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

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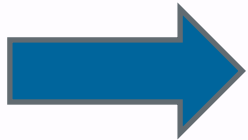


"The importance of heat balance is still totally underestimated in sports. Optimal thermoregulation is more important for performance than the amount of red blood cells".

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**

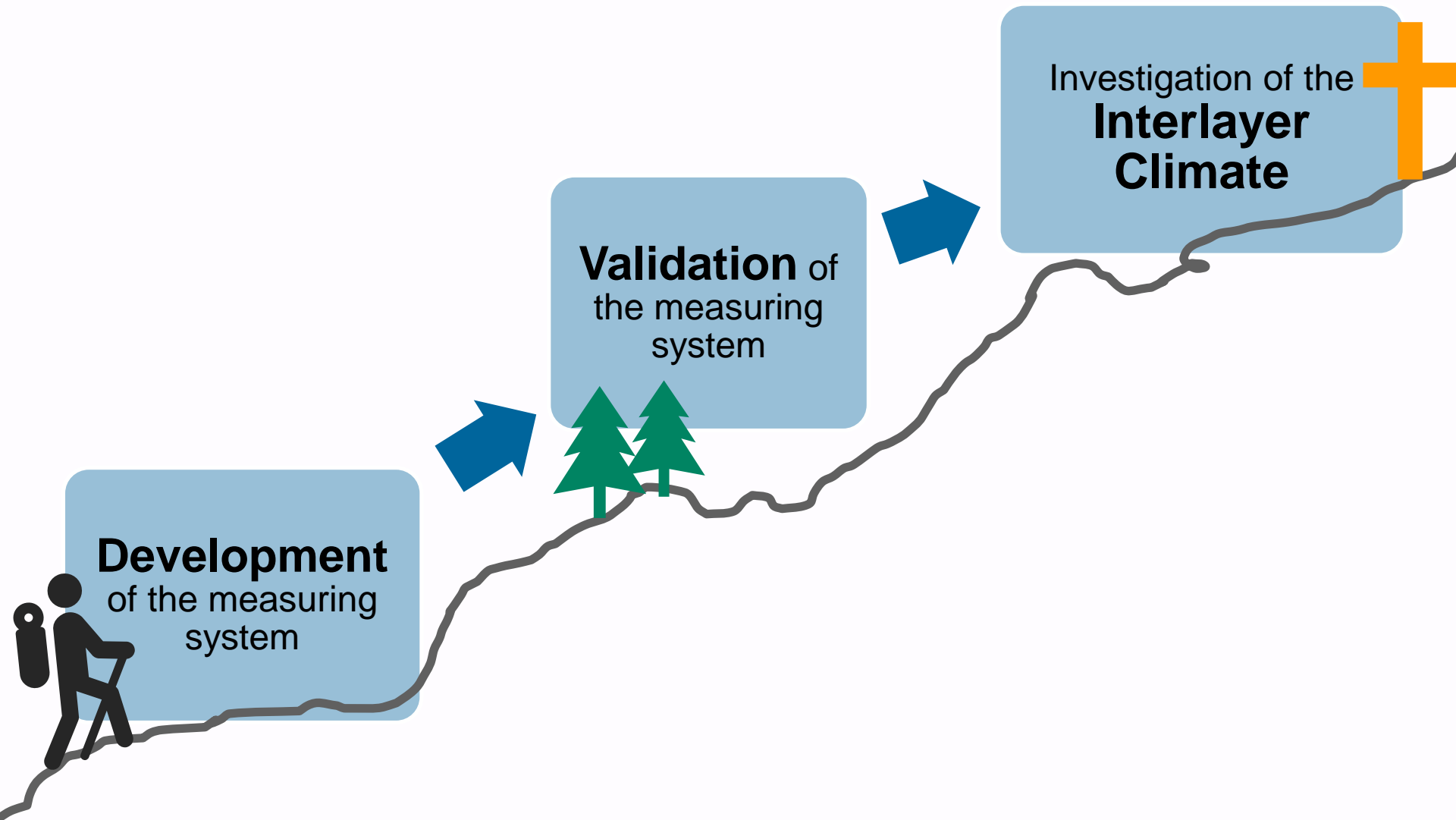


- 1 Base Layer
→ Moisture management
- 2 Mid Layer
→ Insulation
- 3 Outer Layer / Shell
→ Wind & water protection

- **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)



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Investigation of the **Interlayer Climate**

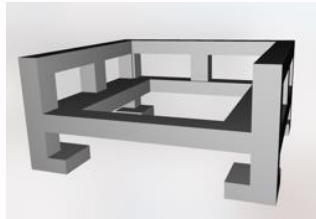
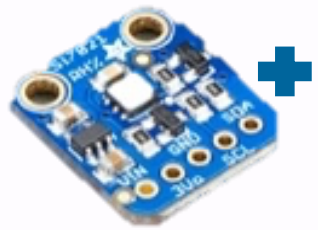
RQ/AIM: How is it possible to develop a measurement system which can be used to determine local temperature and humidity differences whilst carrying different rear ventilated backpack designs?

