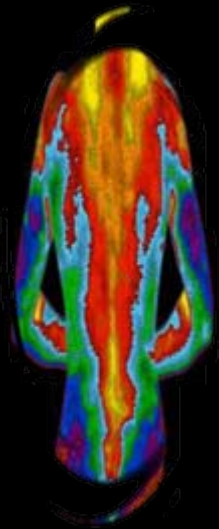


# DOES ERGONOMIC CHAIR DESIGN AFFECT THERMAL COMFORT?

Alan Hedge<sup>1</sup>, Masaya Saito<sup>2</sup> and Jason Jagdeo<sup>1</sup>

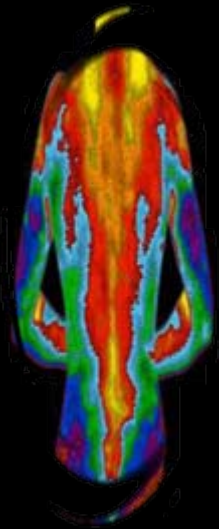
<sup>1</sup> Cornell University, Dept. Design & Environmental Analysis,  
Ithaca, NY 14853.

<sup>2</sup> Built-Environmental Science, Sapporo School of The Arts,  
Geijutsu-no-mori 1, Minamiku, Sapporo 005-0864, Japan



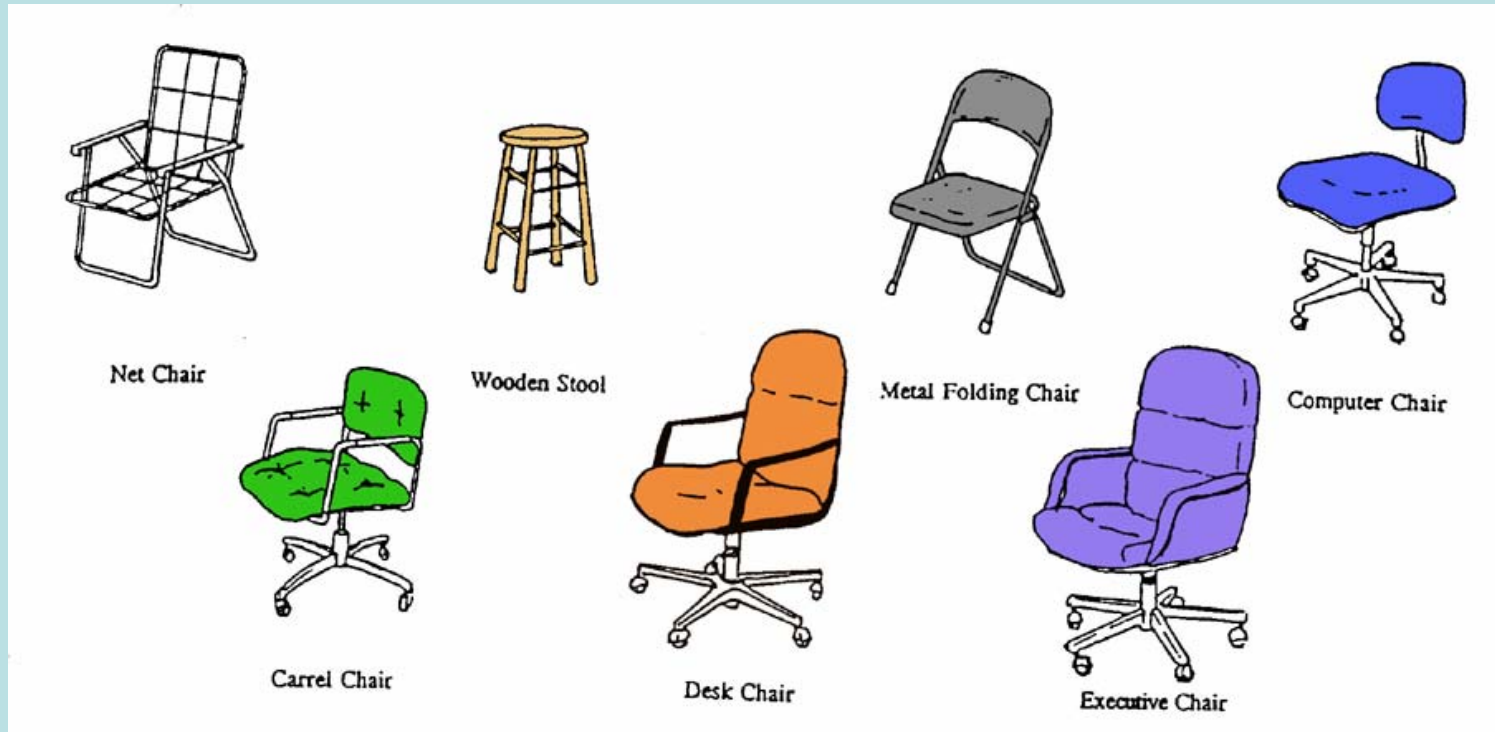
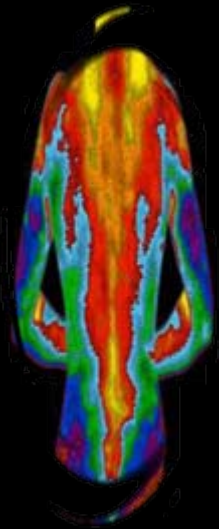
# Acknowledgements

