

Effect of Base Layers on Physiological and Perceptual Responses to Exercise In Personal Protective Equipment (PPE)

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Background

- Firefighting involves strenuous work, often performed under hot and hostile conditions
- Firefighting results in significant physiological strains
- In the U.S. about 45% of deaths are due to sudden cardiac events.





Background

- Personal Protective Equipment (PPE) protects against the hazardous conditions
- However, PPE also adds to physiological and perceptual strain



New Technical Base Layers



- New Technical Base Layers have become available that claim to:
 - Reduce thermal strain
 - Improve wicking of moisture from skin
- Widely Used by Sports Participants
- Being deployed by Military as part of a total ensemble of PPE



“...the armor you need to withstand extreme temperatures and exposure to flames.”

- DRIFIRE



Purpose

- To compare physiological and perceptual responses to 4 different base layers worn under PPE during intermittent work and rest cycles.
- Hypothesis: New technical base layers will improve perceptual measures and decrease physiological strain during rest cycles.





Methods - Design

- Within subjects Repeated Measures Design
- On separate days, participants completed 4 experimental trials that involved alternating work rest cycles (20 min walk/recovery x3)





Methods - Design

- All trials were identical except for the base layer worn under the PPE

100% Cotton



Modacrylic



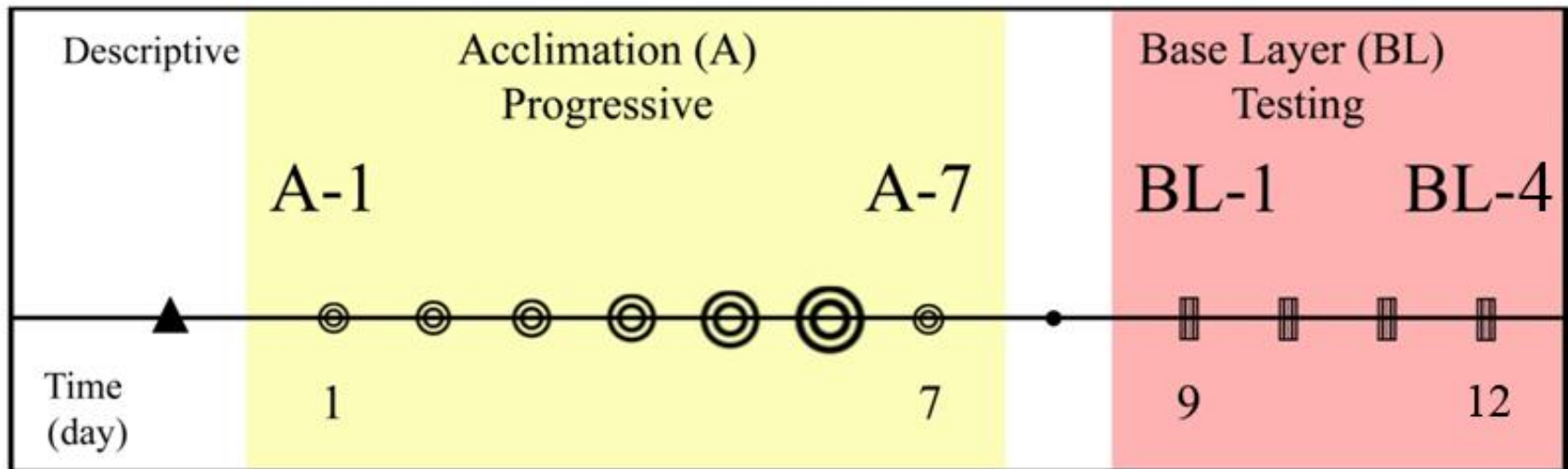
Wool Blend



Phase Change



Study Protocol

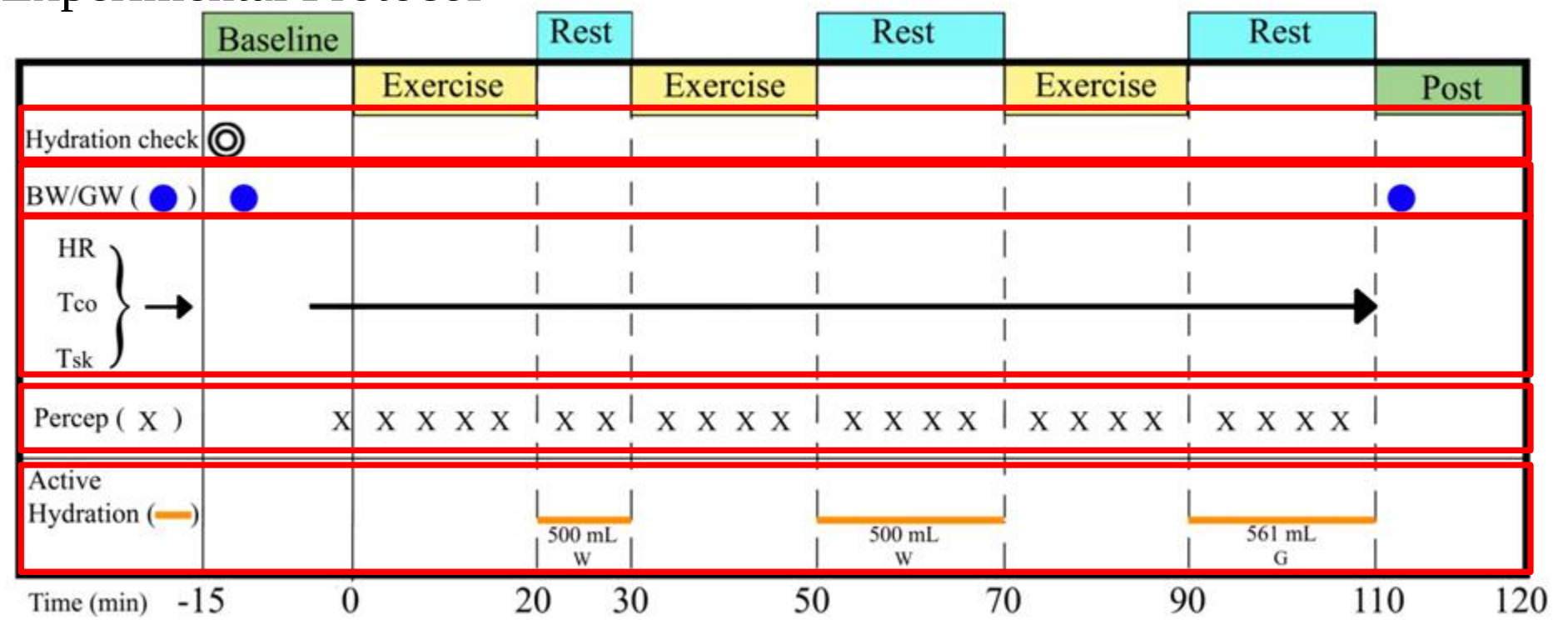


◎ Progressive Acclimation Protocol - Intermittent work/rest bouts

▲ Descriptive measures

▮ Workload constant each day. Base layer order randomized.

Experimental Protocol





Value	Description
1.0	COMFORTABLE
1.5	
2.0	SLIGHTLY UNCOMFORTABLE
2.5	
3.0	UNCOMFORTABLE
3.5	
4.0	VERY UNCOMFORTABLE
4.5	
5.0	EXTREMELY UNCOMFORTABLE

0.0	UNBEARABLY COLD
0.5	
1.0	VERY COLD
1.5	
2.0	COLD
2.5	
3.0	COOL
3.5	
4.0	COMFORTABLE
4.5	
5.0	WARM
5.5	
6.0	HOT
6.5	
7.0	VERY HOT
7.5	
8.0	UNBEARABLY HOT

10	SO TIRED, I CAN'T GO ANYMORE
9	
8	REALLY TIRED
7	
6	TIRED
5	
4	A LITTLE TIRED
3	
2	NOT TIRED AT ALL
1	





Methods

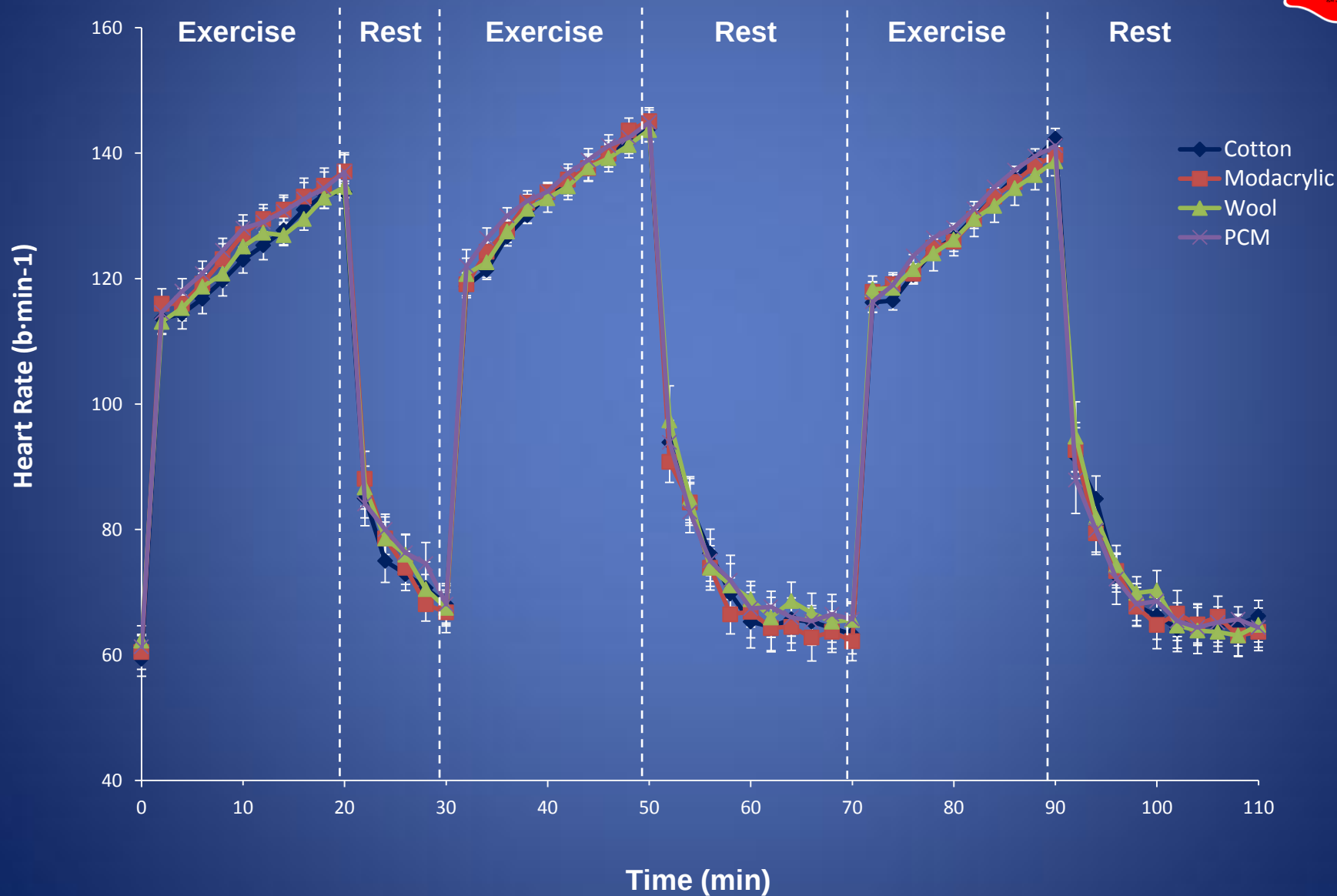
- 10 healthy, college-age male participants
 - Screened for cardiovascular risk factors
 - Highly-trained individuals

