THERMAL AND CARDIOVASCULAR RESPONSES TO ORTHOSTATIC STRESS UNDER MILD COLD EXPOSURE

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I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation.
Background

- Upright posture requires rapid and effective circulatory and neurologic compensations

- Orthostatic tolerance is reduced in a variety of conditions, like autonomic dysfunction, heat stress, prolonged bed rest, after actual or simulated microgravity exposure and in idiopathic cases

- Identification of an effective countermeasure will provide substantial benefit
Background

➢ Research has revealed

➢ Interventions aimed at increasing blood volume and enhancing vasoconstriction should have the highest likelihood of success as an effective countermeasure.

➢ Studies*

➢ Body cooling can provide an alternative method to improve orthostatic tolerance.

➢ No consensus on the optimal cooling conditions to be used or degree of whole body surface cooling to be achieved.


Aim And Objectives

- To examine thermal and cardio vascular responses to an orthostatic challenge under ambient and cold conditions

- To assess and compare whether short term mild cold air exposure alters orthostatic reactions in otherwise normothermic individuals

- To explore the possibility of developing cold exposure as a countermeasure against orthostatic intolerance.
Methodology

• Source Of Data
  ➢ Subjects
    - 15 volunteers, randomly selected from the institute staff
  ➢ Inclusion Criteria
    - Healthy male volunteers
    - Age group 25 – 35 years

• Cross-over study design
Equipments used

- Head Up Tilt Table

- Agilent M3046A Multipara monitor

- Cold Room

- Temperature Monitor (sixteen –channel Intelligent Satellite Unit temperature recorder Century Systems, Bangalore)

- Temperature Probes (Resistance Temperature Detector Type PT- 100 sensors, Century Systems Bangalore)

- Clothing- cotton brief and vest

- Dry and wet bulb thermometer
Methodology

• Protocol

- Evaluation of cardiovascular response to an orthostatic challenge was done in the form of 70 degree Head Up Tilt (HUT) for 20 minutes under comfortable room temperature (26-28°C) and under cold exposure (16° C) in the cold room on two separate occasions.
Experimentation

HUT under ambient condition (26-28°C)

<table>
<thead>
<tr>
<th>Time period</th>
<th>Event/posture</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 10 min</td>
<td>Instrumentation</td>
</tr>
<tr>
<td>Next 20 min(10 +10min)</td>
<td>Supine baseline</td>
</tr>
<tr>
<td></td>
<td>a. Horizontal control</td>
</tr>
<tr>
<td></td>
<td>b. pre-tilt</td>
</tr>
<tr>
<td>Next 20 min</td>
<td>HUT</td>
</tr>
<tr>
<td>Next 10 min</td>
<td>Post-tilt</td>
</tr>
</tbody>
</table>

- HR, Blood Pressure, recording every 2 min
- Oral and skin temperatures (Tchest, Tarm, Tthigh, Tcalf) recording every 5 min
- Room temp monitored every 5 min
**Experimentation**

**HUT under cold condition (Tdb16°C)**

<table>
<thead>
<tr>
<th>Time period</th>
<th>Event/posture</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 10 min</td>
<td>Instrumentation</td>
</tr>
<tr>
<td>Next 10 min</td>
<td>Horizontal control</td>
</tr>
<tr>
<td><strong>Air condition switched on</strong></td>
<td></td>
</tr>
<tr>
<td>Next 10 min</td>
<td>Pre-tilt</td>
</tr>
<tr>
<td>Next 20 min</td>
<td>HUT</td>
</tr>
<tr>
<td><strong>Air condition switched off</strong></td>
<td></td>
</tr>
<tr>
<td>Next 10 min</td>
<td>Post-tilt</td>
</tr>
</tbody>
</table>

- Recording of physiological parameters similar to HUT under ambient condition
Data Collected

1. Primary data
   (a) HR, SBP, DBP
   (b) Skin temperature from four sites (Chest, arm, thigh and calf), Oral temperature

2. Derived data
   (a) MAP, PP
   (b) Mean Skin Temperature (MST)

   Formulae used
   - MST (°C) = 0.3 T chest + 0.3 T arm + 0.2 T thigh + 0.2 T calf
   - Body Surface Area (m2) = 0.202 (Wt)0.425 (Ht)0.725
   Where: Wt = Body weight (kg), Ht = Height (m)
Statistical Analysis

- Descriptive statistics showing mean and SD for each parameter was tabulated.

- Comparison between data collected under the two experimental conditions was done using a paired- t test (two tailed, dependent).
Results

- None of the subjects fainted and showed no signs of circulatory instability

- Under cold exposure, oral temp did not decrease more than ~ 0.6 °C for any of the subjects

- None of the subjects reported discomfort, shivering and urge of micturition
Mean Skin Temperature (°C) response under Cold condition

Values are expressed in mean ± SD
Heart Rate (bpm) responses under ambient and cold condition (n=15)

Less increase in HR during HUT under cold exposure

Values are expressed in mean ± SD
Increased SBP response during HUT under cold exposure

Values are expressed in mean ± SD
Increased DBP responses during HUT under cold exposure

Values are expressed in mean ± SD
Increased MAP response during HUT under cold

Values are expressed in mean ± SD
Comparison of Mean Change in variables between pre-tilt and tilted posture for ambient and cold condition
Comparison of Mean Change in Heart rate (bpm)

