THERMO-PHYSIOLOGICAL RESEARCH OF MICRO AND INTERLAYER CLIMATE DURING CYCLING – INFLUENCE OF TWO DIFFERENT BACKPACK SYSTEMS

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Introduction

Thermoregulation during exercise has an influence on the wearing comfort of functional clothing. The young research area of thermoregulation is very complex because of the variety of impact factors (Wilmore et al. , 2004). Research has been done about the micro climate (between skin and base layer). But during many outdoor activities people wearing backpacks. At the moment there are no studies addressing the thermo-physiological comfort of backpacks. To understand the heat and vapor transfer of the clothing-backpack system, information about the interlayer climate (between clothing and backpack) together with the data of the microclimate is needed. With the generation of these data, the aim of this study was to measure the thermo-physiological impact of two different backpack systems.

Material & Method

Five well-trained males performed the load scenario of 40 minutes cycling (two intervals of basic, one interval of intensive endurance and 15 minutes of resting, **Fig. 1**). Every individual load scenario is based on the result of a lactate step test where the deflection point (individual anaerobic threshold) was defined. The subjects were tested in a climate chamber (**Fig. 2**) at 20 °C and 50 % relative humidity. Temperature and humidity were measured with combination sensors (MSR 147WD) between skin and clothing as well as between clothing and backpack (**Fig. 3**). Based on literature (Schindelka et al., 2013) and adjusted on the scientific issue four sensors are located on the back (2), chest and on the lower arm (micro climate, **Fig. 4**). Regarding the interlayer climate three sensors are positioned on the backpack. Furthermore, the heart rate was tracked with a Polar chest strap. Temperature and humidity perception were gathered every five minutes. During cycling, the subjects wore a VAUDE LS shirt (96 % PES, 4 % EL) as a base layer with a water vapor resistance of $R_{ET} = 5$ m²*Pa/W. Two VAUDE backpack systems which differ in functionality and field of use (regular and ventilated backpack system) together with a reference (without backpack) were tested.

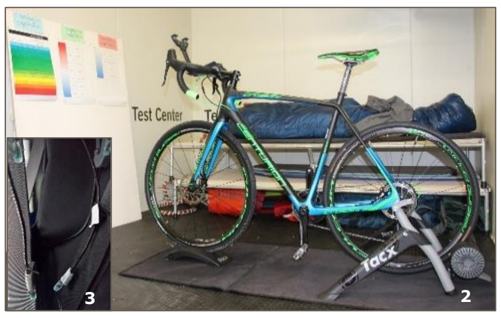

Fig. 2, 3: subject rides the bike on a cycle trainer in the VAUDE climate chamber [1], the combination sensors positioned on skin and backpack measure temperature and relative humidity [2].

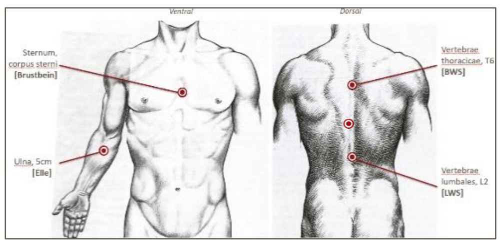

Fig. 4: four sensors are positioned on the skin and three sensors on the back (reference)/ backpack [figure is based on Tittel, 1994]

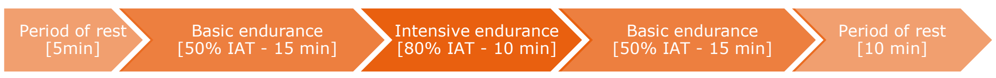

Fig. 1: period and intensity of the load scenario

Results

By wearing a regular backpack, the heat transfer on the back is limited. However, the data clearly indicates that the ventilated backpack system is able to enhance the heat transfer compared to a regular backpack system. Concerning the micro climate, the temperature during cycling with a regular backpack increases up to 26 % compared to cycling without backpack (**Fig. 5**). In contrast, with a ventilated backpack system the temperature increases maximum up to 18 %. In addition, the results show a correlation between micro and interlayer climate. The temperature decreases from the micro climate to distal layers, except when wearing the regular backpack. There, the temperature at the end of the load scenario stays at 37 °C. While using a ventilated backpack, the interlayer temperature decreases significantly (31 °C). Furthermore, the subjects could feel the temperature differences in terms of less perceived exertion and temperature with a ventilated backpack system. Besides comfort, using a ventilated backpack shows a lower heart rate for the subjects (**Tab. 1**). The differences for temperature and humidity perception together with the heart rate getting lower with a increasing duration of the load scenario.

