 3 Outer Layer / Shell  
→ Wind & water protection

- **Standardized methods** for analysing textile properties, such as manikins (Koptuyug et al. 2018, Watson et al., 2018)
- Research of micro and interlayer climate **during cycling** (Klauer & Michel, 2018)





## Investigation of the Interlayer Climate

**RQ/AIM:** How is it possible to develop a measurement system which can be used to determine local temperature and humidity differences whilst carrying different rear ventilated backpack designs?

**Development of the measuring system**



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# Development of the measuring system

- Sensor/data logger selection**



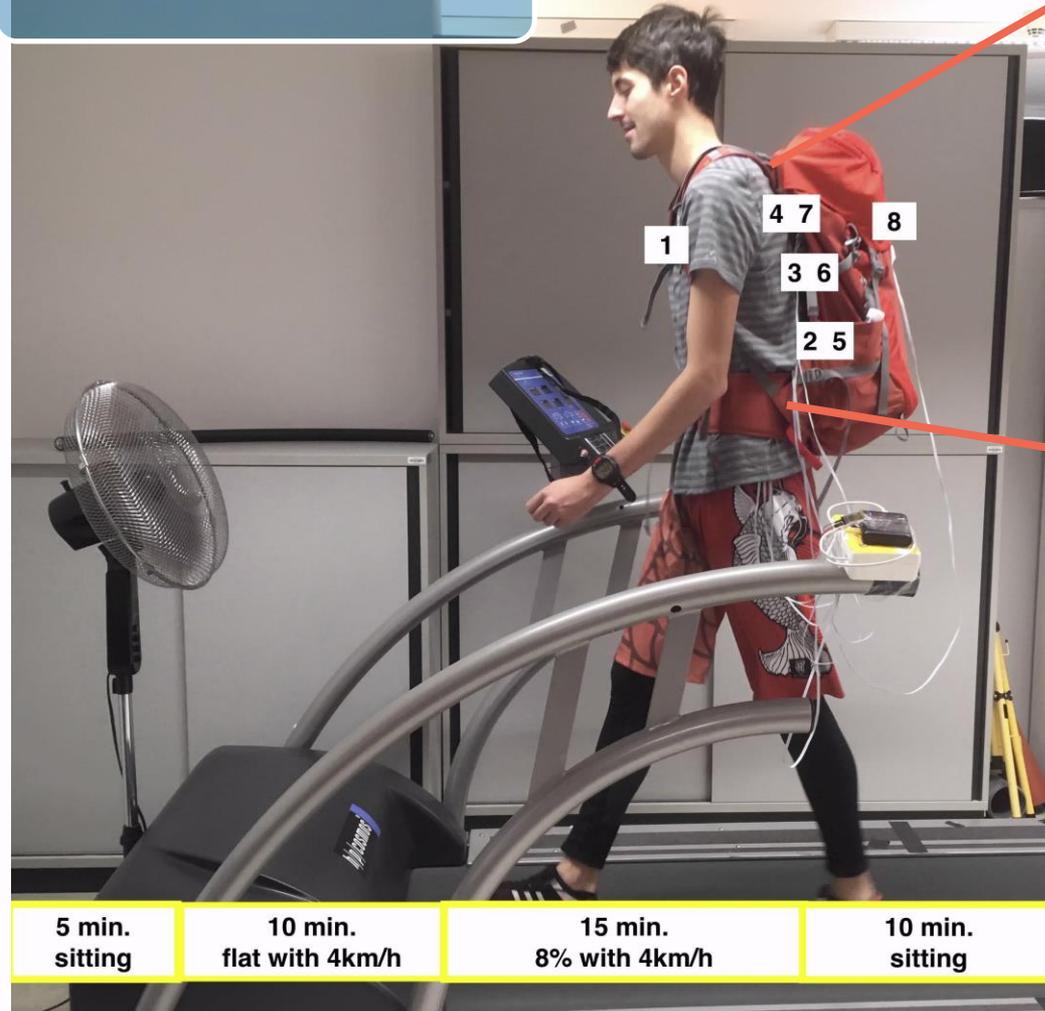
| Sensors               | FHTW (8 * Si7021 Sensors) |
|-----------------------|---------------------------|
| Measurement Principle | capacitive                |
| Relative Humidity     | 0 - 100 % ± 3 %           |
| Temperature           | -10 - 85 °C ± 0,4 °C      |
| Sampling Rate         | 1 Hz                      |

| Datalogger MSR147WD  |
|----------------------|
| capacitive           |
| 0 - 100 % ± 2 %      |
| -20 - 85 °C ± 0,2 °C |
| 1 Hz                 |

# Investigation of the Interlayer Climate



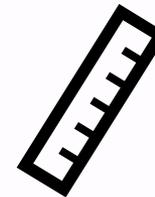
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- 5 male subjects
- FHTW system



## Measured parameters:



RH [%]

T [°C]

HR [BPM]

5 min.  
sitting

10 min.  
flat with 4km/h

15 min.  
8% with 4km/h

10 min.  
sitting

# Investigation of the Interlayer Climate



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**Men's Moyle Shirt III**

(79% Polyester, 15% Lyocell,  
6% Elastane)

