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Thermal strain of fully encapsulating protective clothing: Neutral climate and different workloads

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Introduction

The highest level of personal protection against toxic gasses is offered by fully encapsulating personal protective clothing (PPC). This type of hazmat PPE is referred to EPA/OSHA Level A or NFPA 1991 (2005 ed) and Type 1a (1). This type of PPC provides excellent protection, but also poses high levels of thermal strain since water vapor (e.g., from sweat) cannot pass through the PPC. Because of the impermeability to water vapor the air in the microclimate between the skin and the PPC will saturate rapidly with water vapor. The goal of the present study is to get insight into the core temperature development as well as the sweat production for people wearing Type 1a PPC at different workloads at a neutral climate.

Methods

Eighteen participants divided into three conditions, all wearing Type 1a PPC. Difference among the conditions was the walking speed on a treadmill (all with a 1% slope): light, 2.5 km/h, moderate, 4 km/h, and high, 5.5 km/h. The measurement protocol is given in Table 1. The climate during the exercise phase was 23.3 ± 0.8 °C air temperature and 56.3 ± 4.6% relative humidity. Core temperature was measured using Jonah telemetric capsule in combination with the Equivital system. Weight loss was measured but taking the difference between the body mass before and after exercise (semi nude). In addition, the relative humidity of the microclimate was assessed on five locations.

Table 1: The measurement protocol.

	Habituation / equipping	Exercise
Time (min)	0 — 60	100
Intensity		Variable speed, 1% slope
Exercise mode		Treadmill
Thermal environment	T = 23.3 ± 0.8 ºC, RH = 56.3 ± 4.6%	
Body weigth assessment	x	x
RPE, Temp, Comfort	x x x x	
Type 1 hazmat suit and SCBA		

Results

For the light exercise all participants completed the maximum exercise time of 60 min. For the moderate workload two did not complete 60 min, and for the heavy workload only one participant completed the entire 60 min. Figure 1 gives the core temperature, showing strong differences in rate of increase among the different conditions. Sweat rates were 193 ± 38 g/m^2 h, 197 ± 46 g/m^2 h, and 279 ± 99 g/m^2 h, respectively. Microclimate relative humidity reached 85% after approximately 20 min.

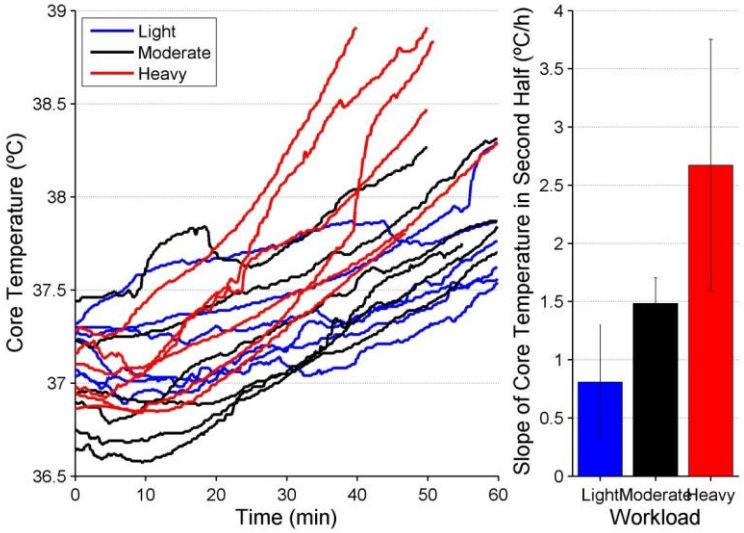

Figure 1: Core temperature during exercise for the different workloads as indicated.

Conclusions

The data indicates a clear effect of heat stress on the heat strain. The information allows for a more accurate prediction of safe-working-time for people using fully encapsulating personal protective clothing.

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References

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