**Development
of the measuring
system**



Development of the measuring system

■ Sensor/data logger selection



Validation System



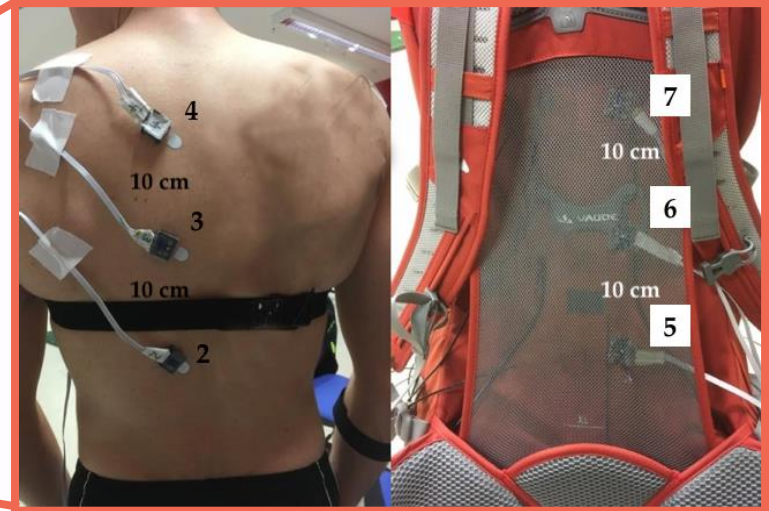
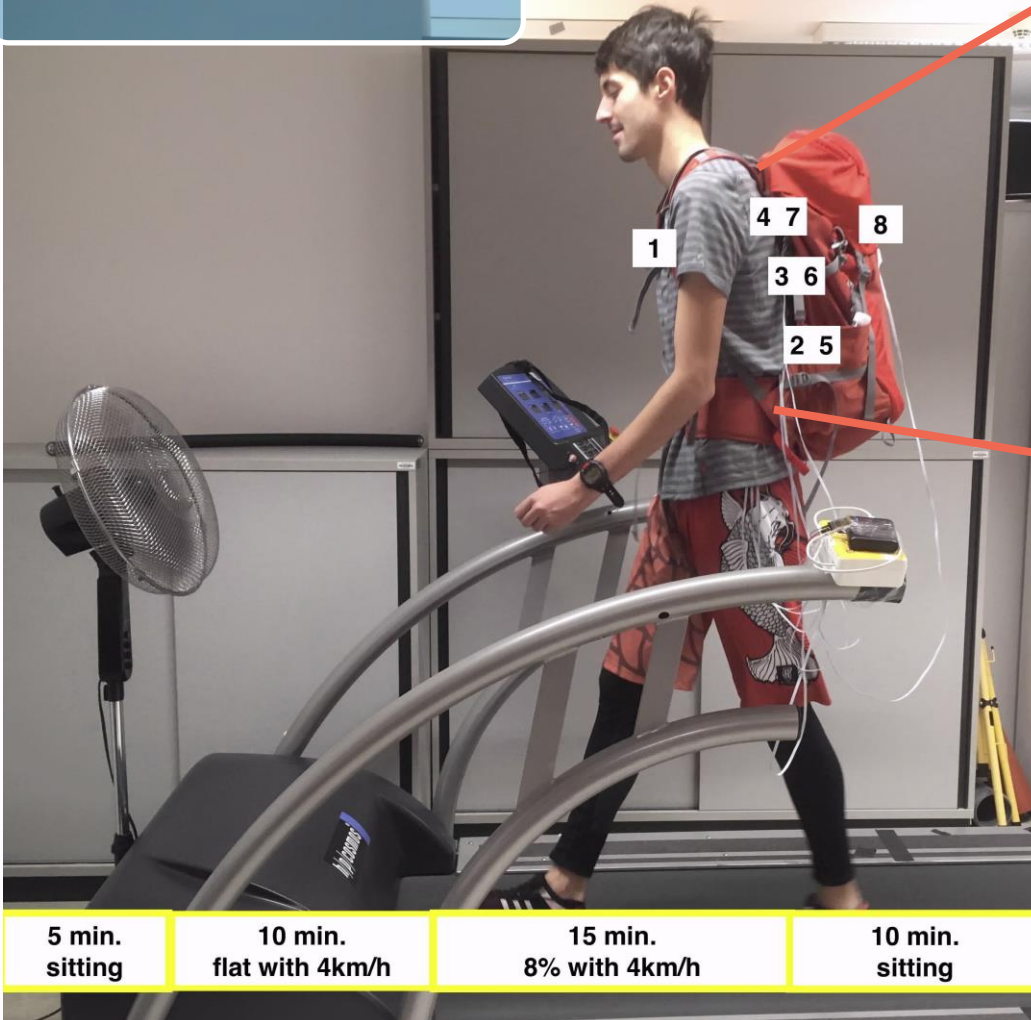
Sensors	FHTW (8 * Si7021 Sensors)
Measurement Principle	capacitive
Relative Humidity	0 - 100 % \pm 3 %
Temperature	-10 - 85 °C \pm 0,4 °C
Sampling Rate	1 Hz

Datalogger MSR147WD
capacitive
0 - 100 % \pm 2 %
-20 - 85 °C \pm 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