- Cornell NYS College of Human Ecology for funding support
- Humanscale (for special Freedom gel chair); Herman Miller (for Aeron chair); Steelcase (for Leap chair)
- Participants
- This research project was reviewed and approved by the Cornell University Committee on Human Subjects.



# Thermal Insulation of Chairs

- McCullough et al. (1994) tested the insulation value for 7 chairs. Value ranged between 0.1 – 0.3 clo for chairs with solid seats and backs.



# Foam vs. Mesh Chairs

- Foam seat and back padding can raise skin temperature and impede moisture movement compared with more porous fabric (Herman Miller, 2003).
- An upholstered chair can insulate up to 25% body surface area which can add up to \$290 per worker in HVAC costs required to maintain thermal comfort (Houghten et al., 1992).

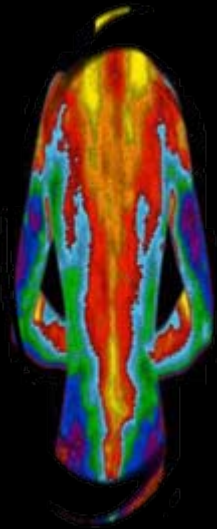
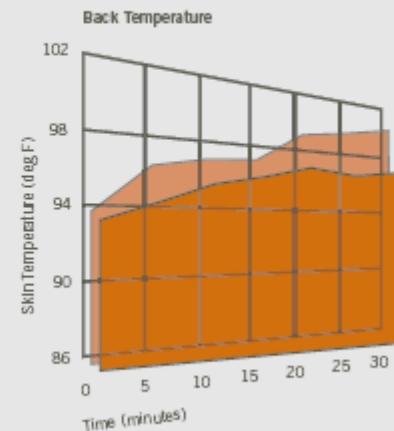
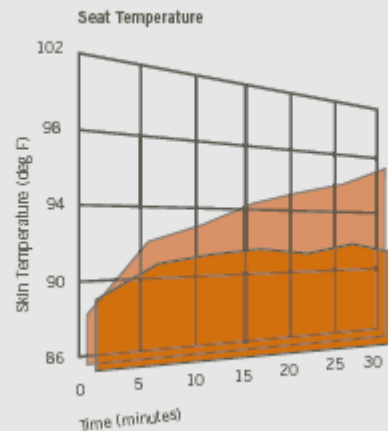
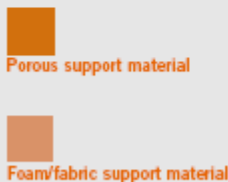


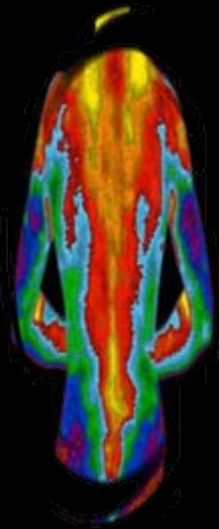
Figure 1

With porous material, seated skin temperature remains essentially constant. With foam, seated skin temperature rises.



# Gel Seating

- New gel seating technologies can be used to create a cool sensation by conducting heat from the body.
- Gel is starting to be used in office seating.



**R&R Cold / Hot Gel Cushion**  
*STAY COOL AND COMFORTABLE*

**Features:**

- Prevent pressure ulcers.
- Provide pressure relief and sitting comfort.
- Provide long and lasting relaxation.
- Distribute pressure around the hip
- Minimizing heat
- Multi-Function for Cold / Hot Therapy
- Lightweight for easier transport
- Easy clean.