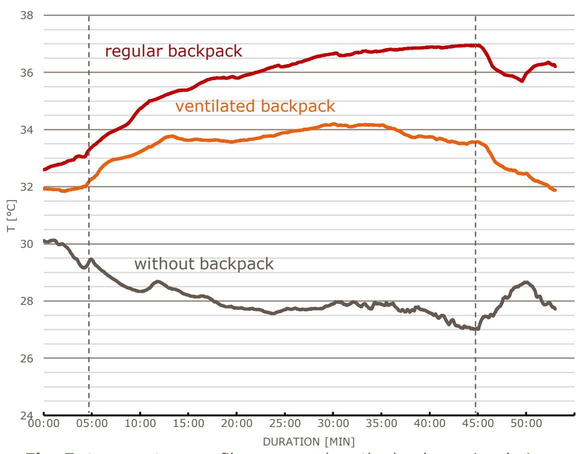

Fig. 5: temperature profile measured on the lumbar spine (micro climate, n=5)

Heart rate [bpm]	**without backpack**	**ventilated backpack**	**standard backpack**
Basic endurance (from min 5-20)	111 +/- 7	114 +/- 6	117 +/- 8
Intensive endurance (from min 20-30)	144 +/- 9	147 +/- 5	149 +/- 7
Basic endurance (from min 30-45)	125 +/- 8	131 +/- 5	132 +/- 8

Tab. 1: mean and standard deviation of heart rate during load scenario (without resting, n=5)

Discussion, Conclusion & Application

The measured temperature and humidity data during cycling are the base for the comparison of the two different backpack systems regarding the thermo-physiological comfort. Results for the micro climate without wearing a backpack are confirmed by the data of Jack (2009).

Due to the lack of literature a comparison with other thermo-physiological studies concerning the influence of different backpack systems is so far not possible. But with the standardized load scenario and the sensor position based on other studies (Schindelka et al., 2013; Jack, 2009) most parts of the test method are validated.

In conclusion, the ventilated backpack system during submaximal cycling exercise has a positive effect on the whole climate management, by reducing the temperature and by delaying the increase of the moisture (micro climate). The advantage of the ventilated backpack is shown in **Fig. 6**. Heated air from the micro climate can escape between the net and the main part of the backpack construction. This effect seems to be big enough to not only affect the thermal comfort (temperature and humidity perception), but also the performance (heart rate) of the cyclist.

The findings of the study are the base for the design of thermo-physiological optimized backpack systems. The study identifies the temperature profiles of the heating points on the back. This knowledge can be integrated in the 3D modeling process of backpack construction to optimize the climate management between the shirt of the cyclist and backpack (**Fig. 7**).

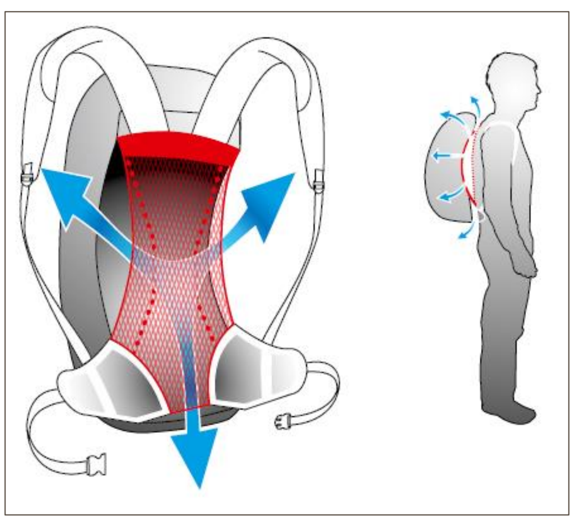

Fig. 6: VAUDE ventilated backpack system (Aeroflex)

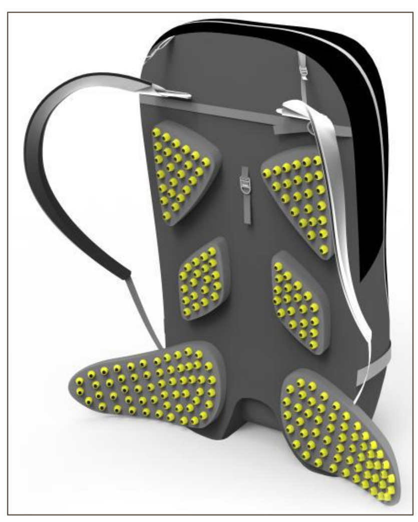

Fig. 7: CAD model of an optimized ventilated backpack system (student project at the OVGU Magdeburg)

References

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