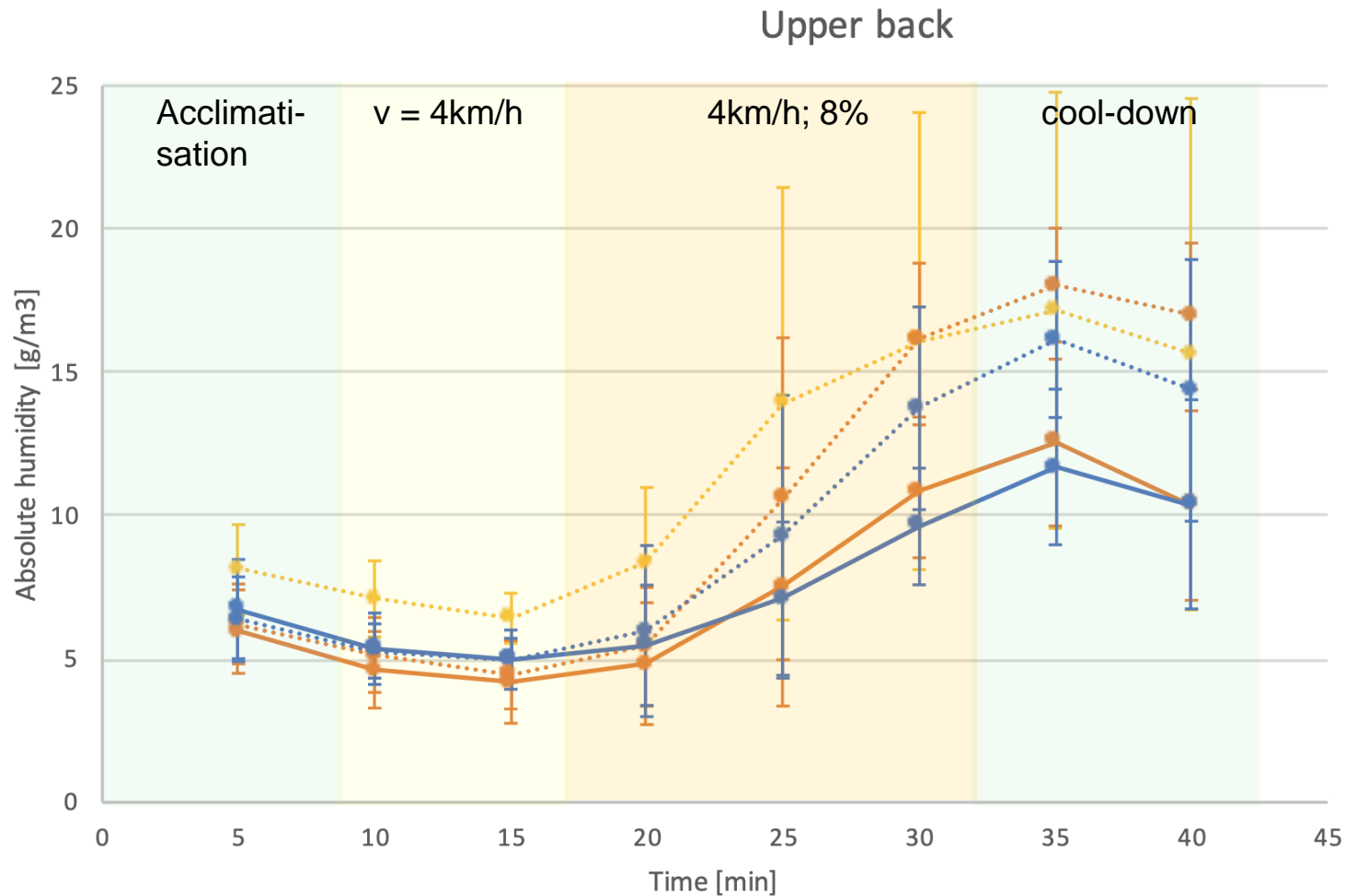
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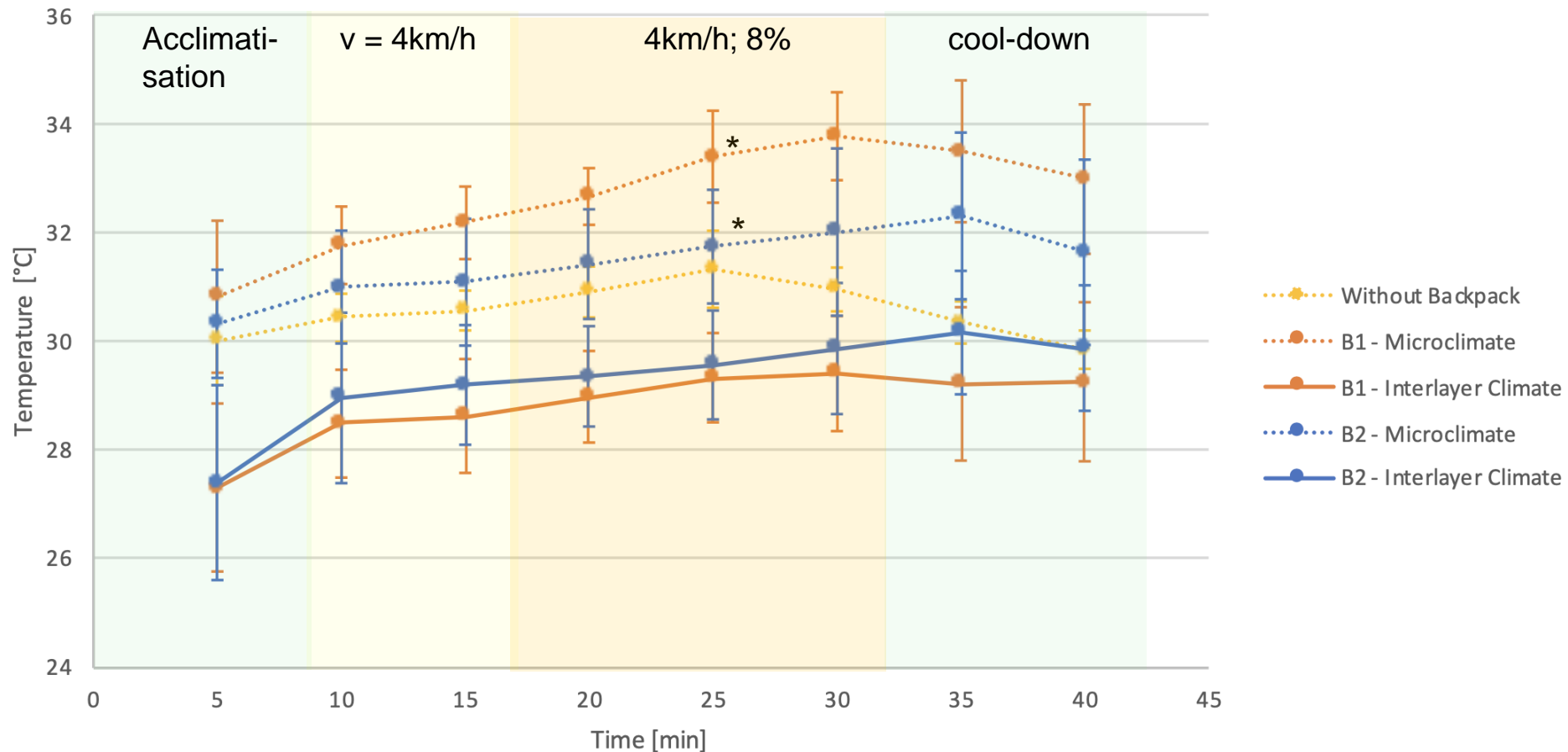


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Upper back





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

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

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

(Vaisala, 2013)