**VAUDE Brenta 50**

**B1**

**VAUDE modified Brenta**

**B2**

4.1kg

5.4kg

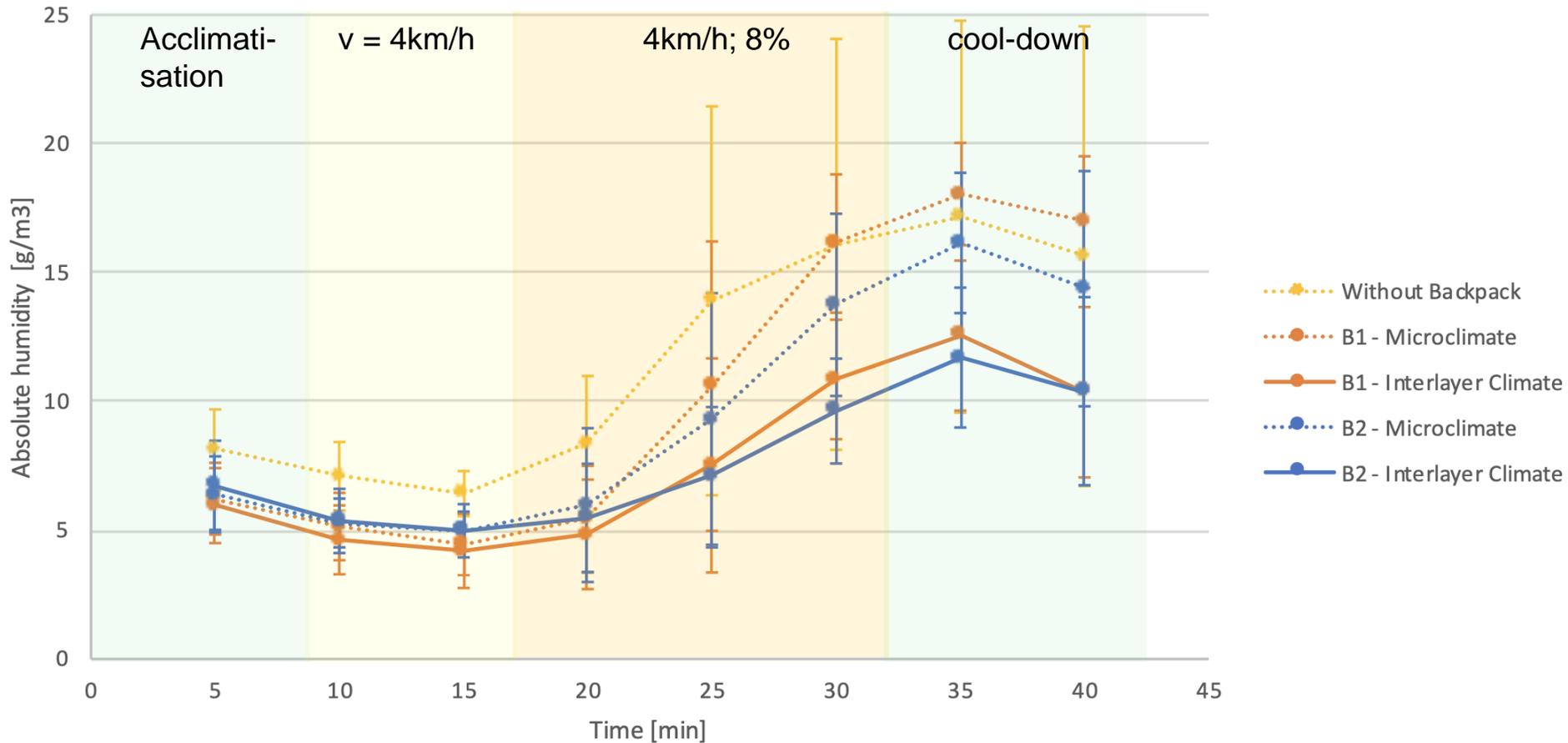
# Investigation of the Interlayer Climate



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## Upper back



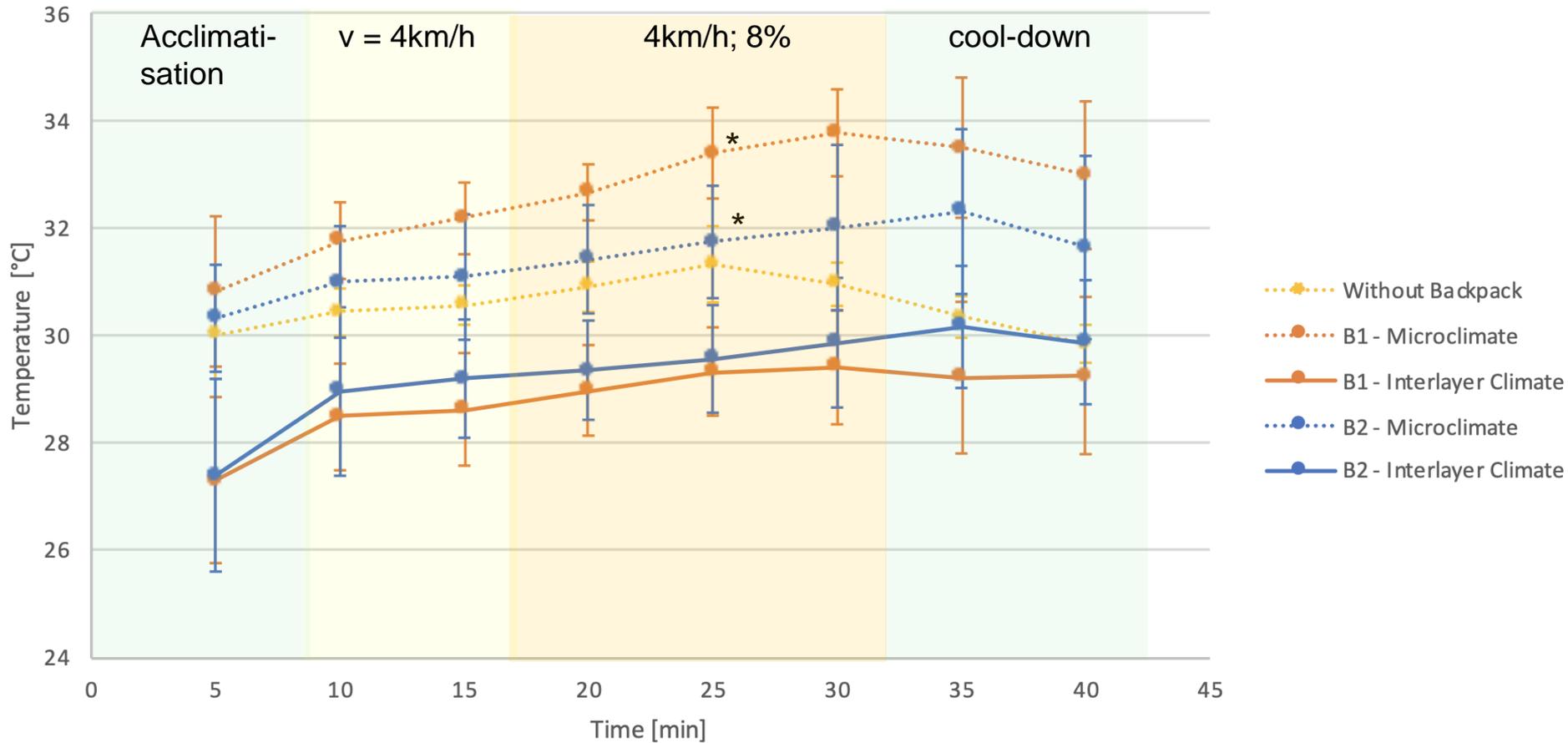
# Investigation of the Interlayer Climate



