The Effects of Direct Airflow of Wall-Mounted Air Conditioner on the Thermal Sensation of the Body by Using the Equivalent Temperature Analysis

Objective

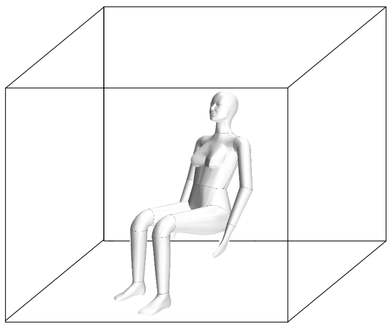
This research is focusing on evaluating thermal environments of air conditioned rooms based on equivalent temperature and identifying the effect of this controlling method.

Equivalent temperature

Calculating the equivalent temperature of real environment, the total heat transfer coefficient should be derived from a uniform standard environment. The total heat transfer between skin temperature and environments can be expressed by convective heat transfer coefficient and radiative heat transfer coefficient.

t_r: Radiative temperature t_a : Air temperature
t_{eq}: Equivalent temperature
t_s: Skin temperature in a standard environment
$t_{s,a}$: Skin temperature in a real environment
q_t: Heat flux rate $[W/m^2]$
h_r: Radiative heat transfer coefficient $[W/m^2 \cdot K]$
h_c: Convective heat transfer