# Research Questions

- How is human thermal comfort and computer work performance affected by sitting on each of three different chair designs:

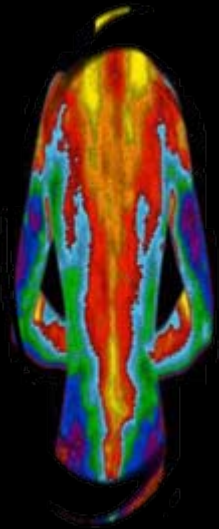
Foam chair  
(Leap)



Mesh chair  
(Aeron)

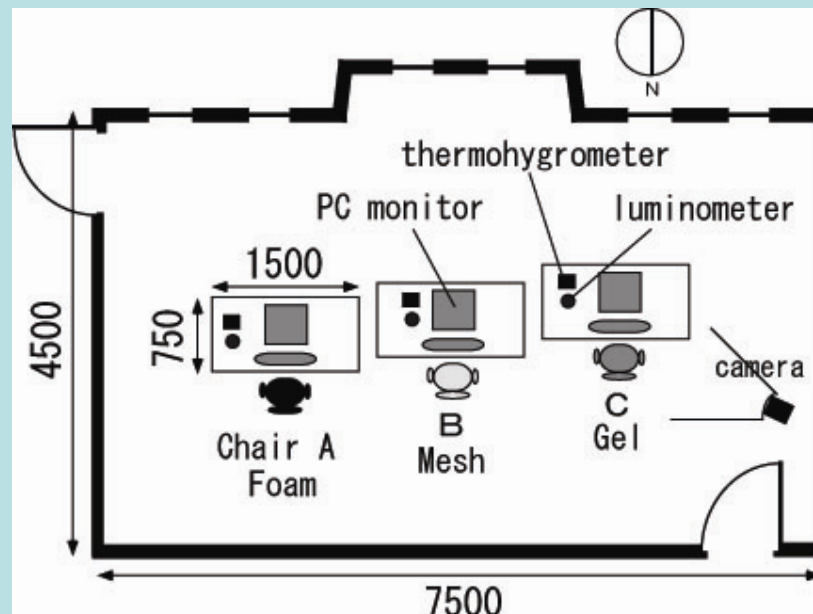
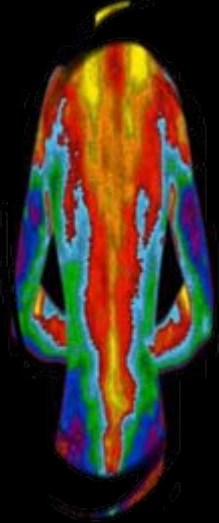


Gel chair  
(modified Freedom)



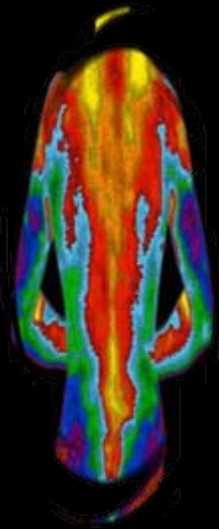
# Experimental Design

- An independent groups design.
- 36 normal healthy Ss (18 men and 18 women students) were tested in same-sex groups of 3. Testing occurred in the Cornell Human Factors and Ergonomics Laboratory.



# Procedure

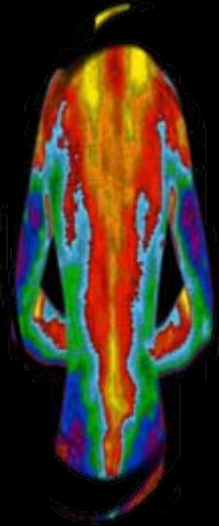
- 30 minute acclimation in lab. where environmental conditions, held constant at  $22.4^{\circ}\text{C} + 0.1^{\circ}\text{C}$  and  $21.1\% + 1.0\%$  relative humidity (logged throughout). Run in Feb. 2004.
- Ss sat in same gender triads on one of the chairs for a 1.5 hours session (4 x 20 minutes typing tasks - Ss were able to stand during each of 3 brief breaks between these tasks to minimize any fatigue).
- Ss were randomly allocated to test conditions.
- Ss were tested in mornings or afternoons and the time-of-day factor was statistically analyzed.