Validation of the measuring system

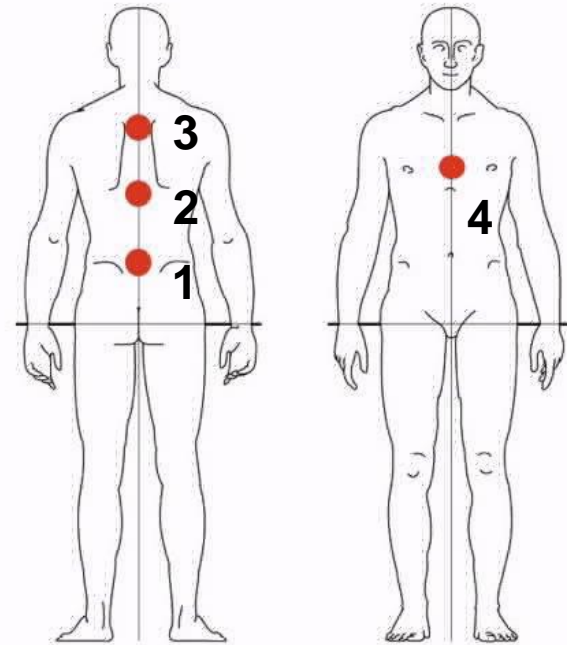


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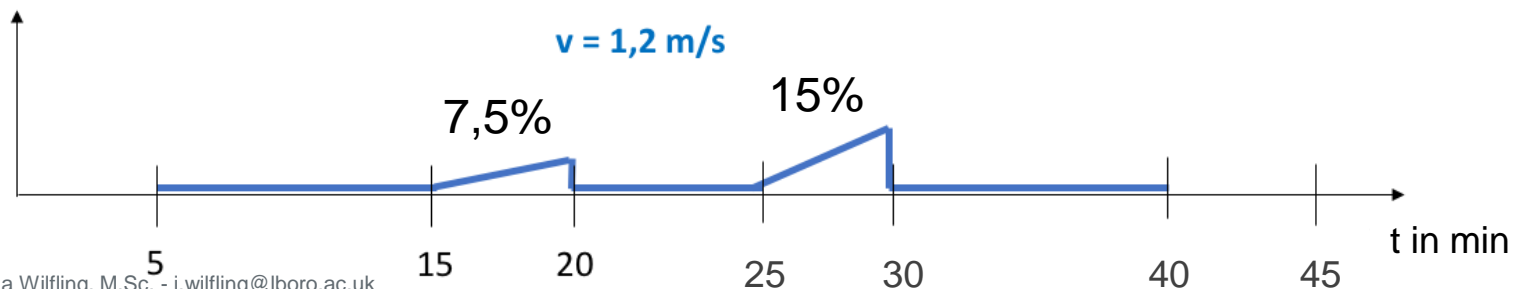
- Treadmill
- FHTW System & MSR System



- RH [%]
- T [°C]
- HR [BPM]