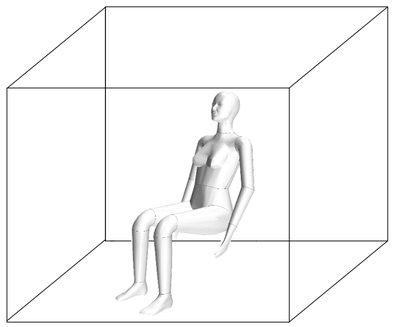
$t_r = t_a = t_{eq}$
$v \approx 0$



Standard environment

同一
熱損失
q_t
=

$t_r \neq t_a$
$v \neq 0$

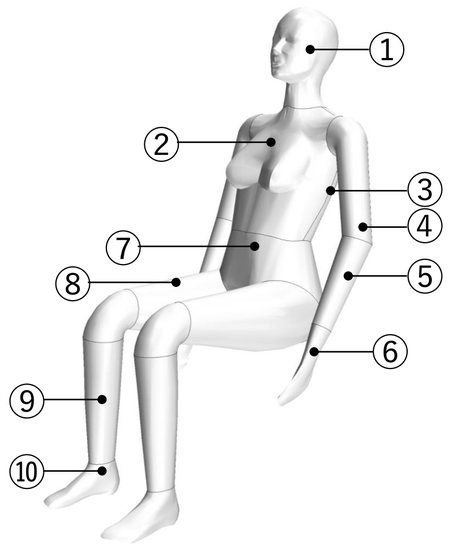


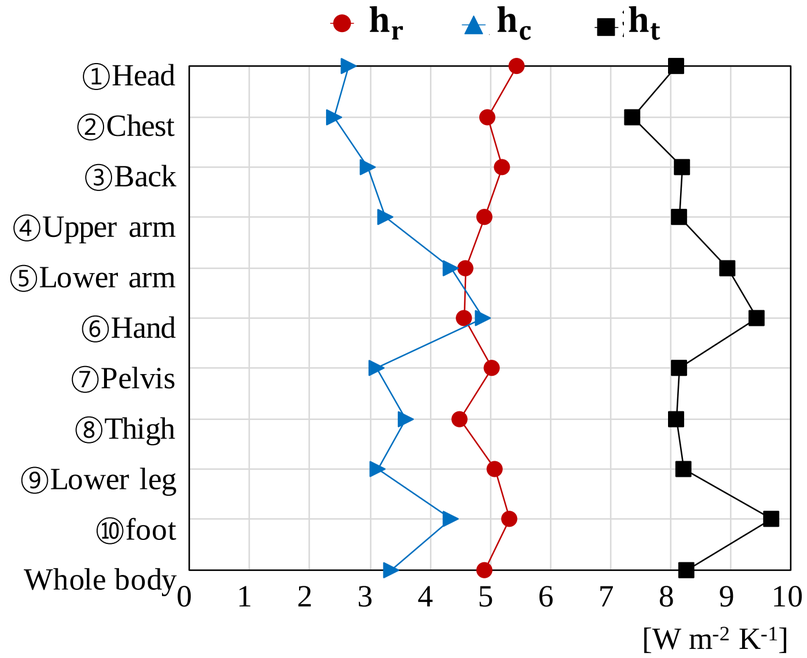
Real environment

$$q_t = h_r(t_s - t_r) + h_c(t_s - t_a)$$
$$q_t = h_t(t_s - t_o)$$

$$q_t = h_t(t_{s,a} - t_{eq})$$

$$t_{eq} = t_{s,a} - \frac{q_t}{h_t}$$





Radiative and convective coefficients of each parts in a standard environment.(24℃)

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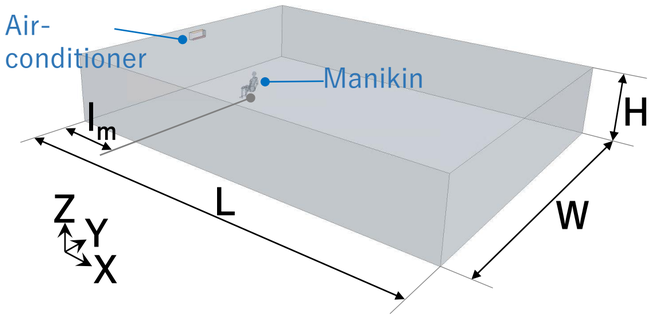
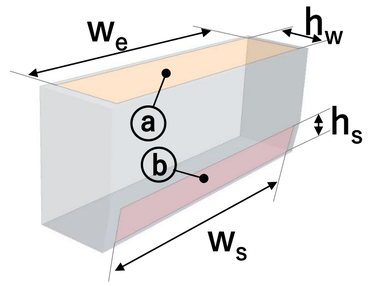
Air-conditioned room

Air flow speed becomes slow according to increase in distance from the inlet openings and the air speed rapidly decreases as it passed the penetration length. Therefore, the dimensionless ratio L/H is considered 6 to reduce the effects of return air flows. The Reynolds number is same as Re=5740 based on the inlet length h for the 1 to 4 simulation cases.