Table 1: Mean descriptive characteristics

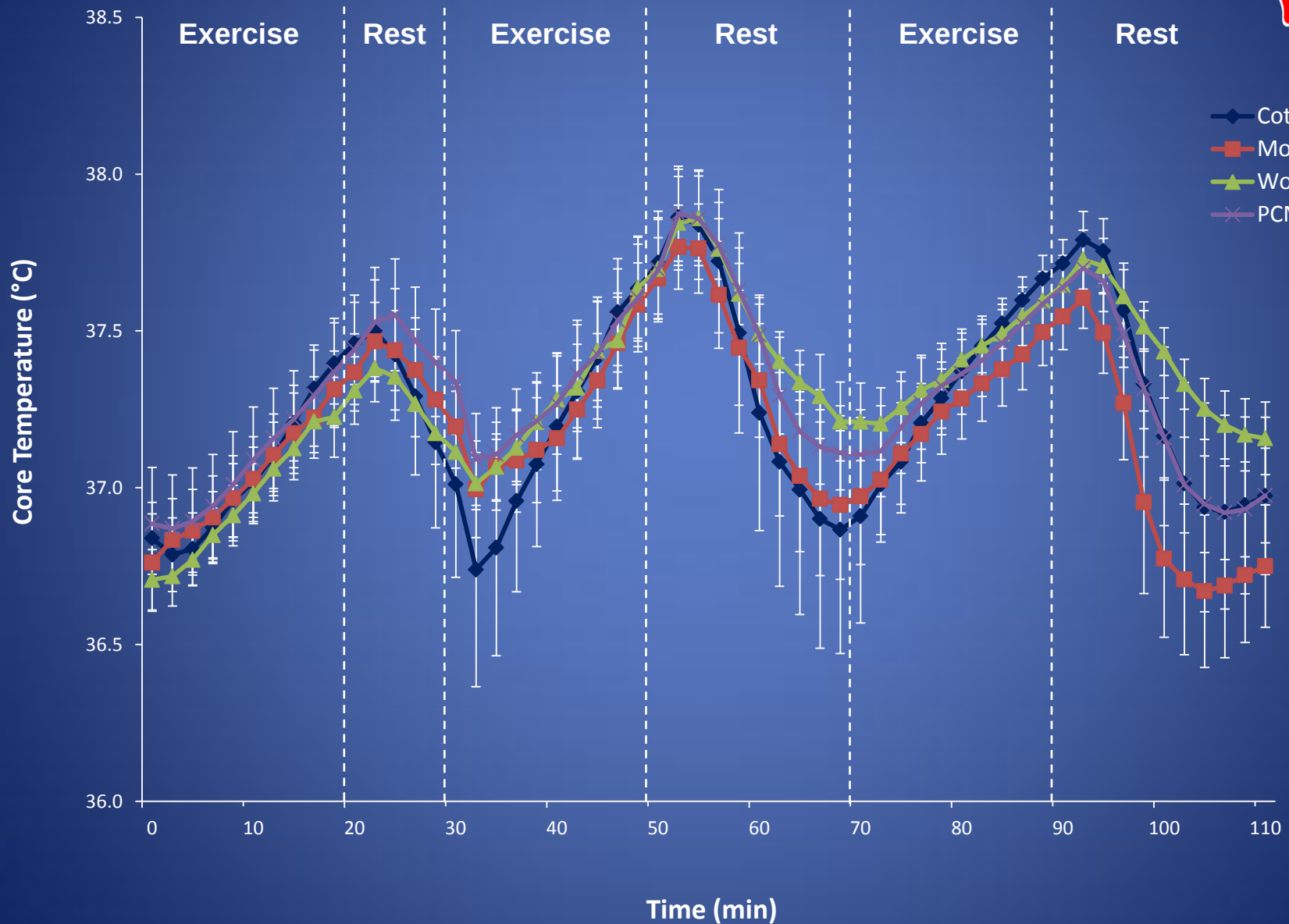
Age (yrs)	Height (cm)	Weight (kg)	VO ₂ max (ml·kg ⁻¹ ·min ⁻¹)	Resting HR (bpm)	body fat (%)
20.8 ± 0.8	174.1 ± 6.4	74.3 ± 7.4	58.9 ± 6.3	55.0 ± 6.0	15.8 ± 4.0