Incline in %

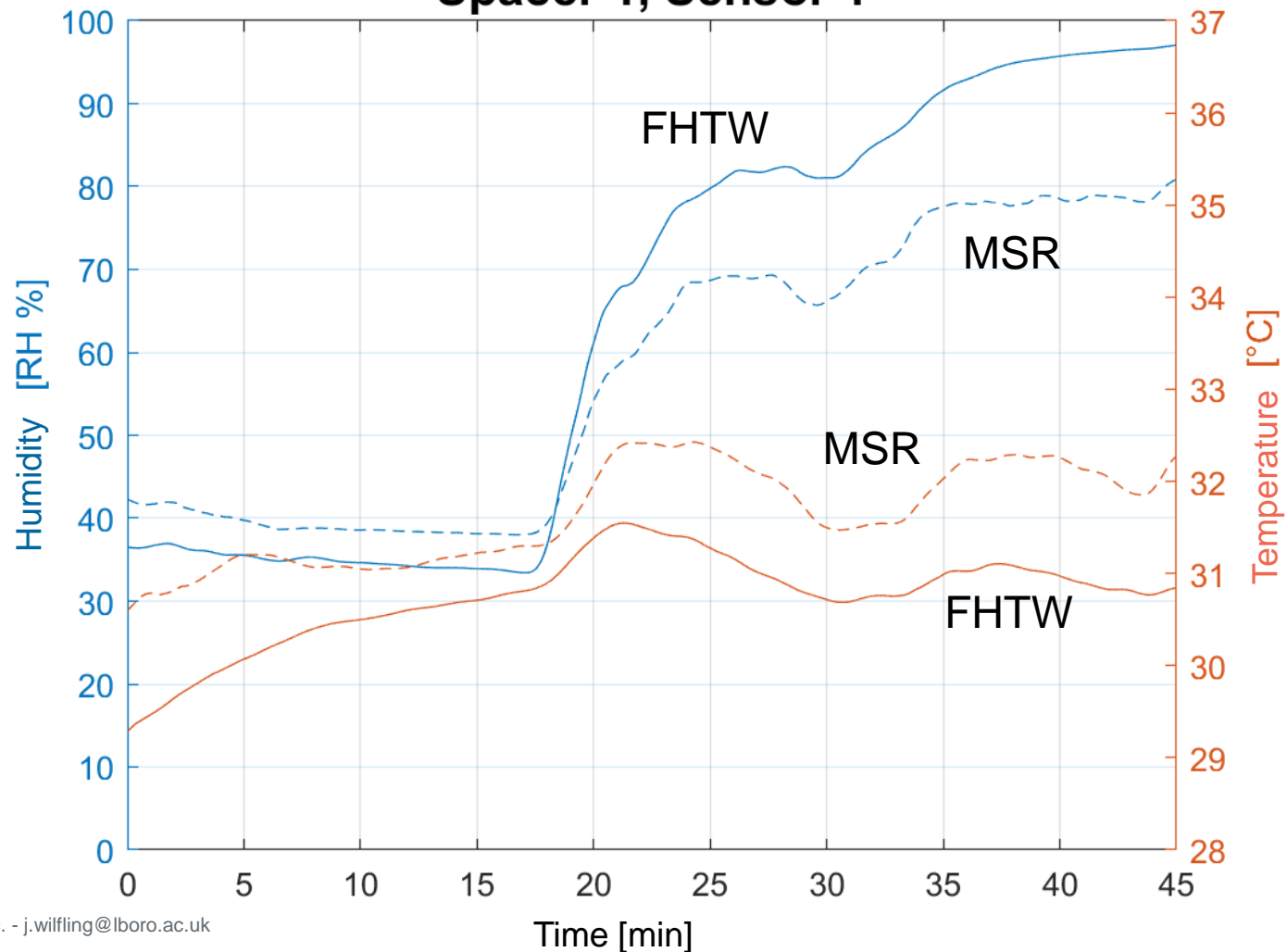


Validation of the measuring system



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Spacer 1, Sensor 1

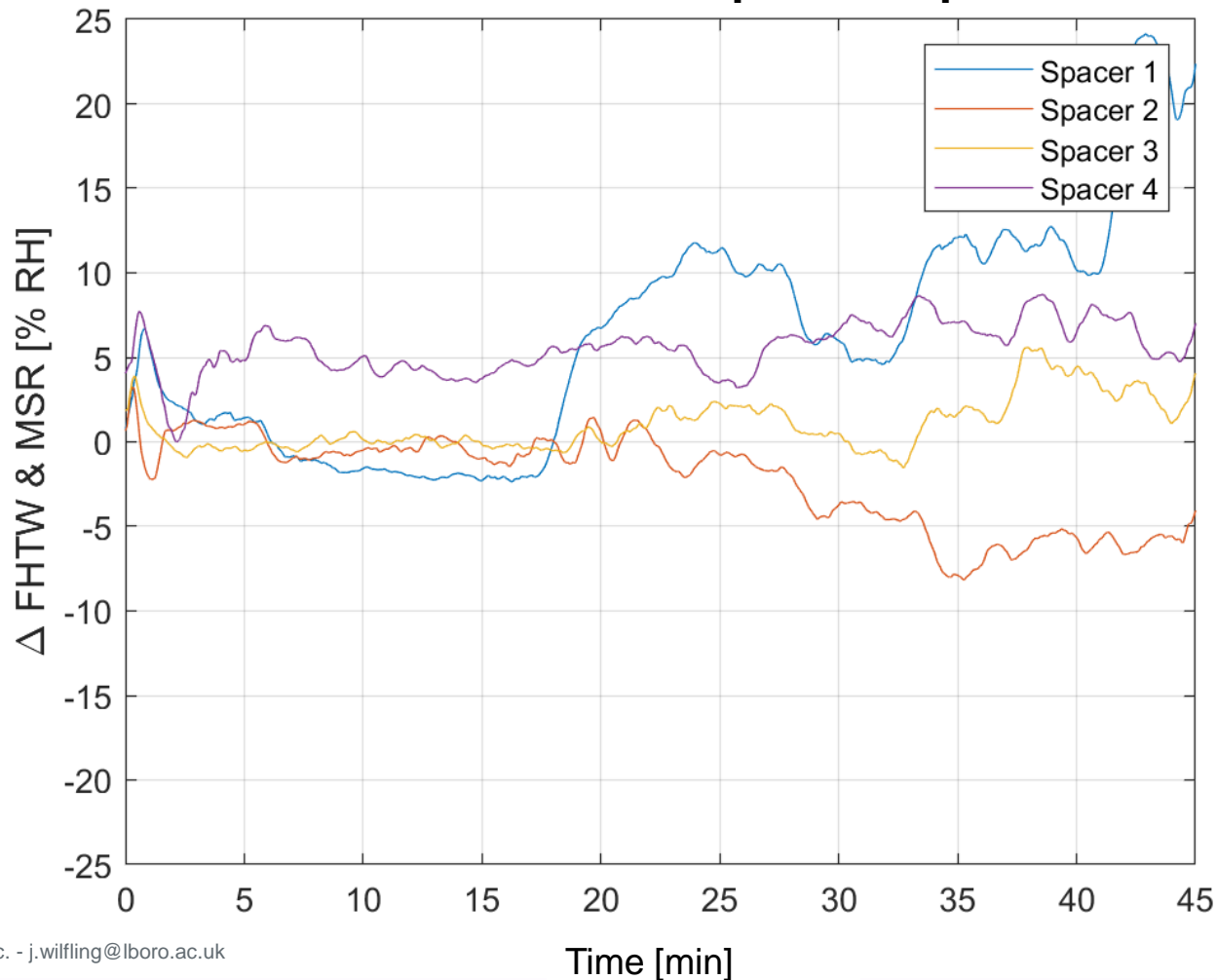


Validation of the measuring system

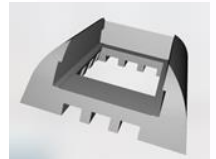


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Difference between Spacer – Spot 4



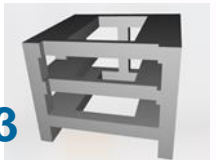
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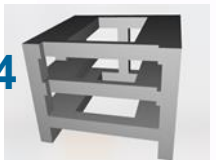
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3



