

Protection of Face against Cooling while Using Powered Air Purifying Respirators in the Cold

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Respiratory Protective Devices (RPDs) in the Cold

- RPDs protect airways from airborne particles and gases
- RPDs are frequently used in several outdoor professions for example in mining, construction and industrial work
- Cold ambient temperature complicates the use of RPDs
 - Fogging and icing of goggles and visors
 - Moisture condensation inside the mask
 - Facial cooling

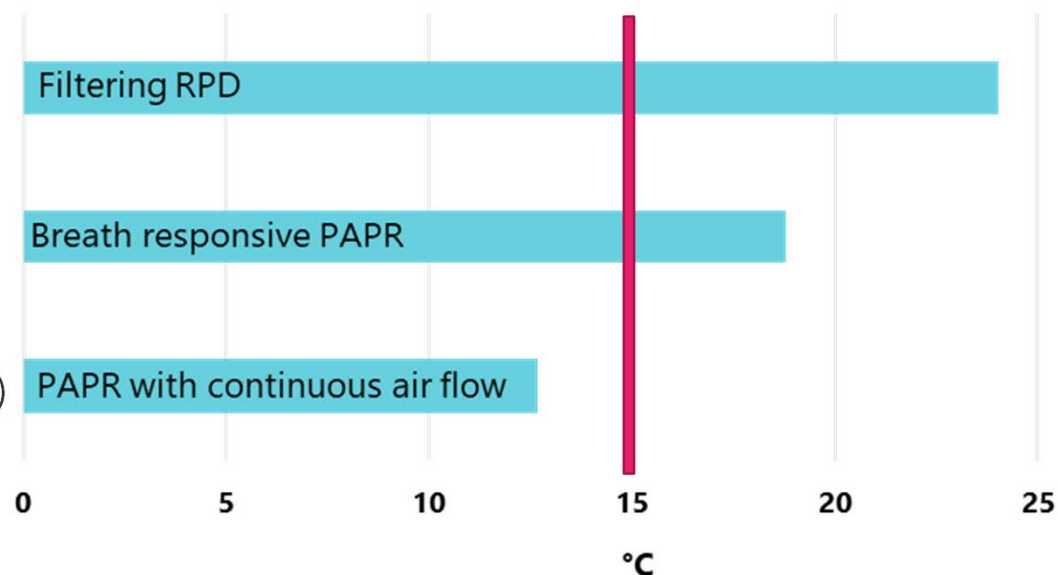


Facial cooling while using RPDs in the cold

- Non-powered respirators
 - Protect face from cooling
- Powered air purifying respirators (PAPRs)
 - Air flow in response to breathing rhythm
 - Continuous air flow
 - severe facial cooling (Mäkelä et al. 2019)
- Skin temperature decreament to lower than 15 °C is uncomfortable and even painful (Rissanen et al. 2017)

40min exposure at -20 °C, 10 subjects

Minimum mean face skin temperatures



Mean face skin temperature: average of forehead, cheek, nose and chin temperatures



Protection of face against cooling

- Aim of the study was to compare different facial cold protections used together with loose-fitting PAPR
- Facial cold protections
 - Merino wool balaclava (WO 75%, PP 22%, PA 3%)
 - Windproof balaclava (PES 96%, EL 4%)
 - FIOH Face Protection against Cold (own design)



Cold protection	Thickness (mm)	Air permeability (mm/s)	Thermal insulation (m ² K/W)
Merino wool balaclava	1.0	1202	0.089
Windproof balaclava	1.6	6	0.091
FIOH Face Protection against Cold	2.3	504	0.078

FIOH Face Protection against Cold

- Covers only the facial area
- Compatible with earmuffs
- Mouth exposed
 - no moisture condensation on the fabric
- Design: attachment to the headband of the helmet-integrated PAPR