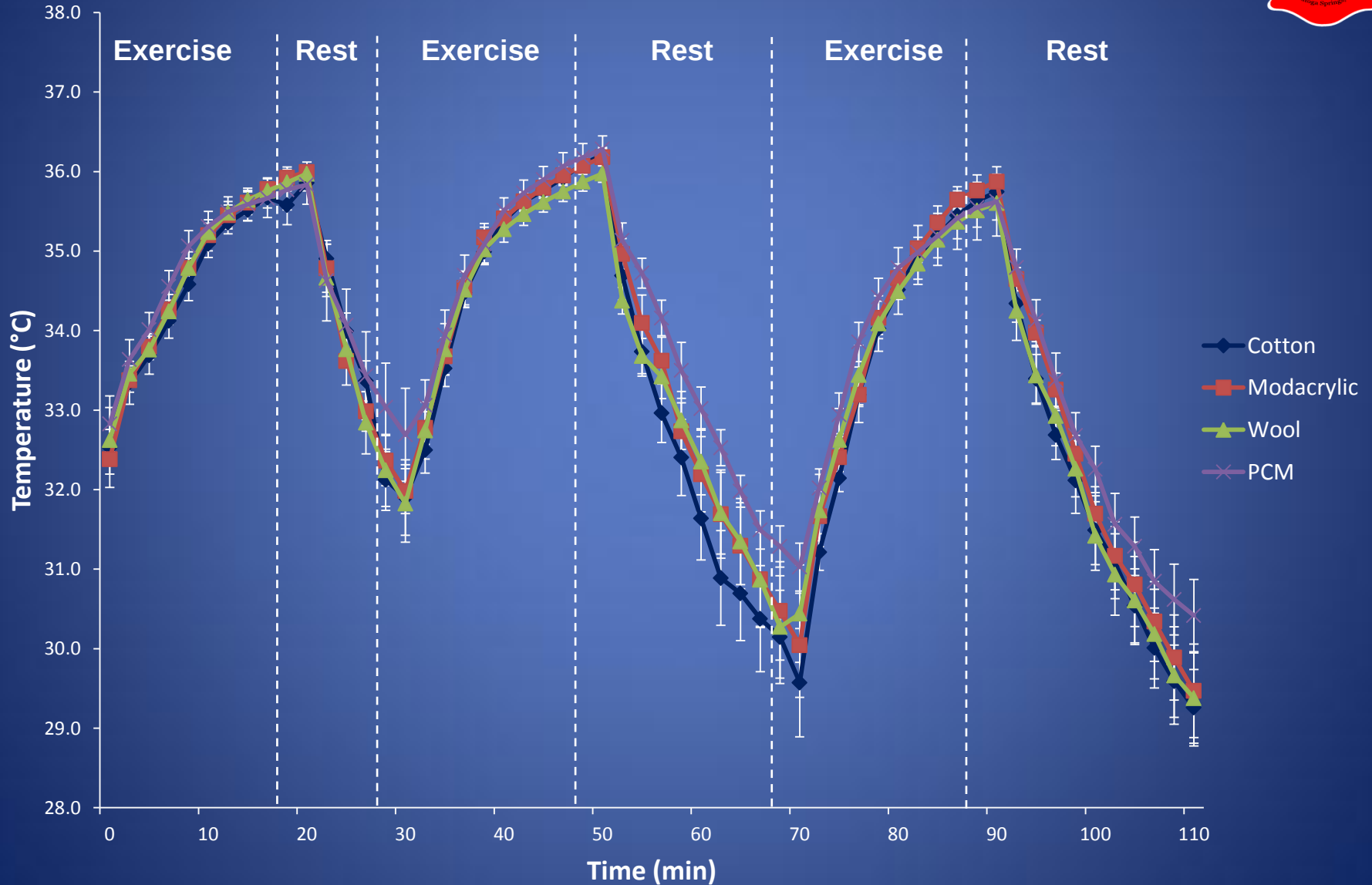
Results - HR



Core Temperature



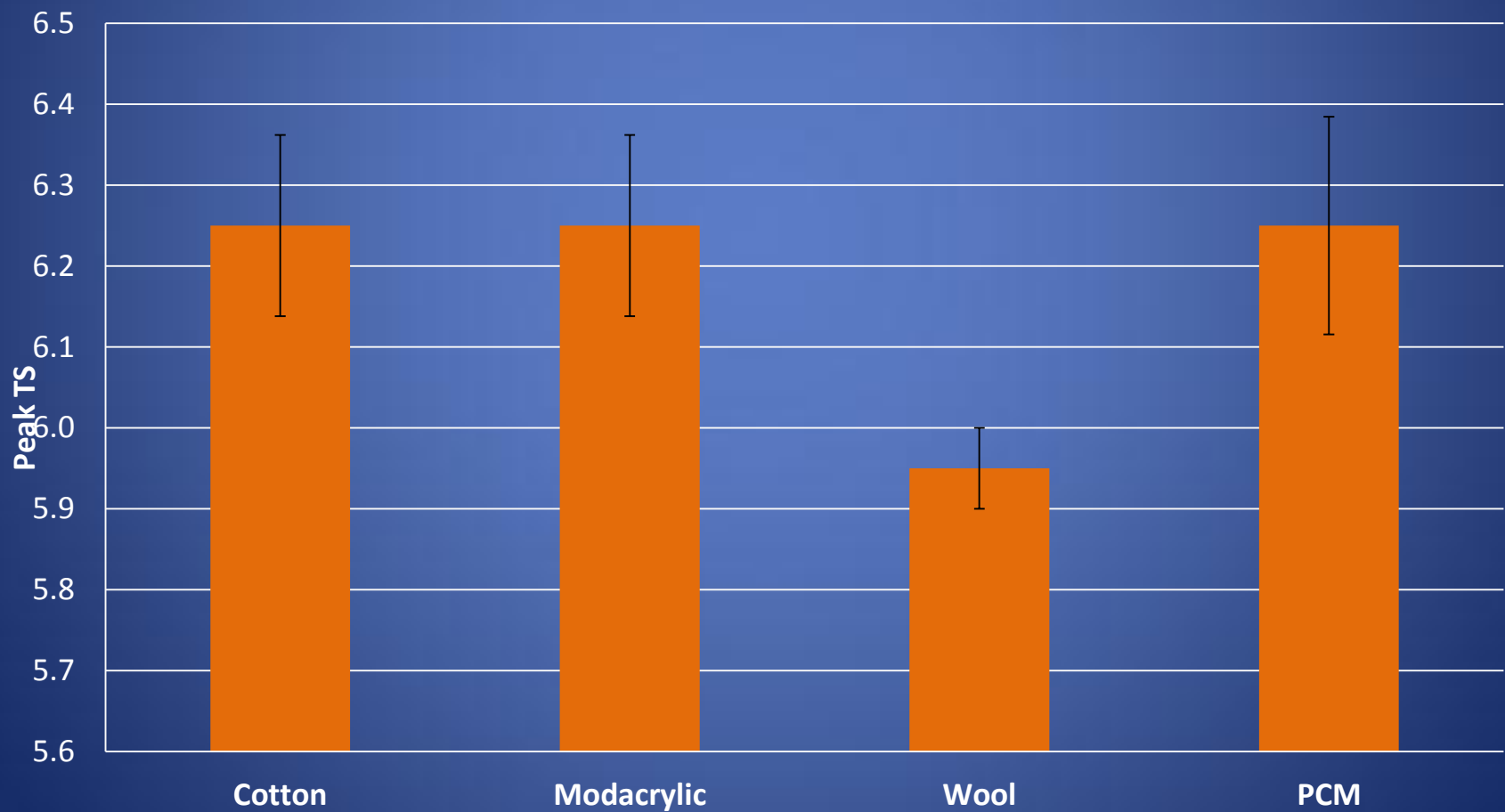
Chest Skin Temperature



THERMAL SENSATIONS

0.0	UNBEARABLY COLD
0.5	
1.0	VERY COLD
1.5	
2.0	COLD
2.5	
3.0	COOL
3.5	
4.0	COMFORTABLE
4.5	
5.0	WARM
5.5	
6.0	HOT
6.5	
7.0	VERY HOT
7.5	
8.0	UNBEARABLY HOT