4

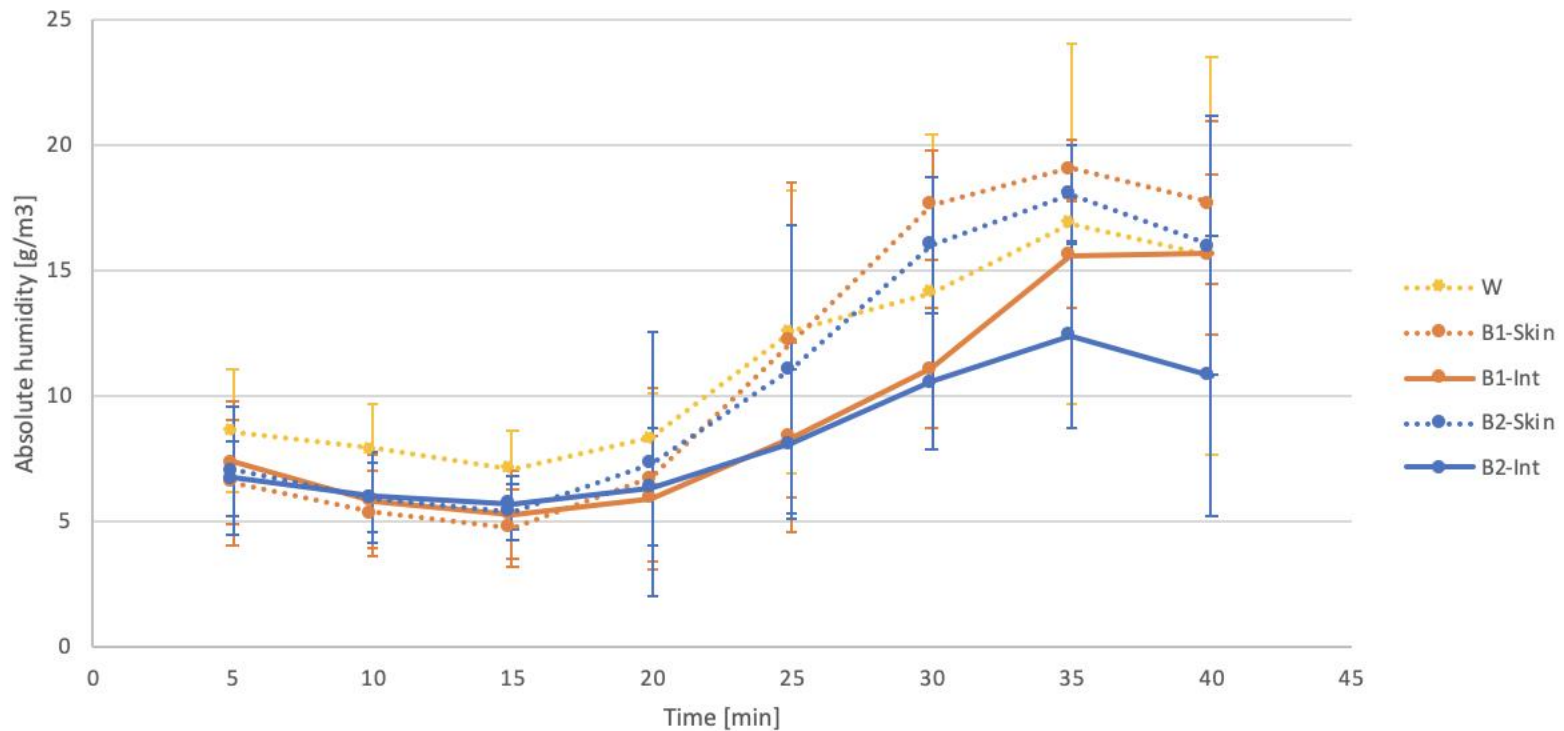


Investigation of the Interlayer Climate



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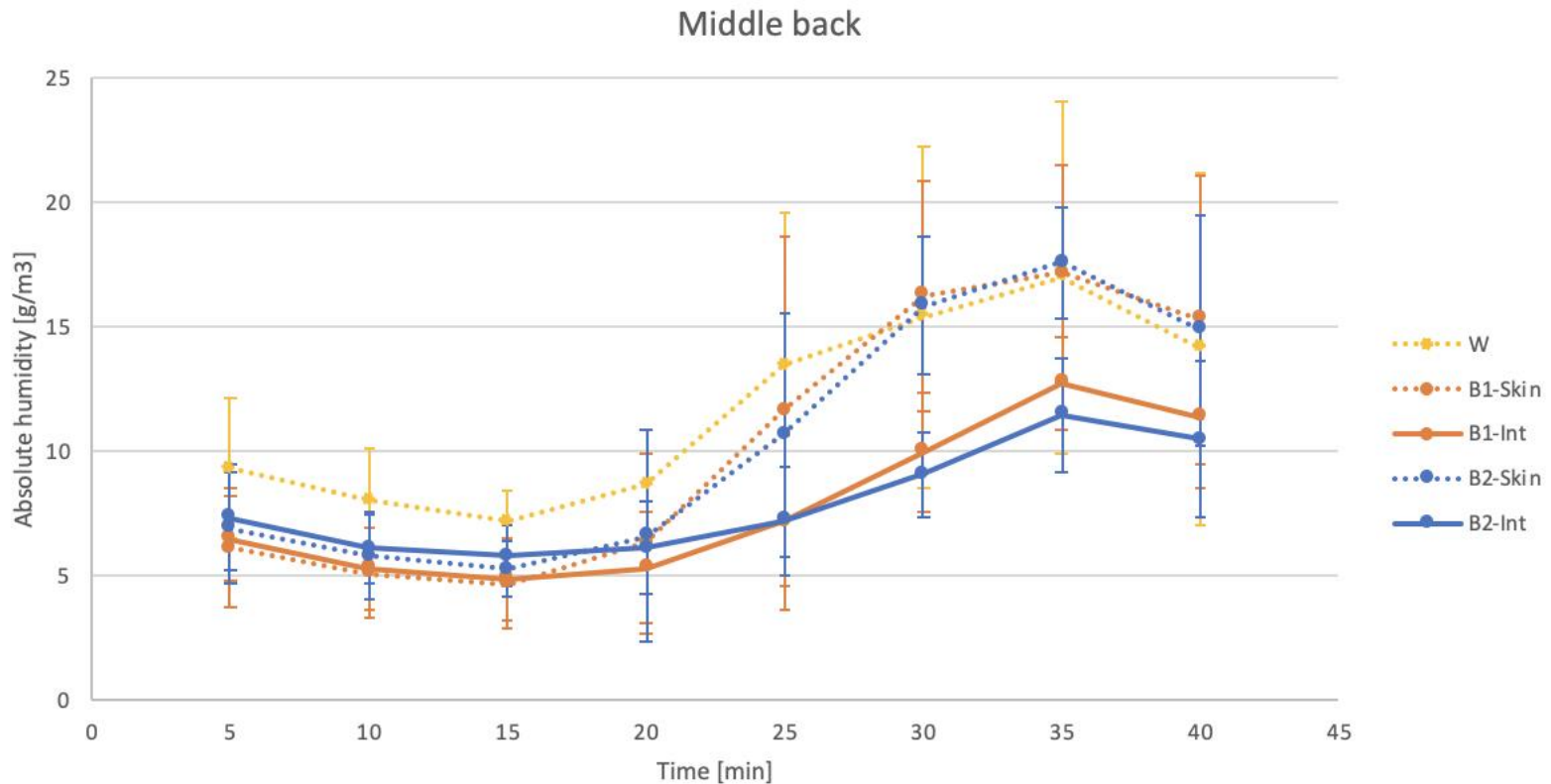
Lower back