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## Upper back





# Discussion

- **Personal/non-personal factors**



- Different **sweating behaviour**

→ Current training & Sports focus



- **Subjects** (lower standard deviation)



- **Climatic chamber**



- **Measurement system**



→ Accumulation of sweat due to the relatively big sensorboard

→ Not possible to test extreme szenarios due to saturation of sensors



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# Conclusion

- **Reduction of the mesh**
  - Reduced contact area back - backpack



- Useable for **different outdoor activities**
  - More layers



Thank you for your attention!  
**Any questions?**

# Calculation of the absolute Humidity



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- Calculation of the **saturation vapor pressure  $P_{ws}$**

$$P_{WS} = A * 10^{\left(\frac{m*T}{T+T_n}\right)}; [hPa]$$

|       | A        | m        | Tn       | max error | Temperature range |
|-------|----------|----------|----------|-----------|-------------------|
| water | 6.116441 | 7.591386 | 240.7263 | 0.083%    | -20...+50°C       |
|       | 6.004918 | 7.337936 | 229.3975 | 0.017%    | +50...+100°C      |
|       | 5.856548 | 7.27731  | 225.1033 | 0.003%    | +100...+150°C     |
|       | 6.002859 | 7.290361 | 227.1704 | 0.007%    | +150...+200°C     |
|       | 9.980622 | 7.388931 | 263.1239 | 0.395%    | +200...+350°C     |
|       | 6.089613 | 7.33502  | 230.3921 | 0.368%    | 0...+200°C        |
| ice   | 6.114742 | 9.778707 | 273.1466 | 0.052%    | -70...0°C         |

- Vapor pressure  **$P_{wmeans}$**  and **absolute Humidity A**

$$P_{W_{meas}} = P_{WS} * \frac{RH}{100}; [hPa]$$

$$A = C * \frac{P_{W_{meas}}}{T}; \left[ \frac{g}{m^3} \right] \quad (C = 2,16679 \text{ gK/J})$$

(Vaisala, 2013)

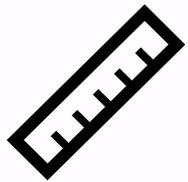
# Validation of the measuring system



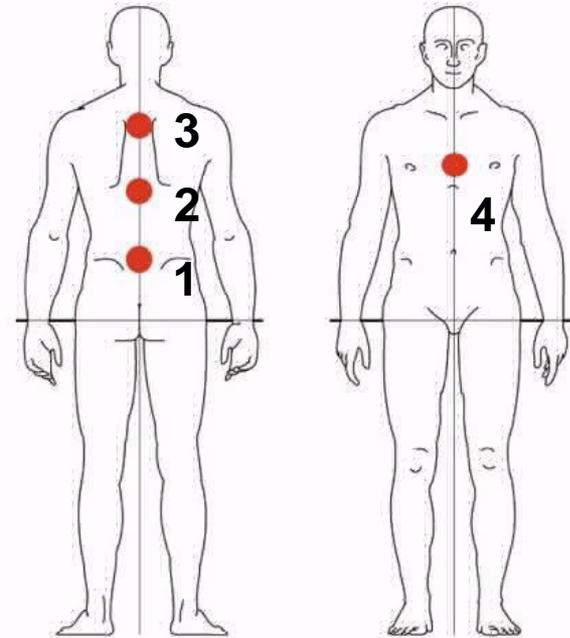
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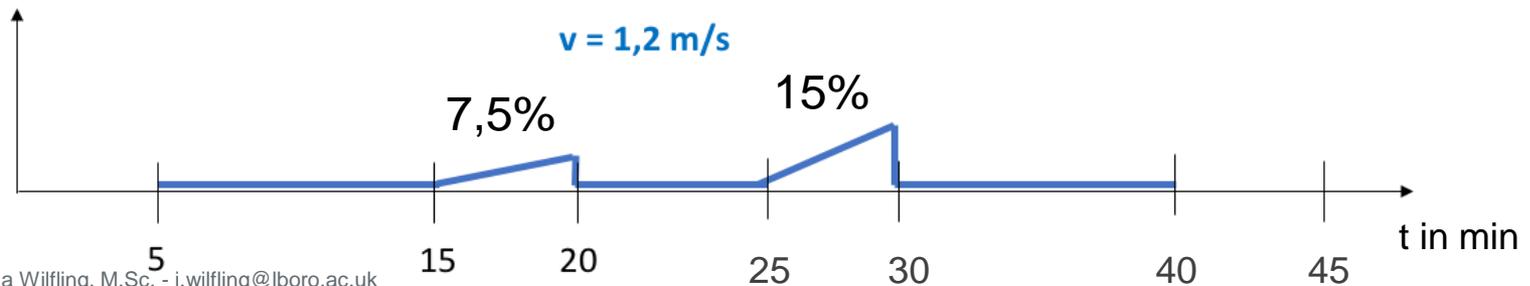
- Treadmill
- FHTW System & MSR System