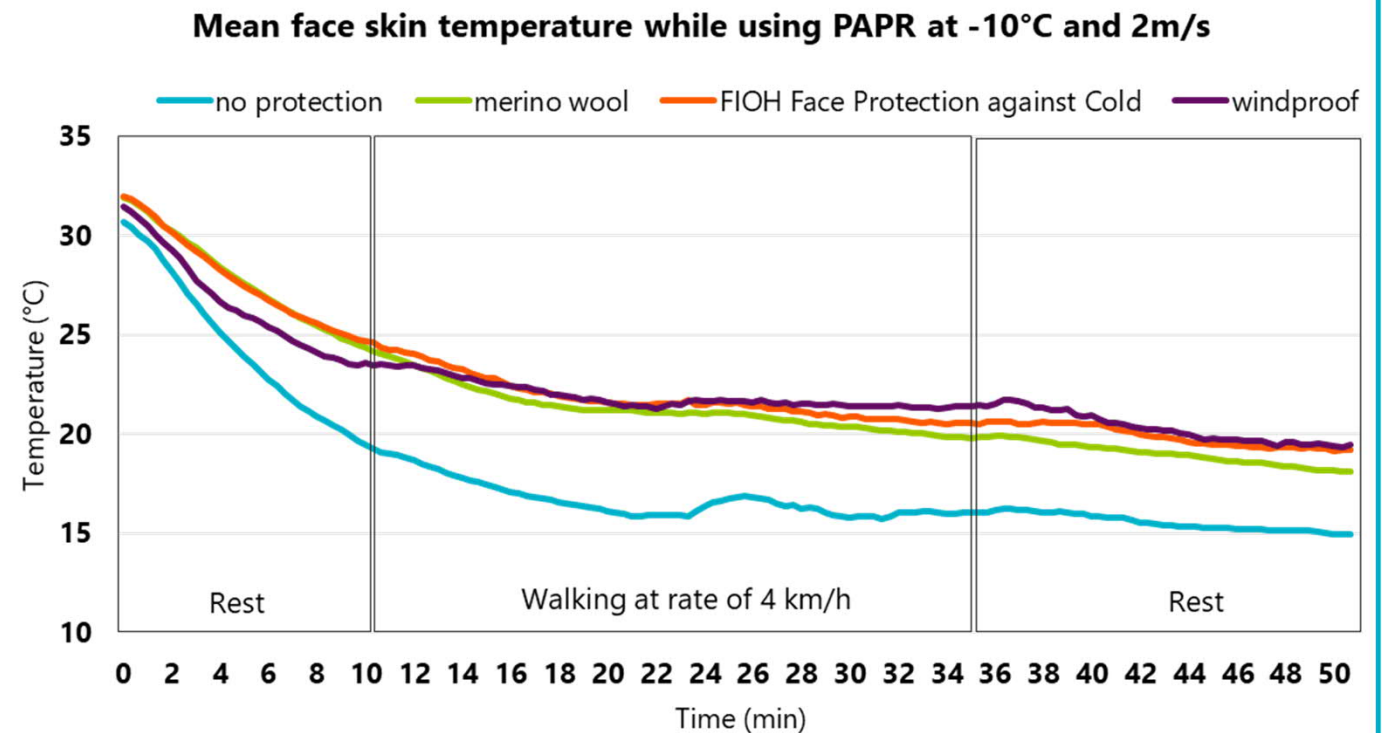
Methods

- 5 subjects (3 females, 2 males) wore PAPR integrated with a helmet at an ambient temperature of -10°C , wind speed 2 m/s
- 50-min trial consisted of 10min rest, 25min walking at 4 km/h, 15min rest
- Skin temperatures of forehead, cheek, nose and chin were measured
 - Mean face skin temperature (MFST) was calculated as the average of four skin temperatures
- Facial and whole-body thermal sensations were recorded at the beginning of test and at the end of each task



Results

- MFST lowered to
 - 14.95 ± 0.86 °C without protection
 - 18.09 ± 3.89 °C with merino wool balaclava
 - 19.43 ± 2.37 °C with windproof balaclava
 - 19.18 ± 1.25 °C with FIOH Face Protection
- MFST at the end of the test was ~ 4 °C higher while facial cold protection was worn compared to without protection
- Without protection face was perceived as "*cool*" or "*cold*"
- With cold protection face was "*slightly cold*" or "*neutral*"



Conclusions

- Facial cooling was severe while no protection was worn under the PAPR
- Cooling of the face was reduced while cold protection was worn under the facepiece of PAPR
 - Cold protection was at the same level regardless the tested thermal protections varied by design, thickness, air permeability and fabric content
 - Facial cold protections do not affect the protection efficiency of the respirator (Mäkelä et al. 2019)
- Facial cold protection can be used together with loose-fitting PAPRs
- Design of facial cold protection should be compatible with other PPE worn on the head area
 - Presented FIOH Face Protection against Cold is compatible with earmuffs



Thank you!