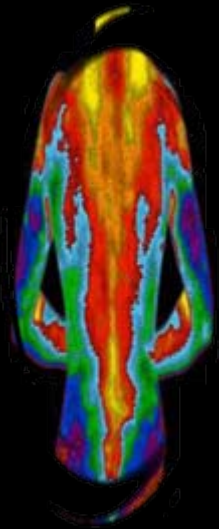
# Measures

- Thermal comfort vote (+3=hot; +2=warm; +1=slightly warm; 0=neutral; -1=slightly cool; -2=cool; -3=cold).
- Skin temperature was measured at the four Ramanathan points (front of chest, upper arm, thigh and lower leg) using IR thermometer.
- Core temperature measured with IR ear thermometer.
- Ratings of thermal, lighting, air quality and acoustic conditions and level of comfort, stress and arousal were made after each typing trial.
- Ss were videotaped from the right-hand side to record body movements over the duration of the study (movements generate heat and can decouple the body from the insulation of the chair).



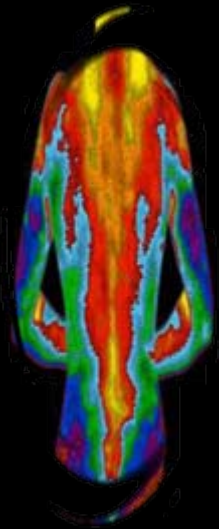
# Results: Chair

- No significant effect of chair type on thermal comfort votes (Foam Chair = 3.83; Mesh Chair = 3.81; Gel Chair = 3.81).
- No significant effect of chair on the total number of body movements per trial (twist, slide, recline, forward lean) - (Foam Chair = 16; Mesh Chair = 6; Gel Chair = 9).



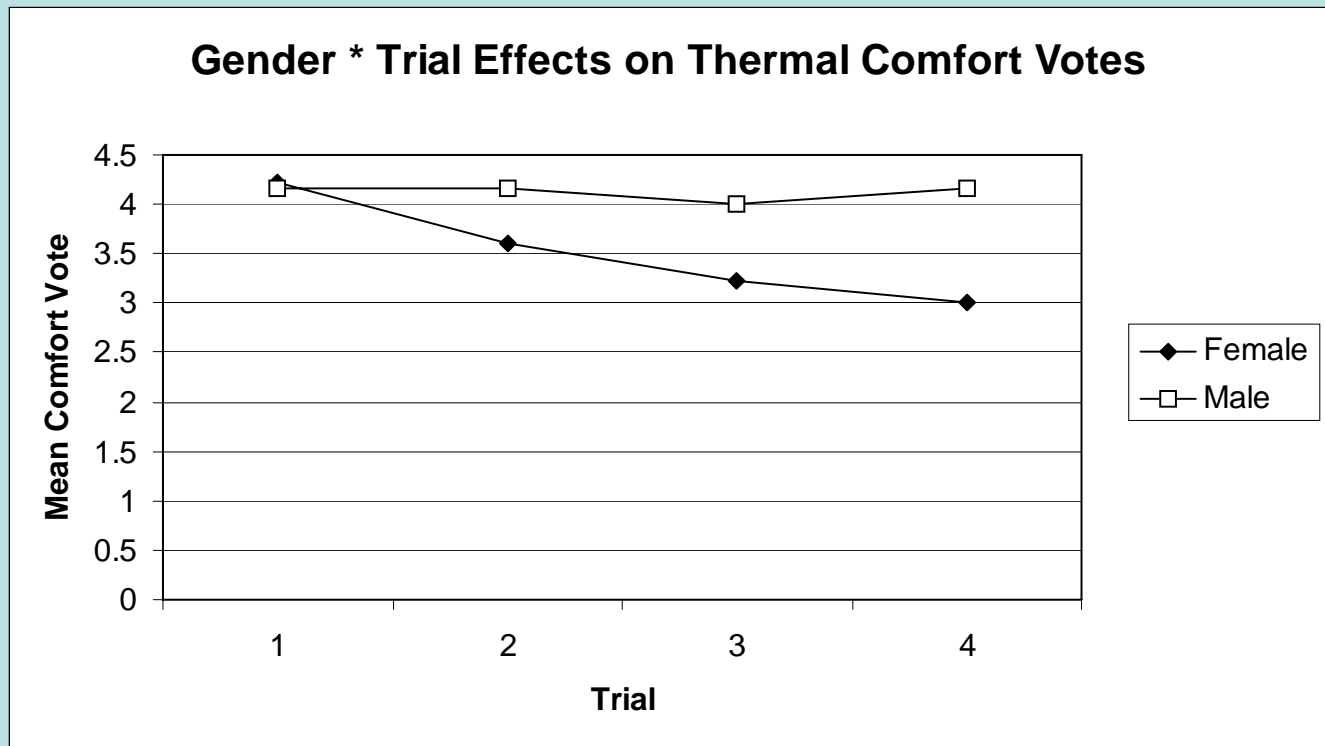
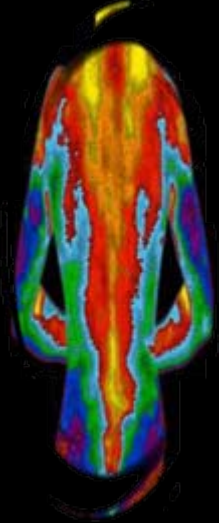
# Results: Gender, Trial