- RH [%]
- T [°C]
- HR [BPM]



Incline in %



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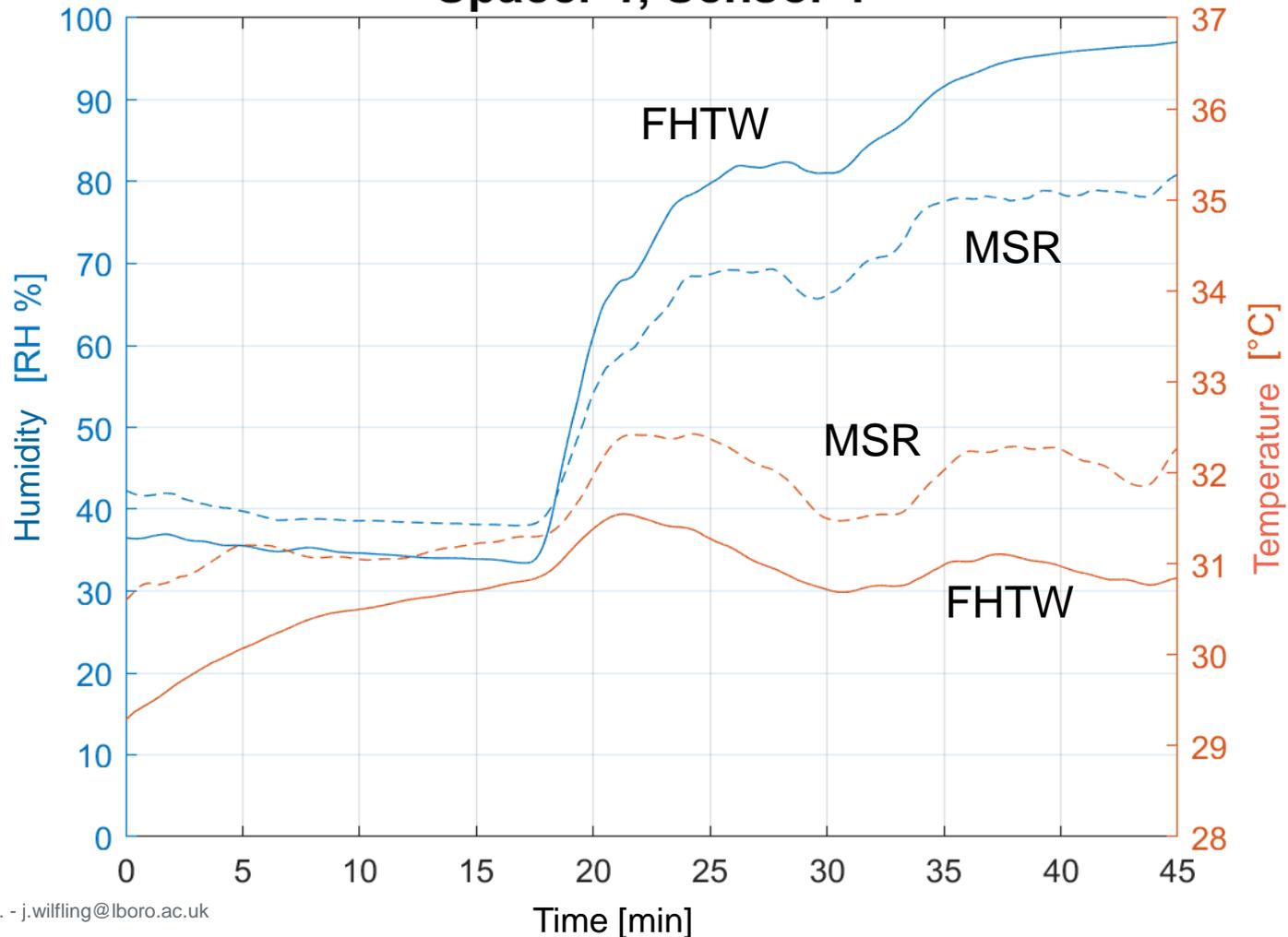
