講演番号 113

Effects of Regional Airflow from a Fan-Integrated Car Seat on Thermoregulatory Responses and Thermal Comfort under a Comparable Resting Skin-Temperature Environment

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KEY WORDS: **human engineering, driver condition, physiological measurement, air conditioning, comfort** [C2]

To reduce energy consumption in vehicles while maintaining in-car thermal comfort, personal cooling systems may provide a potential solution. Conventional automotive air conditioning systems (AC) that cool the entire cabin increases fuel consumption, with fuel economy reported to decrease by approximately 5–50%. A recent study showed that the airflow from fan-integrated car seats significantly improved thermal comfort in a 30°C environment. However, this ambient temperature is lower than the typical resting skin temperature in humans, suggesting that convective heat loss may have substantially contributed to the observed improvement. Under condition where ambient temperature approaches skin temperature, the effectiveness of convective heat loss is reduced. Therefore, it remains unclear whether providing airflow in an ambient temperature comparable to resting skin temperature improves thermal comfort and attenuate core temperature elevation. The present study aimed to investigate whether airflow from a fan-integrated car seat in an ambient temperature comparable to resting skin temperature, improves thermal comfort and attenuate core temperature elevation following walking in the heat.

Twelve healthy young males walked on a treadmill at 5 km/h for 10 min, followed by 20 min of seated rest on a fan-integrated car seat under four conditions in a controlled environment (33°C, ~60% relative humidity): airflow from the backrest only (BACK), airflow from the seat cushion only (CUSHION), airflow from both the backrest and seat cushion (BOTH), or no airflow (CON). A Latin square design was used to minimize order effects.

Rectal temperature changed significantly during the 20-min cooling period within all conditions ($p \leq 0.03$); however, the magnitude of increase was small (approximately 0.1°C). In contrast, mean skin temperature significantly decreased from 10 min of cooling in the BACK and BOTH conditions ($p \leq 0.05$), whereas it remained unchanged in the CON and CUSHION conditions throughout the cooling period ($p \geq 0.06$). These results suggest that airflow at ~33°C is insufficient to reduce rectal temperature, whereas it effectively lowers mean skin temperature during the early phase of cooling.

For subjective perceptions of whole-body thermal sensation (Fig. 1A) and thermal comfort (Fig. 1B), whole-body thermal sensation in the BACK, CUSHION, and BOTH conditions showed significantly lower values compared to the CON condition immediately after the onset of cooling. However, in BOTH and BACK conditions, those values gradually drifted back towards "neutral (0)" in the latter half of the cooling period. For whole-body thermal comfort (Fig. 1B), values in the BOTH, BACK, and CUSHION conditions were significantly higher than those in the CON condition immediately after the onset of cooling, whereas values in all conditions tended to return toward neutral (0) over time.

These findings suggest that airflow from a fan-integrated car seat at ~33°C primarily enhances thermal comfort through transient reductions in skin temperature, although its effect on core temperature is limited. Therefore, such systems may be most effective when applied during the initial phase of cooling or with appropriate control strategies to sustain perceptual benefits, with airflow from the backrest specifically contributing to improved comfort.

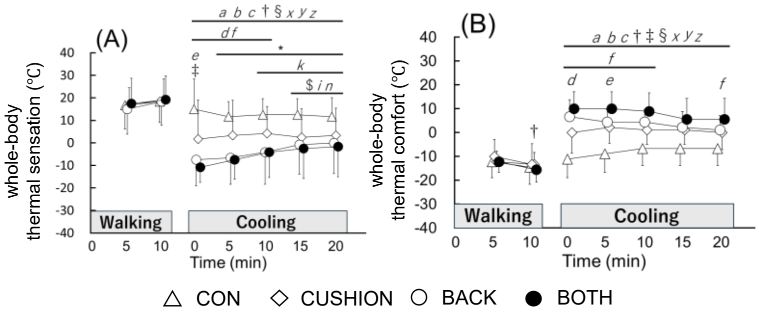

Fig.1 Changes in whole-body thermal sensation (A) and whole-body thermal comfort (B) during the experiment. *a–f* indicate $p<0.05$ for comparisons between CON and BACK, CON and CUSHION, CON and BOTH, BACK and CUSHION, BACK and BOTH, and CUSHION and BOTH, respectively. †, ‡, § indicate $p<0.05$ vs. BACK, CUSHION, and BOTH, respectively, at Walk 5 min. *x*, *y*, *z* indicate $p<0.05$ vs. BACK, CUSHION, and BOTH, respectively, at Walk 10 min. $, * indicate $p<0.05$ vs. BACK and BOTH, respectively, at Cooling 0 min. i indicates $p < 0.05$ vs. BACK at Cooling 5 min. n indicates $p < 0.05$ vs. BACK at Cooling 10 min.