- Significant main effect of gender on thermal comfort votes ( $F_{1,30} = 6.065$ ,  $p=0.020$ ): women reported that conditions were thermally cooler than did men (men = 4.125; women = 3.51).
- Significant main effect of trial on thermal comfort votes ( $F_{1,30} = 11.406$ ,  $p=0.002$ ) and conditions were perceived as thermally cooler by trial 4 than on trial 1 (trial 1 = 4.19; trial 2 = 3.89; trial 3 = 3.61; trial 4 = 3.58).



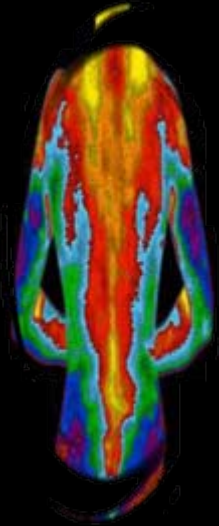
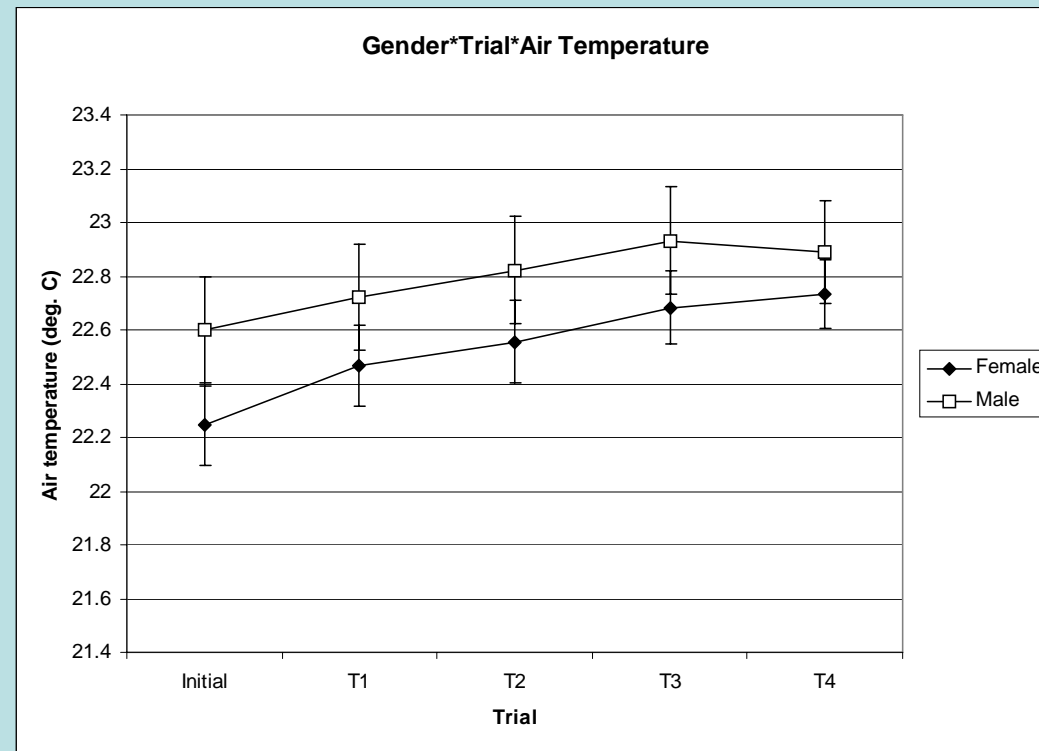
# Results: Gender x Trial

- Significant interaction effect of gender and trial on thermal comfort votes ( $F_{1,30} = 9.676, p=0.004$ ): comfort votes were unaffected by trial for men, but votes decreased between trials 1 and 4 for women