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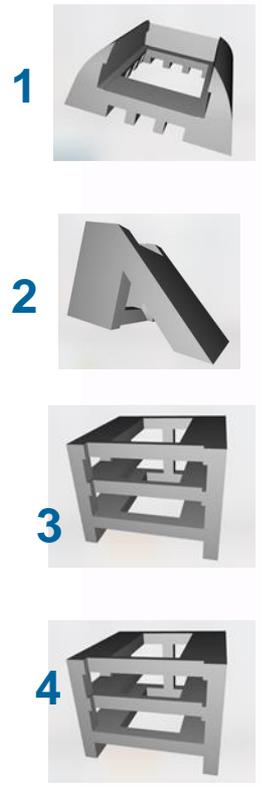
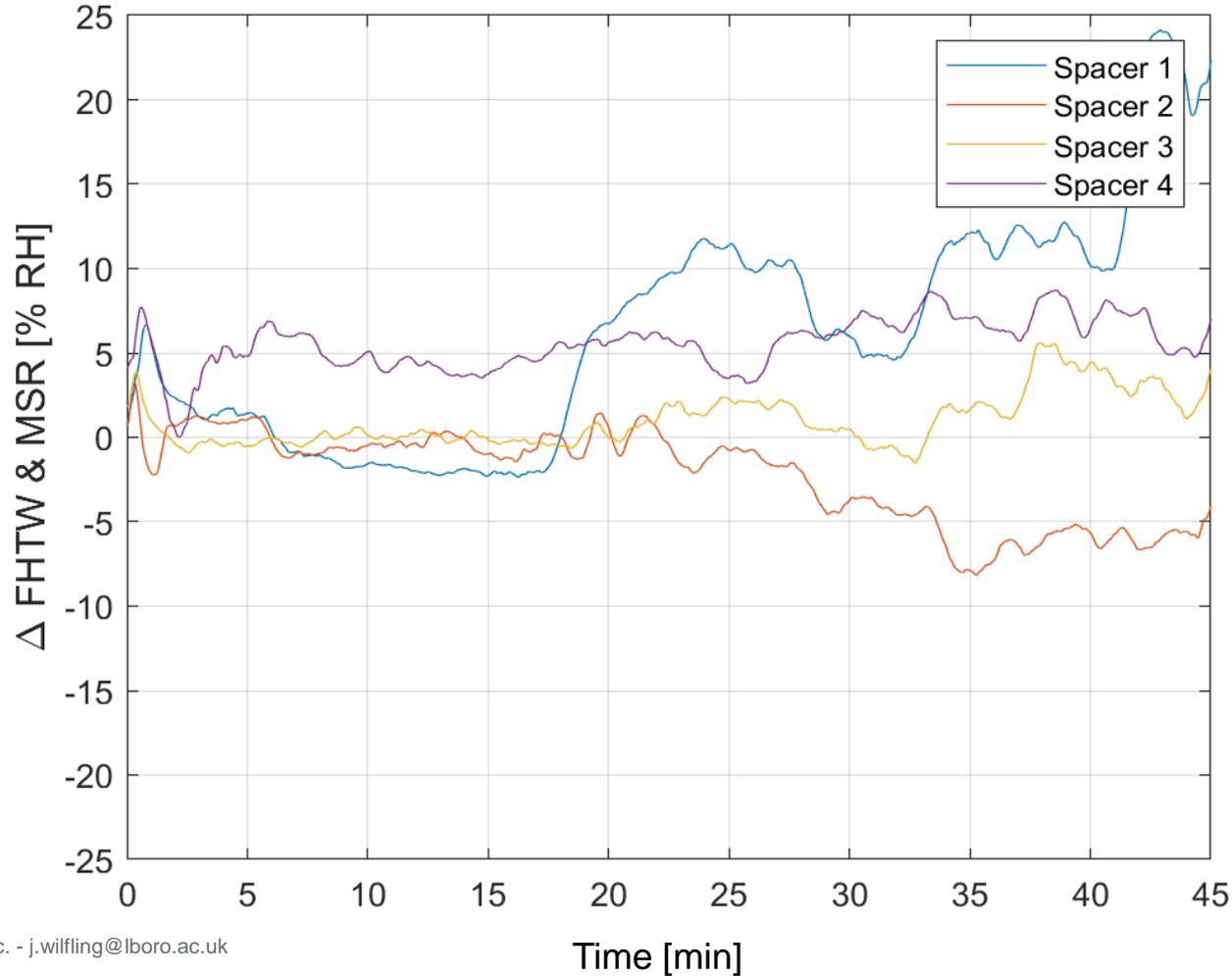