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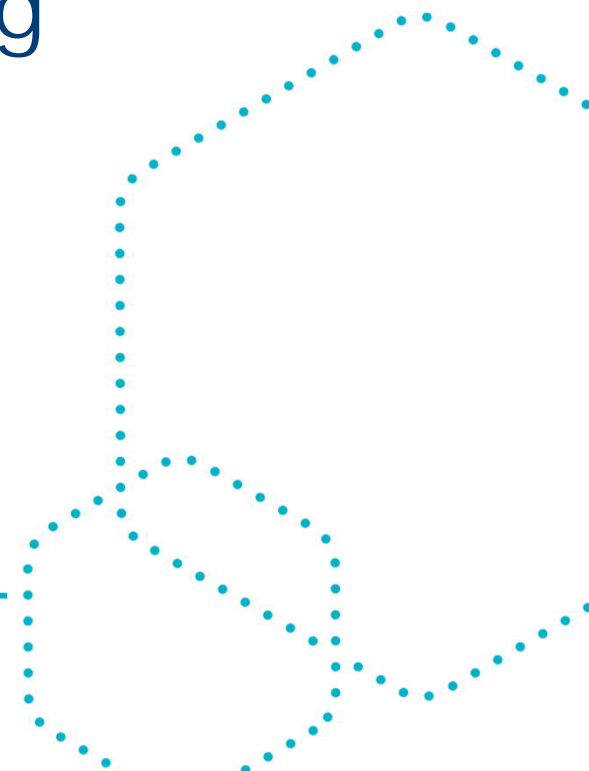
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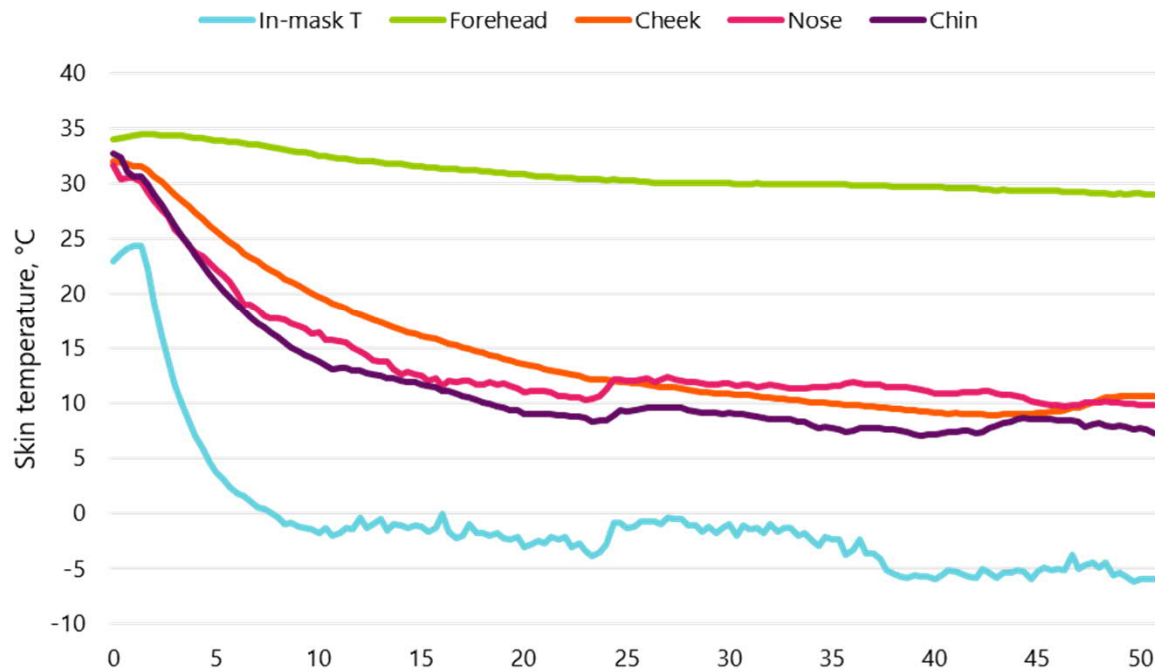
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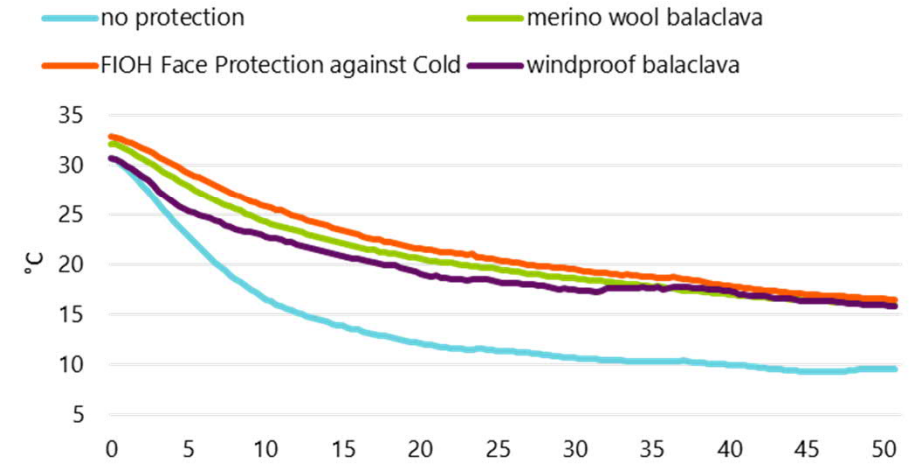
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1 subject, no facial cold protection, -10 °C, 2 m/s



Cheek (n=5)



Chin (n=5)