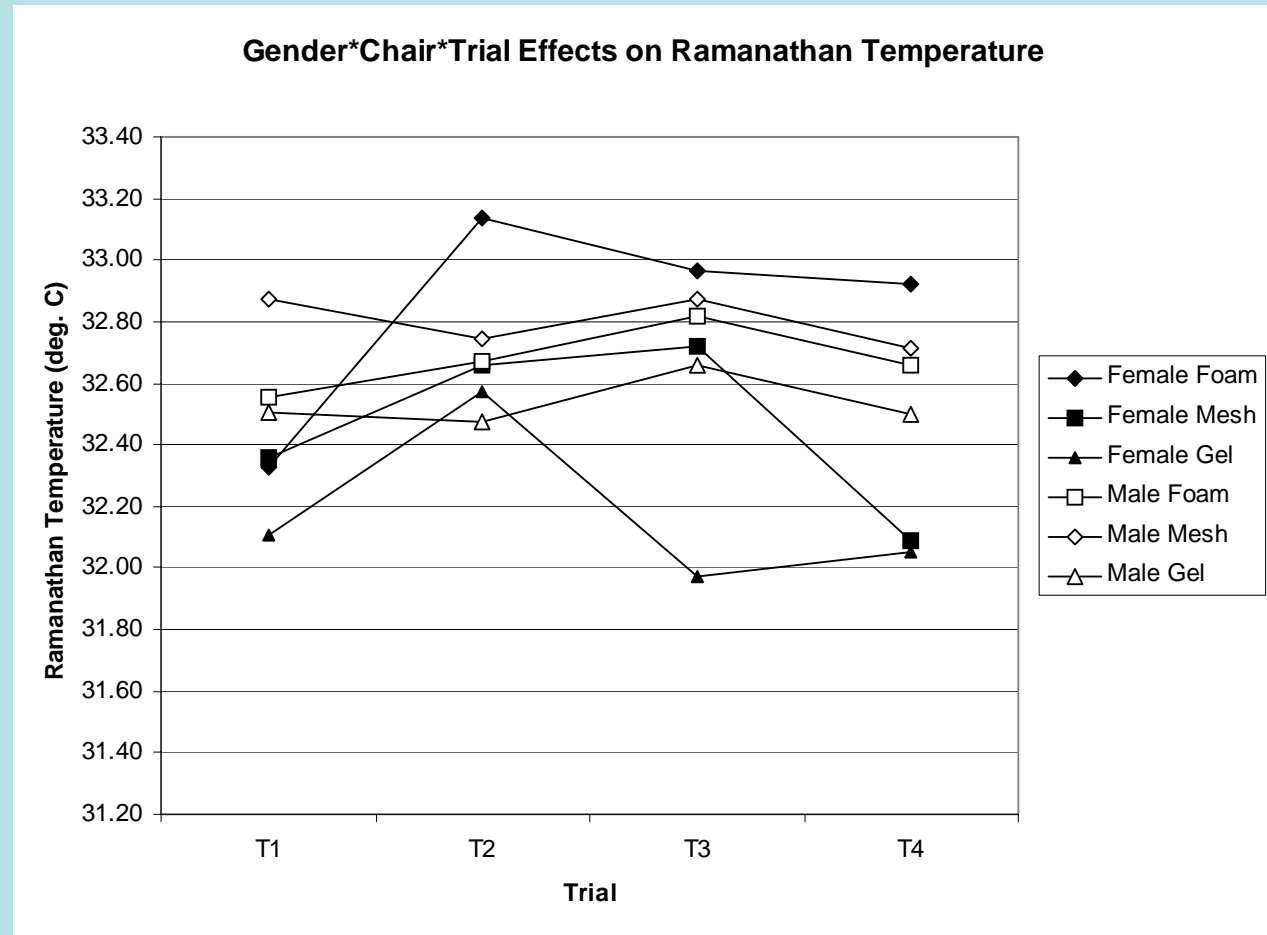
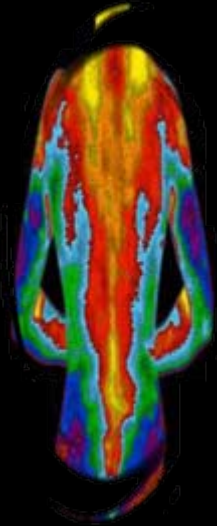
# Results: Trial

- Mean air temperature consistently was slightly lower for those trials for the female subjects the differences were small (average of  $0.26^{\circ}\text{C}$ ).
- Air temperature rose throughout the trials whereas female comfort votes reported increased cooling.
- Less body heat generated or chance?