## Spacer 1, Sensor 1



# Validation of the measuring system

## Difference between Spacer – Spot 4



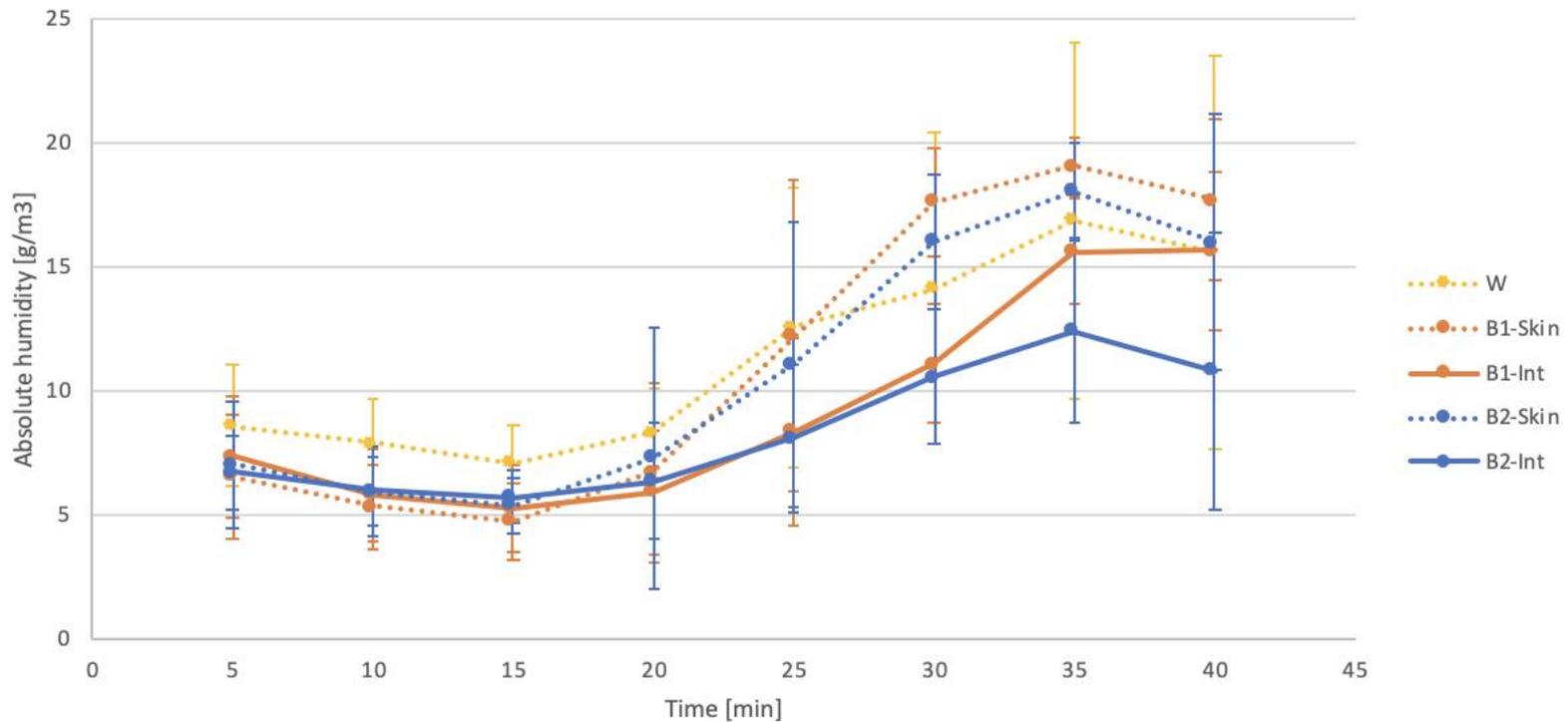
# Investigation of the Interlayer Climate



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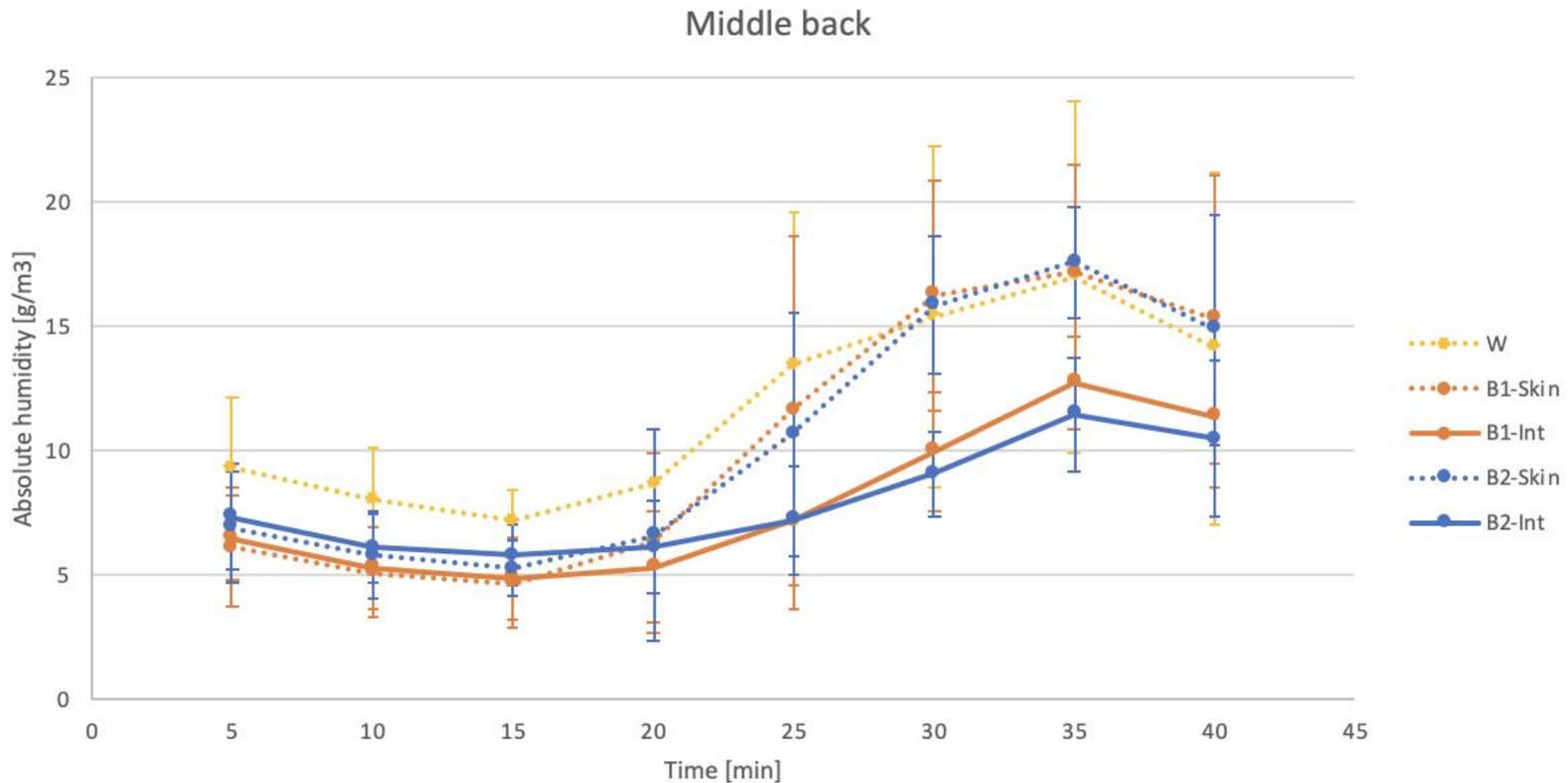
Lower back