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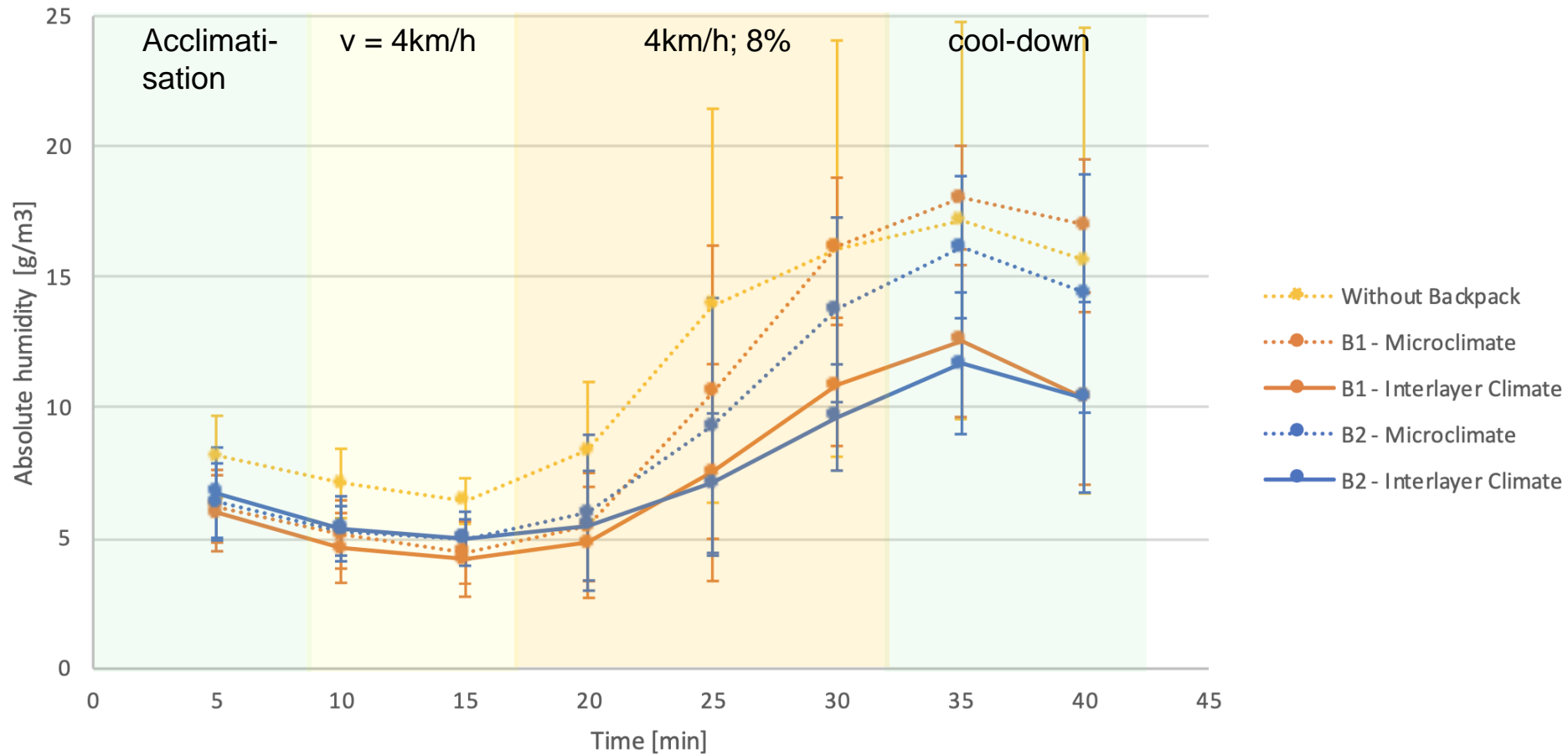
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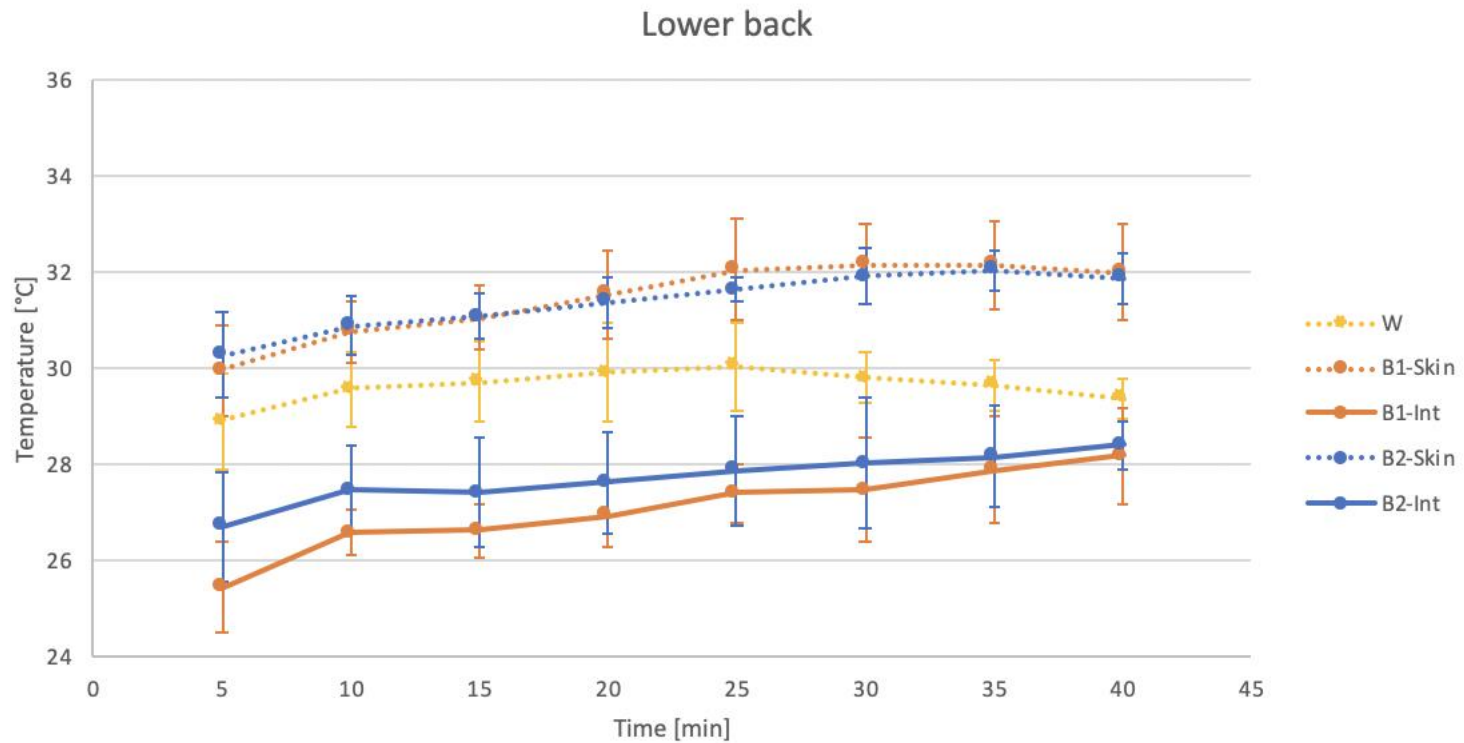
Upper back