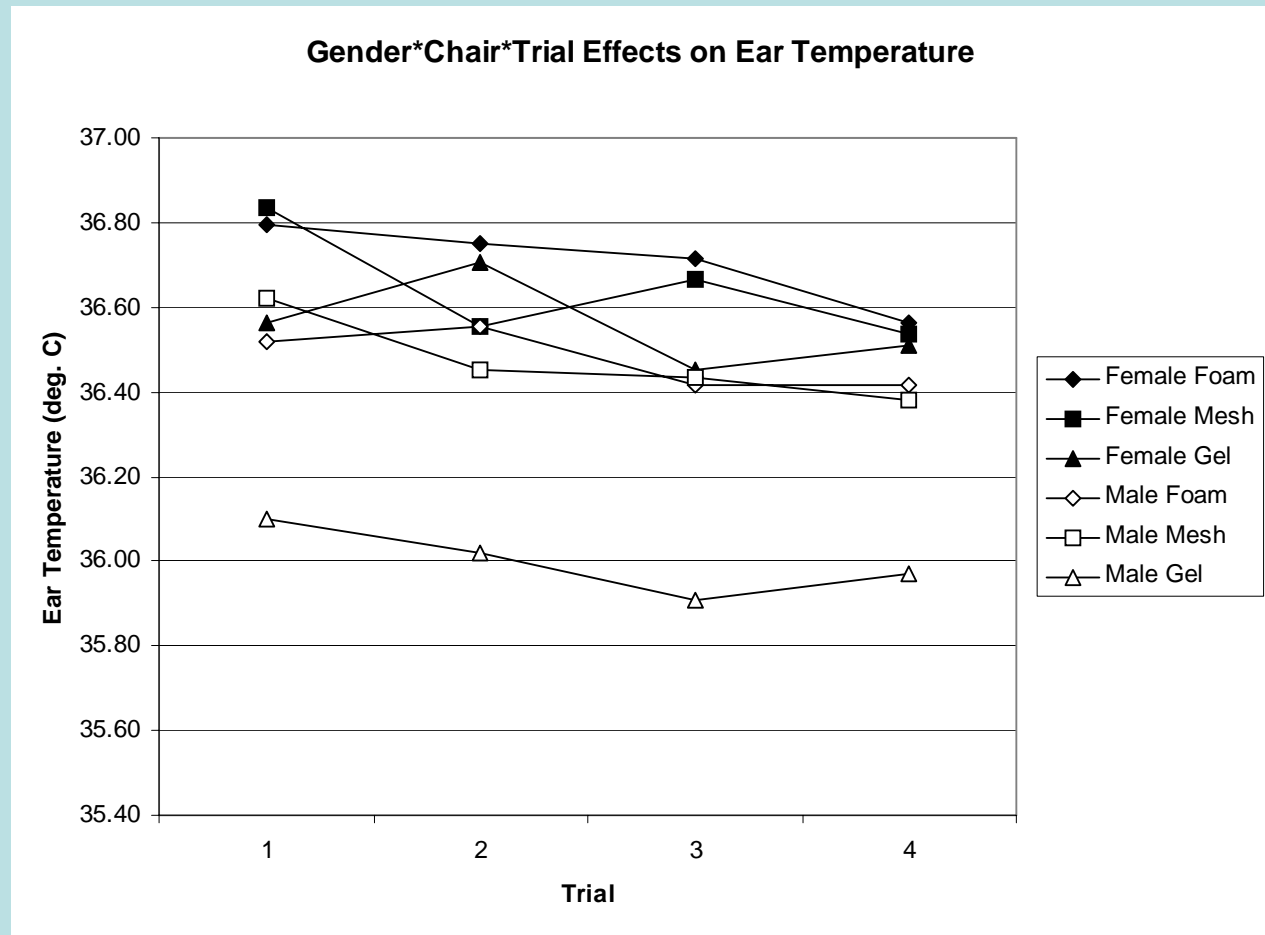
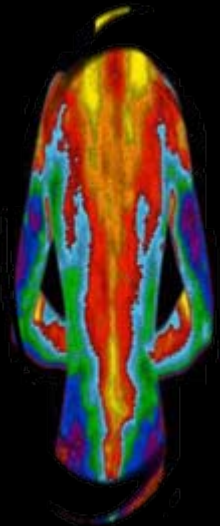
# Results: Ramanathan Temperature

- No significant differences in Ramanathan temperatures between subjects sitting in each of the chairs or for each trial.