# Investigation of the Interlayer Climate



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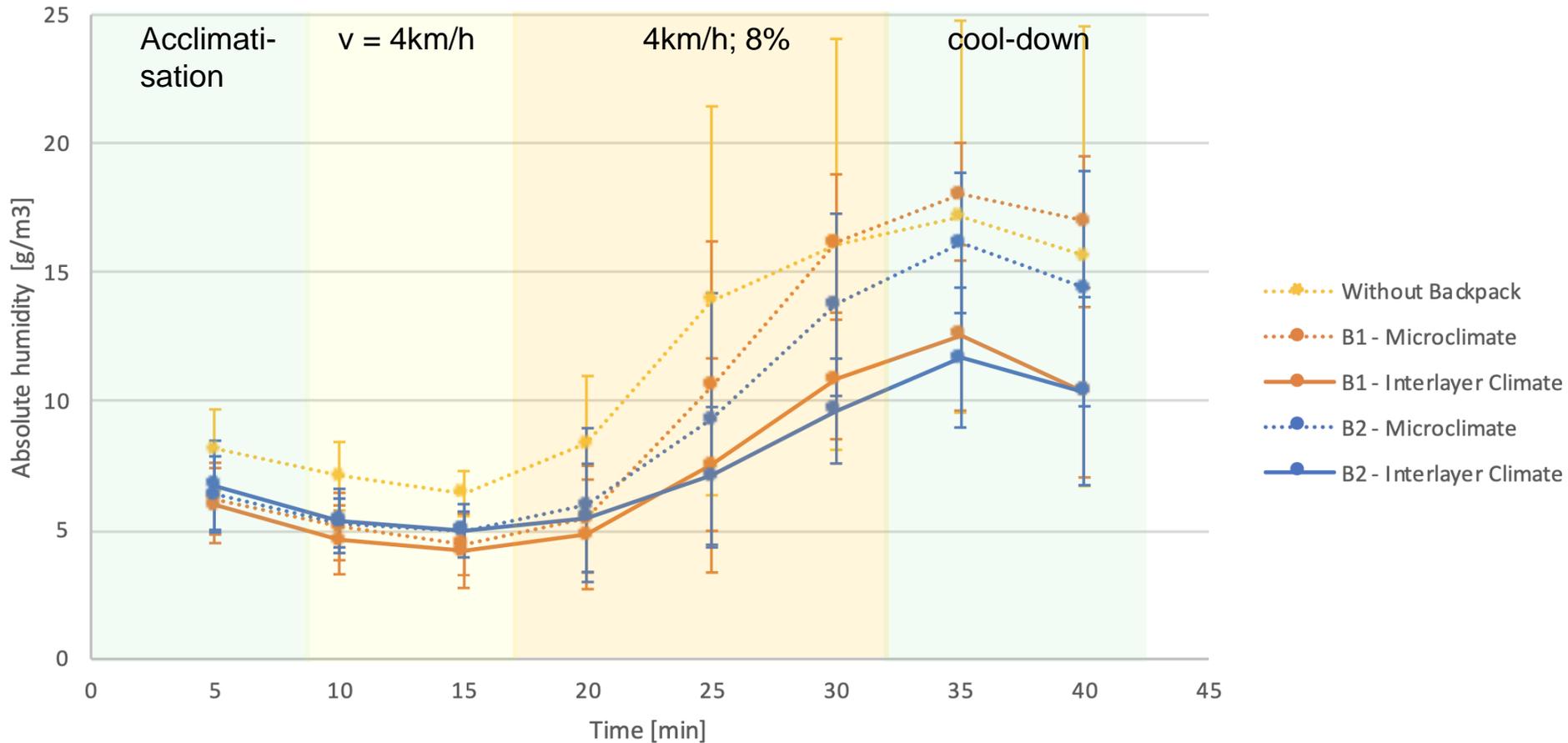
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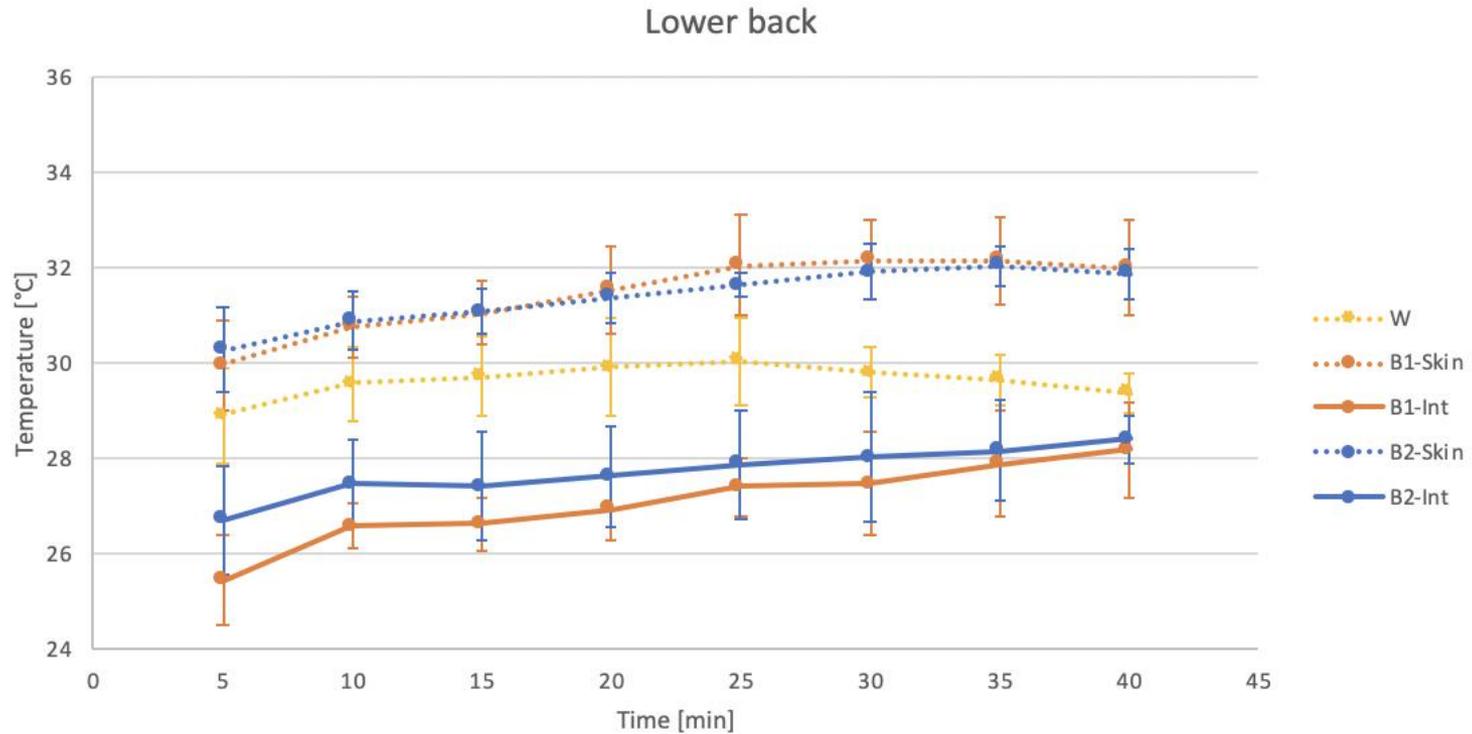
## Upper back