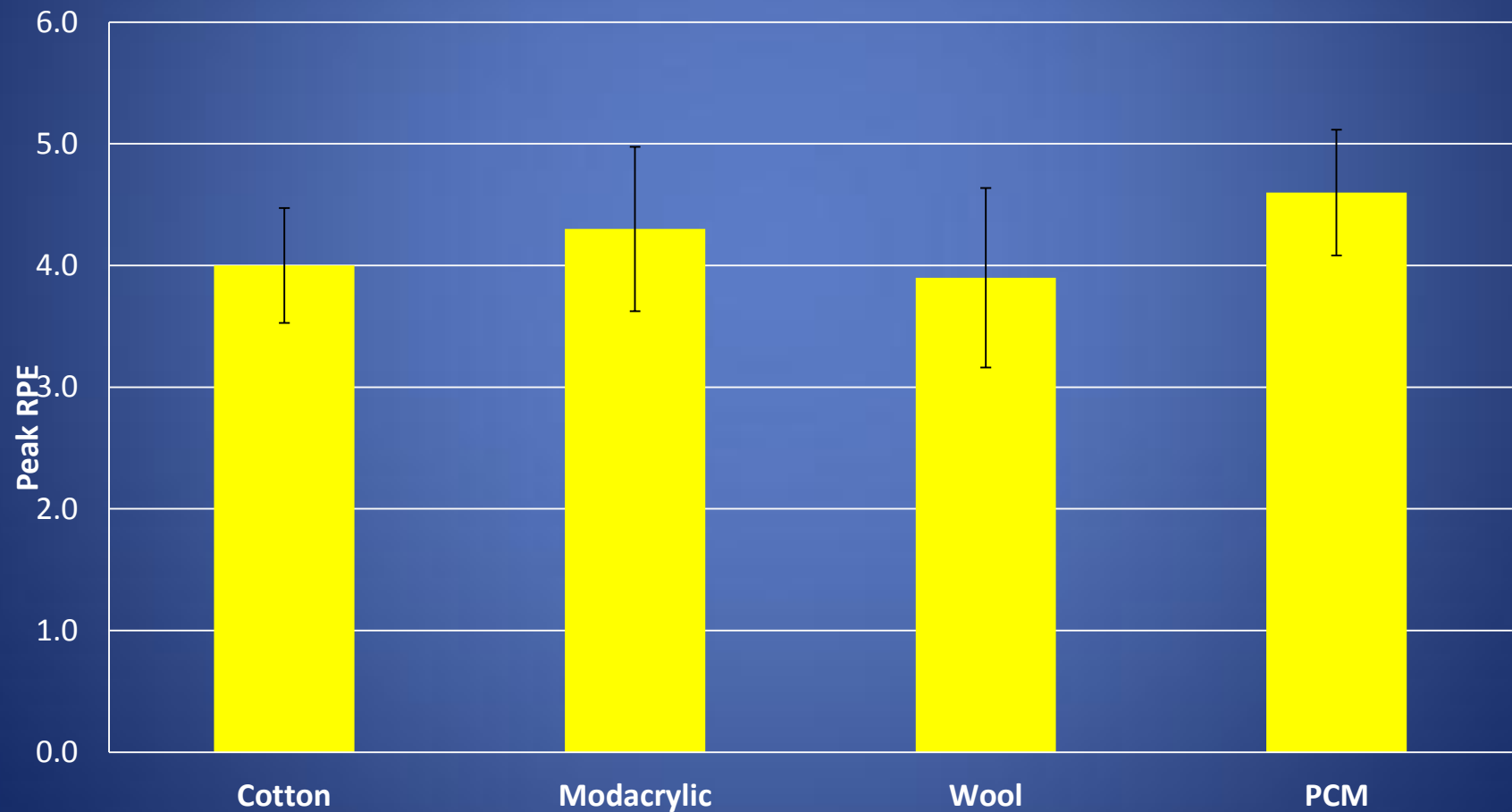
Peak Thermal Sensations



PERCEIVED EXERTION INDEX	
10	SO TIRED, I CAN'T GO ANYMORE
9	
8	REALLY TIRED
7	
6	TIRED
5	
4	A LITTLE TIRED
3	
2	NOT TIRED AT ALL
1	



Peak Rate of Perceived Exertion



Discussion



- Different base layer configurations did not provide any significant reduction in cardiovascular, thermal, or perceptual strain during the intermittent work/rest protocols.



Discussion



- Consistent with previous research on the use of base layers under firefighting gear, hazardous materials uniforms and military garments



Conclusion



- The choice of appropriate base layers for firefighters should consider the comfort of chosen material and the cost of the shirt.