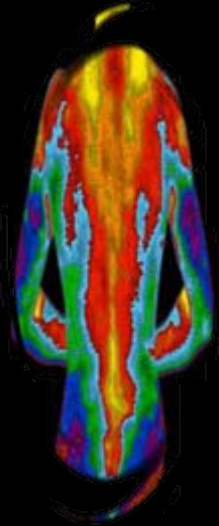
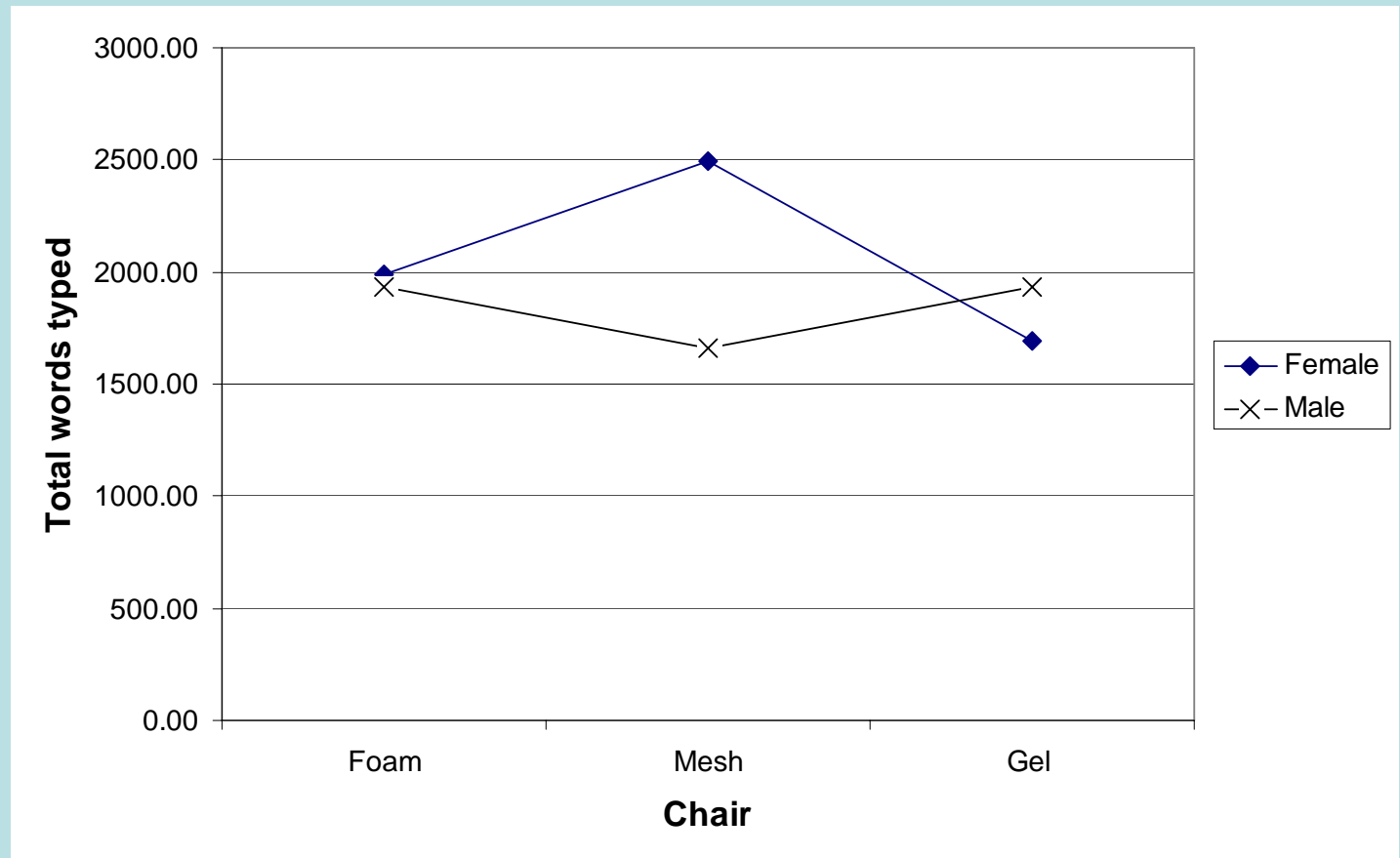
# Results: Ear temperature

- Variations in tympanic membrane temperature measures do not explain the effects seen with thermal comfort votes



# Results: Productivity

- No significant effect of chair or gender or trial on typing productivity (total number of words typed)





# Conclusions

- Evidence of a gender difference in ratings of thermal comfort, with women reporting cooler conditions than men, with a 1.5 hours exposure to controlled climate conditions. This difference could not be explained by measured differences in skin or body temperature.
- Differences in the insulation value of the chair did not significantly affect the thermal comfort votes in controlled climate conditions for the exposure duration studied.
- No evidence that differences between chairs changed the typing productivity of Ss.