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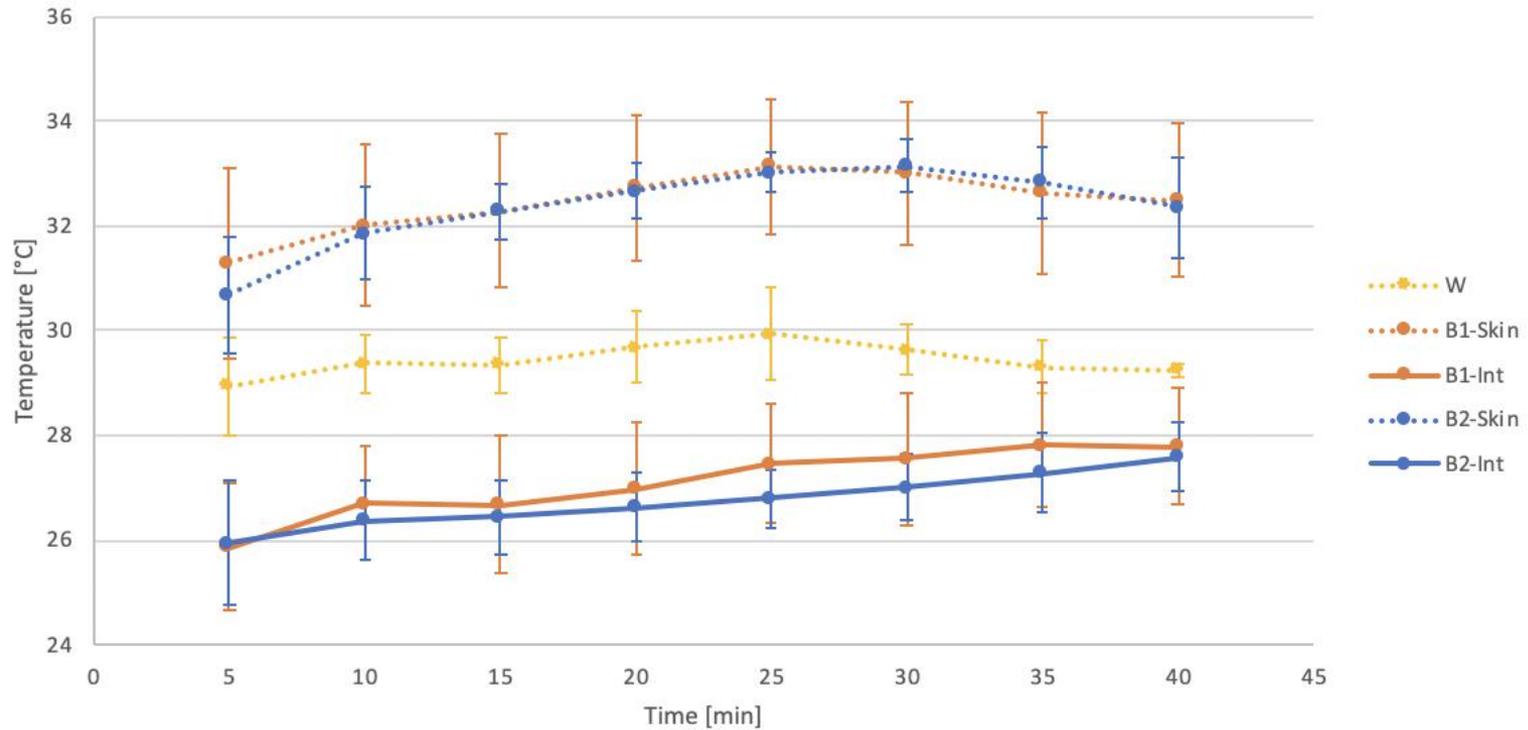
# Investigation of the Interlayer Climate



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Middle back



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## Upper back