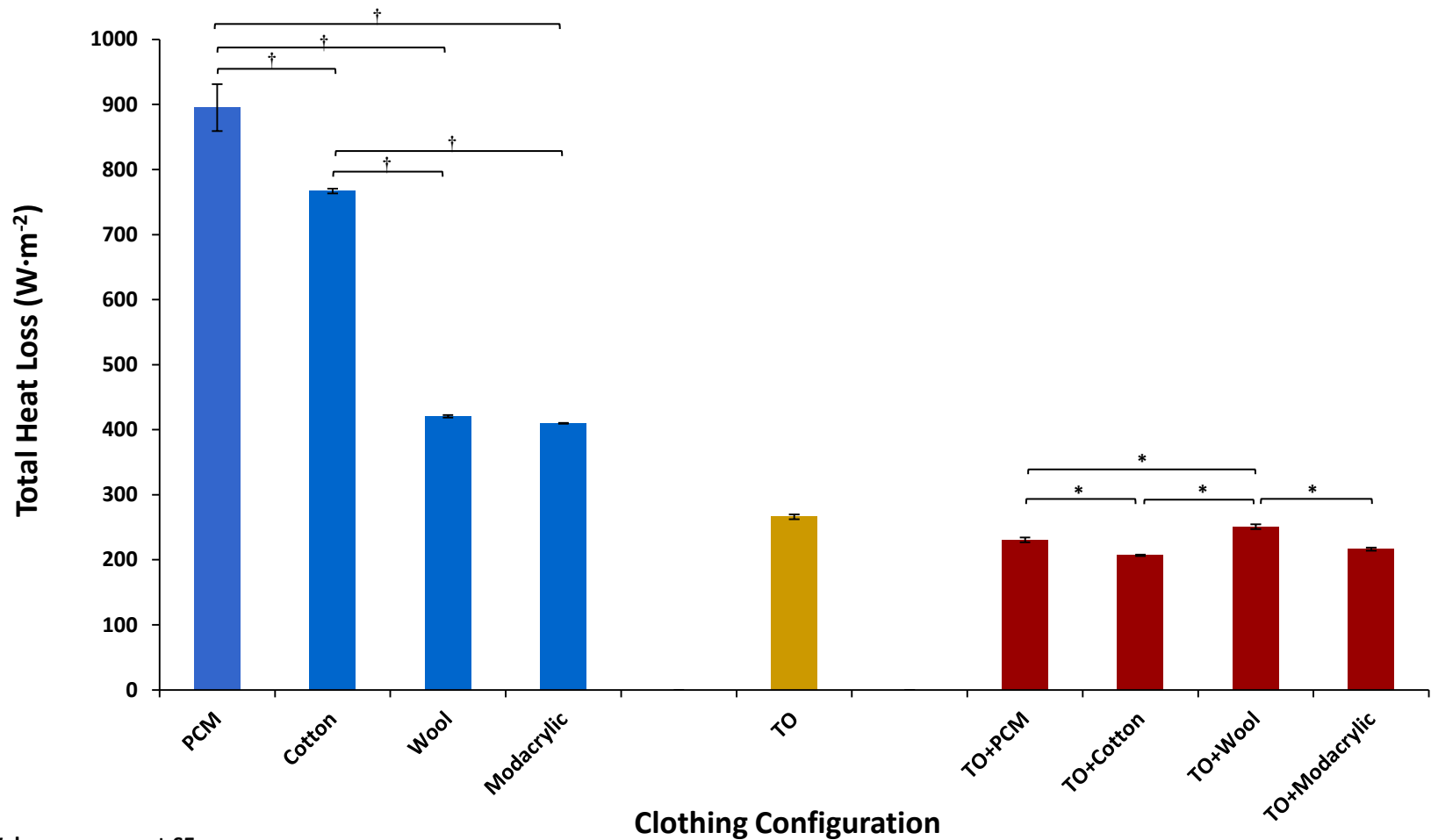


Acknowledgments



- Department of Homeland Security
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- Our research team
- Our participants
- Our colleagues