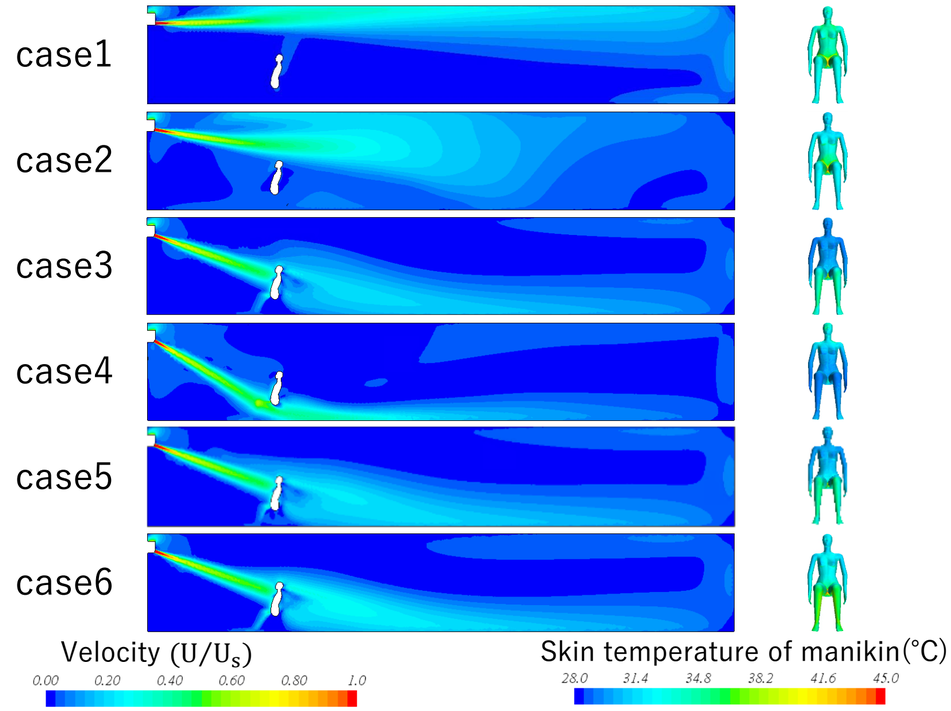
Boundary condition

Room	W × L × H=11.75m × 15.0m × 2.5m W/H=4.7, L/H=6.0
Inlet	Velocity(U_s), Temperature(T_s) h_s/H=0.032, w_s/W=0.063
Outlet	Pressure outlet(P_e=0), h_e/W=0.068, w_e/W=0.063
Wall	Temperature(T_w=28°C)
Manikin	Heat flux(h_t=69.6W/m²), emissivity=0.95, l_m/L=0.2

Additional boundary conditions for each simulation case

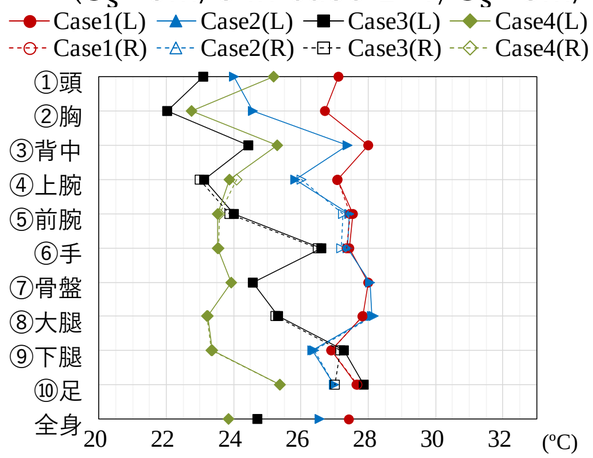
case	1	2	3	4	5	6
Velocity, U_s [m/s]	5	5	5	5	3	1
Angle, [degree]	0	-10	-20	-30	-20	-20
Temperature, T_s [°C]	28	28	28	28	28	28
Wall temperature, T_w [°C]	28	28	28	28	28	28

Simulation results

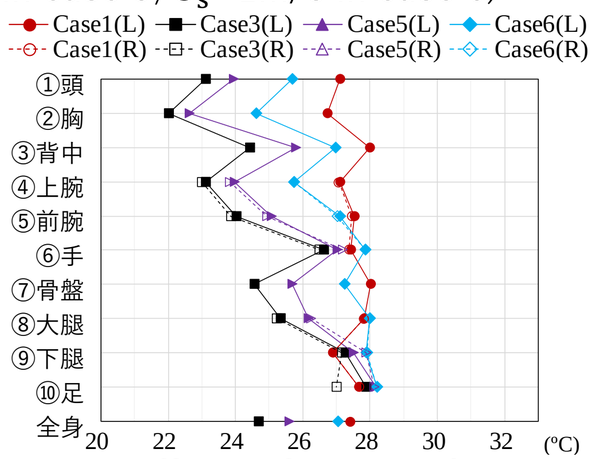


Distribution of U/U_son air flow rate changes in a section view of room center and body temperature on the surface of the manikin

(U_s=5m/s in case 1–4, U_s=3m/s in case 5, U_s=1m/s in case 6)



Effects of Air flow direction



Effects of Air speed

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