<table>
<thead>
<tr>
<th>Event/ Mean changes in HR</th>
<th>Ambient Temperature</th>
<th>Cold Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 Degree HUT: 1st 10 minutes vs Pre Tilt (cold exposure)</td>
<td>10.98±2.95***</td>
<td>6.16±1.92##</td>
</tr>
<tr>
<td>70 Degree HUT: last 10 minutes vs Pre Tilt (cold exposure)</td>
<td>10.59±3.09***</td>
<td>5.42±1.92##</td>
</tr>
<tr>
<td>70 Degree HUT: 20 minutes vs Pre Tilt (cold exposure)</td>
<td>10.8±2.92***</td>
<td>5.83±1.99##</td>
</tr>
</tbody>
</table>

*Level of significance between ambient and cold temperature
# Level of significance within group
**& # Significance (p value: p ≤ 0.01)
Comparison of Mean Change in Systolic BP (mm Hg)

<table>
<thead>
<tr>
<th>Event</th>
<th>Mean changes in SBP</th>
<th>Ambient Temperature</th>
<th>Cold Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-0.97±1.31**</td>
<td>4.75±1.49##</td>
</tr>
<tr>
<td>70 Degree HUT: 1st 10 minutes vs Pre Tilt (cold exposure)</td>
<td></td>
<td>-1.42±1.21**</td>
<td>5.05±1.49##</td>
</tr>
<tr>
<td>70 Degree HUT: last 10 minutes vs Pre Tilt (cold exposure)</td>
<td></td>
<td>-1.17±0.99**</td>
<td>4.88±1.96##</td>
</tr>
</tbody>
</table>

*Level of significance between ambient and cold temperature
# Level of significance within group
** & ## Significant (p value: p < 0.01)
Comparison of Mean Change in Diastolic BP (mm Hg)

![Graph showing comparison of mean change in diastolic blood pressure between ambient and cold temperatures.](image)

<table>
<thead>
<tr>
<th>Event/ Mean changes in DBP</th>
<th>Ambient Temperature</th>
<th>Cold Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 Degree HUT: 1st 10 minutes vs Pre Tilt (cold exposure)</td>
<td>7.3±0.8***</td>
<td>11.64±2.4##</td>
</tr>
<tr>
<td>70 Degree HUT: last 10 minutes vs Pre Tilt (cold exposure)</td>
<td>6.36±1.01###</td>
<td>11.60±2.4##</td>
</tr>
<tr>
<td>70 Degree HUT: 20 minutes vs Pre Tilt (cold exposure)</td>
<td>6.87±0.72###</td>
<td>11.62±2.58##</td>
</tr>
</tbody>
</table>

*Level of significance between ambient and cold temperature

# Level of significance within group

**& # Significant  (p value: p ≤0.01)
Comparison of Mean Change in MAP (mm Hg)

<table>
<thead>
<tr>
<th>Event/ Mean changes in MAP</th>
<th>Ambient Temperature</th>
<th>Cold Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 Degree HUT: 1st 10 minutes vs Pre Tilt (cold exposure)</td>
<td>4.56±0.67***</td>
<td>9.04±1.49**</td>
</tr>
<tr>
<td>70 Degree HUT: last 10 minutes vs Pre Tilt (cold exposure)</td>
<td>3.82±0.71***</td>
<td>9.47±1.49**</td>
</tr>
<tr>
<td>70 Degree HUT: 20 minutes vs Pre Tilt (cold exposure)</td>
<td>4.22±0.51***</td>
<td>9.24±1.78**</td>
</tr>
</tbody>
</table>

*Level of significance between ambient and cold temperature  
# Level of significance within group  
**& ## Significant (p value: p \( \leq 0.01 \))
Discussion

- Previous reports suggested that skin surface cooling improves orthostatic tolerance in normothermic and heat stressed subjects.*

- Present study - an attempt to investigate whether cold air exposure also causes favorable hemodynamic responses to orthostasis.

- Study designed to determine the optimal degree of whole body surface cooling causing favorable cardiovascular reflex responses.


Thermal responses

- Favorable

- Cold condition at 16 °C for 30 minutes did not impose cold stress of sufficient intensity to decrease oral temp beyond acceptable limits or to cause shivering/discomfort.
Cardiovascular responses

- **HR** - Lower increase under cold exposure

- **Cause**
  - Vasoconstriction
  - Increased TPR and pressure responses
  - Decreased HR

- **Vagal response** – cold exposure of face causing trigeminal stimulation


Cardiovascular responses

- Augmented Pressure responses during HUTT under cold exposure

- Cause
  - SSC
  - Cutaneous and peripheral vasoconstriction
  - Shift of peripheral blood volume into central circulation
  - Increased venous return and SV (Pre-load)
  - Increased CO

- Higher sympathetic activation and increased plasma norepinephrine levels

- Synergistic effect of combined cold exp and orthostatic stress
Conclusion

- Effects of mild cold exposure with orthostatic stress on augmenting pressure responses may contribute to improvement in OT

- Decrease of MST by 3-4°C caused favourable orthostatic reactions

- A cooling protocol in terms of magnitude, duration and frequency may be beneficial in protecting against orthostatic intolerance

- Whole body cold exposure deserves further exploration as an antiorthostatic intervention
THANKYOU