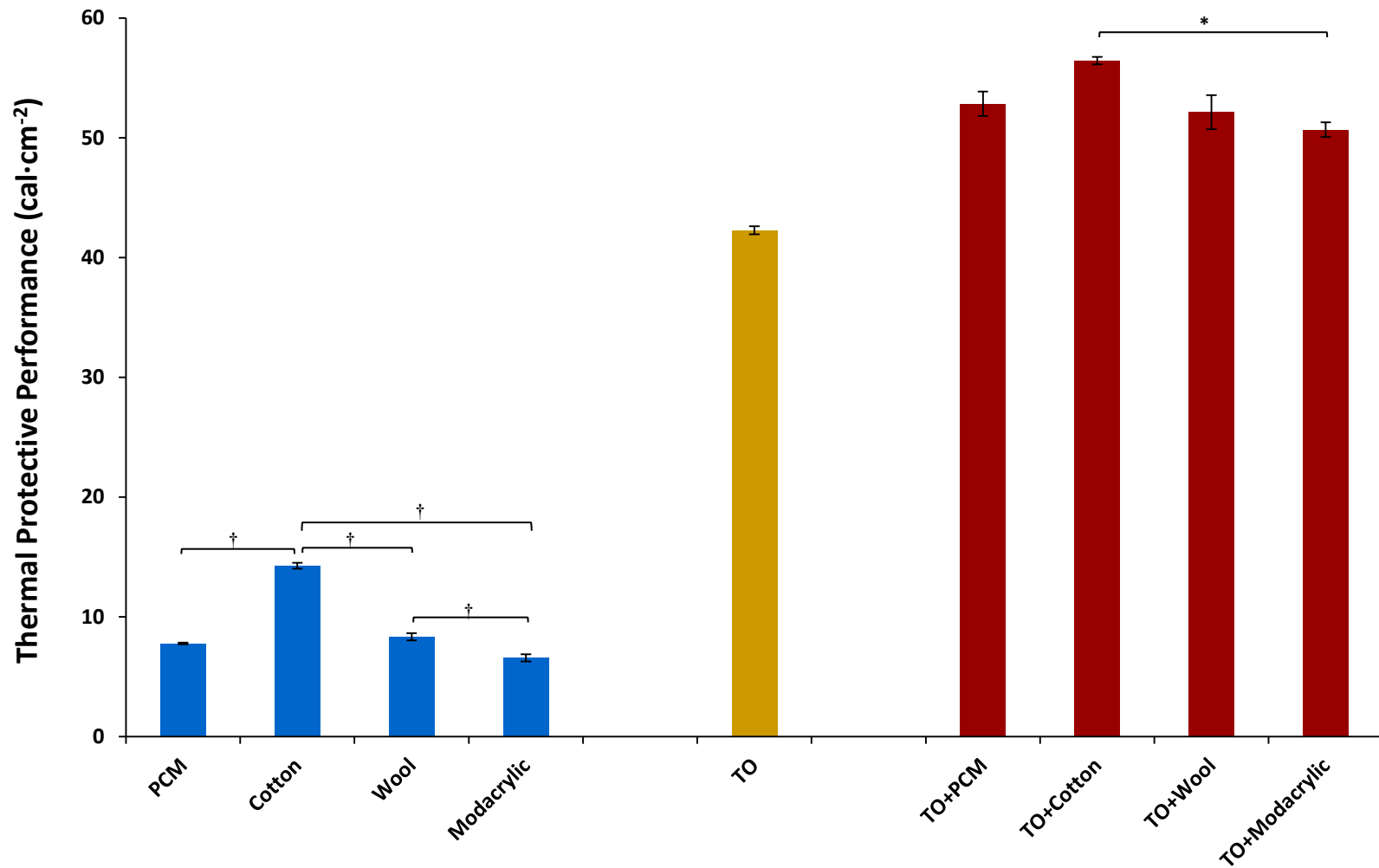


Values are mean $\pm$ SE

†P < .05, comparisons among the 4 base layers

*P < .05, comparisons among the 4 base layer plus TO configurations

PCM: phase change material; TO: turnout gear

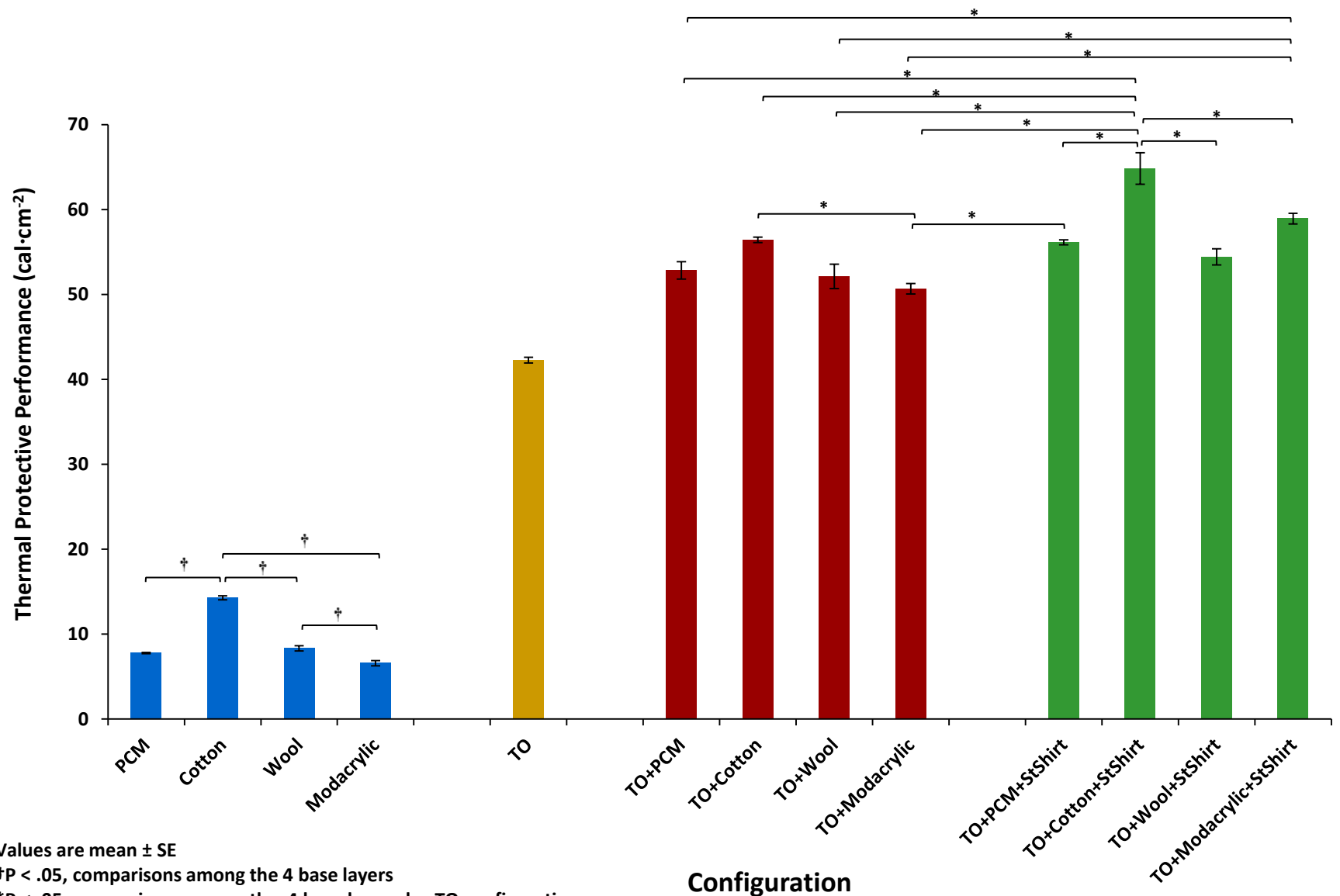


Values are mean $\pm$ SE

†P < .05, comparisons among the 4 base layers

*P < .05, comparisons among the 4 base layer plus TO configurations

PCM: phase change material; TO: turnout gear



Values are mean ± SE

†P < .05, comparisons among the 4 base layers

*P < .05, comparisons among the 4 base layer plus TO configurations

PCM: phase change material; TO: turnout gear