Investigation of the Interlayer Climate



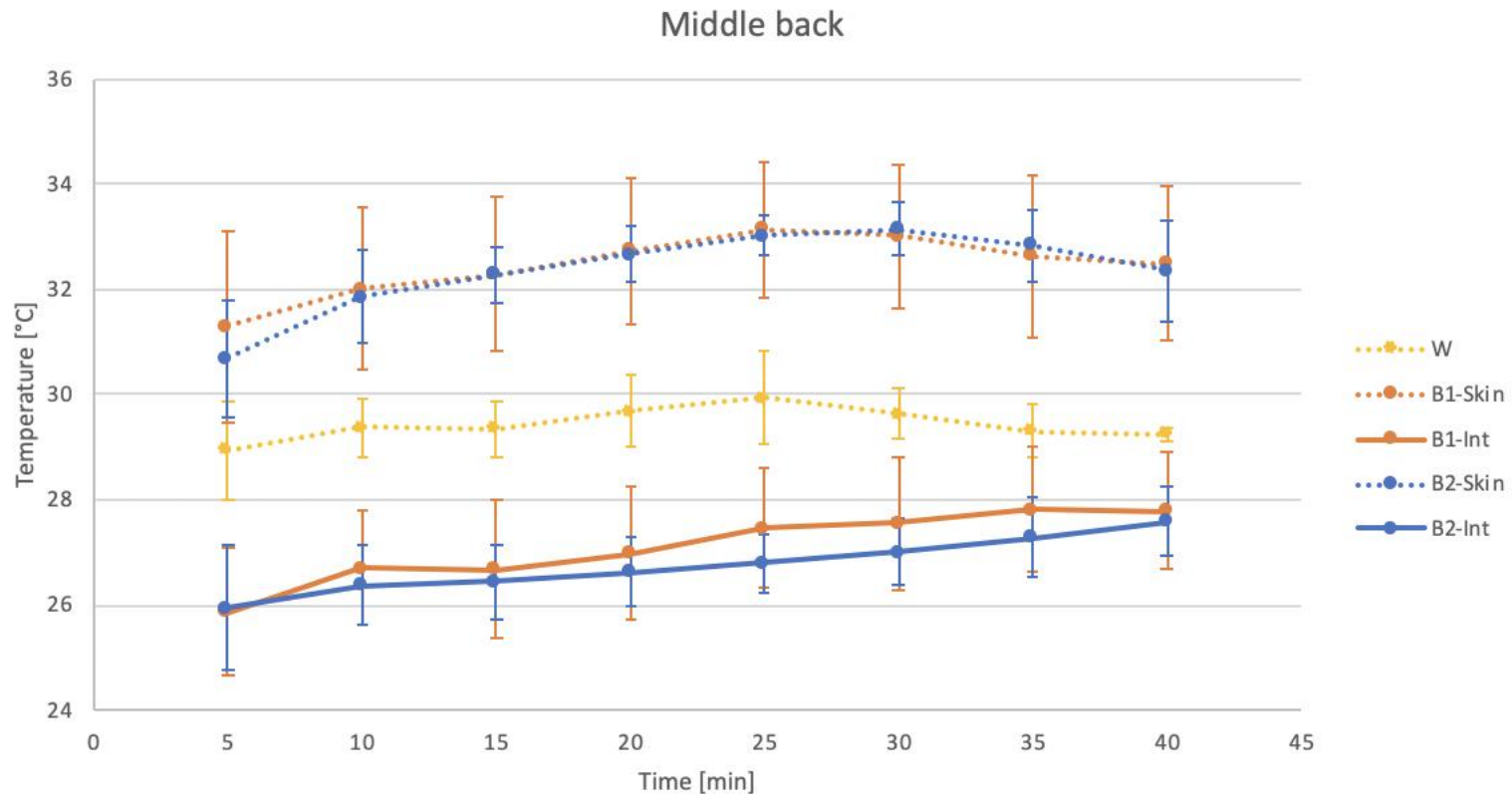
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Upper back

