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The effects of novel graphene-based heated garments on body temperature and peak power output post-warm-up

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INTRODUCTION:
Heated garments can attenuate the drop in muscle temperature often observed during 'heat loss windows' prior to competition (1). However, these garments traditionally use wire heater elements, which are limited by an inability to generate heat uniformly. A printed graphene-based solution enables more uniform heating over larger areas and avoids local hot spots (2). This study aimed to quantify the technical performance of garments containing graphene-based heaters, and the effects of the use of these garments on lower-body peak power output (PPO) following a simulated post-warm up 'heat loss window'.
METHODS:
Firstly, in off-person testing, the graphene-based garments were hung inside out whilst images of the heater panels were captured using a thermal imaging camera. Time to reach target temperature, mean temperature, battery life, and rate of temperature decline over battery life were quantified. These were compared to two wire heater-based commercially available garments. Secondly, the graphene-based garments were worn by six participants resting in a controlled 20°C environment for 15-min to assess the effects on body surface temperature using thermal imaging immediately after their removal. Finally, nine participants completed a standardised cycling warm-up, followed by 30-min passive rest in cold (5°C) and temperate (20°C) environments with the graphene-based garment heating either enabled or disabled (i.e. four trials in total). PPO during counter-movement jumps was assessed at various times pre and post warm-up.
RESULTS:
In the off-person testing, the trousers and jacket took 4.4-min and 10.6-min to reach target temperature, respectively. The mean temperature across all panels was 47.0°C (trousers) and 42.7°C (jacket). On full power, the batteries lasted for 2.49-h (trousers) and 3.22-h (jacket), with a temperature decline of 0.6 and 1.2°C/h, respectively. When activated, the garments led to an increase in body surface temperature in all heated regions after just 15-min. Post warm-up, compared to an inactivated worn garment, the activated garments significantly increased skin temperature, thermal comfort and thermal sensation in both cold and temperate conditions (all $p < 0.05$). Core temperature was raised but not significantly at any measured timepoint. When the garments were activated, PPO was 57 W (1.6%) to 145 W (3.9%) greater in the 30-min post warm-up, and this difference was significant in the cold environment after 30-min.
CONCLUSION:
Graphene-based heaters integrated into competition-ready garments provided greater heat output than commercial wire-heater garments. The graphene-based garments increased body surface and skin temperature, and attenuated the reduction in PPO during the 30-min post warm-up. Further consideration of garment control and design could improve the practicality and performance further.

1. Faulkner et al., Med. Sci. Sports Exerc., 2013
2. Claypole et al., J. Coat. Technol. Res., 2022

Topic: **Sport Technology**

Presentation **Oral**