Physiological Monitoring of Firefighters

Denise L. Smith, Ph. D.

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Overview

Physiological Monitoring - Where are we?

Section 1 - What are the goals?
Section 2 - What are the challenges?
Section 3 – What may affect physiological responses?
Section 4 – What have we learned? (Recent Studies)
Goals of Physiological Monitoring

- Predict CV or heat related event or fatigue
- Warn of high CV and thermal strain or fatigue
- Know if dead or alive
- Quantify difficulty of exercise
- Post incident analysis

Mechanism of Sudden Cardiac Death

- Dehydration
- Increased Body Temperature
- Adrenaline
- Decreased Plasma Volume
- Altered Electrolytes
- Increased Viscosity
- Changes in HR and BP
  - Circulatory Shock
  - Arrhythmias
  - Clot Formation
  - Plaque Disruption

Heart Attack
What are the challenges?

- Can we measure variables that predict or reflect risk?
- Individual Variability
- Technological/Durability
- Practical (union, admin, privacy, liability)
- Making sense of vast amount of data
  - amount of data
  - individual variability
  - prediction accuracy
Factors affecting physiological responses

- Environmental Factors
  - Work Performed
  - Gear
  - Thermal Environment

Physiological Responses to Firefighting

- Personal Factors
  - Health Status
  - Fitness
  - Hydration Level
  - Medication
## Alarm as a Vulnerable Period

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time Spent (%)</th>
<th>Fatalities (%)</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Suppression</td>
<td>1%</td>
<td>32.1%</td>
<td>136</td>
</tr>
<tr>
<td>Response to Alarm</td>
<td>4%</td>
<td>13.4%</td>
<td>14.1</td>
</tr>
<tr>
<td>Return From alarm</td>
<td>7%</td>
<td>17.4%</td>
<td>10.5</td>
</tr>
<tr>
<td>Physical Training</td>
<td>8%</td>
<td>12.5%</td>
<td>6.6</td>
</tr>
<tr>
<td>Nonfire emergencies</td>
<td>15%</td>
<td>9.4%</td>
<td>2.6</td>
</tr>
<tr>
<td>Nonemergency duties</td>
<td>65%</td>
<td>15.4%</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Line of Duty Deaths - CHD related**  
*N=449, 1994-2004*

Kales, et al., NEJM, 2007
Physiological Monitoring of Firefighters

30,000,000 heart beats
Integrated 2 Study Project

Field-Based Study

Training Status
- Strength
- Aerobic
- Combination
- Low Fitness

24 hours of monitoring – PSM
CV strain/Autonomic function

Alarm response
During FF activities
Recovery
Field Study - Oxnard

- 24 hour data collection:
  - Heart Rate - on a beat-to-beat level
  - Respiration Rate
  - Skin Temperature
  - Activity Level
  - Heart Rate variability
What Have We Learned?

What are we interested in?

Fire Call  Emergency Call  Training  Exercise  Sleep

24hr Monitor

Alarm Response  Rehab  Recovery
Sleep
Pre/Post alarm

![Graph showing amplitude over time with a start and end marker.](image-url)
Enroute
Exercise/Recovery
Heart Rate Response to Alarm

3 Participants;
365 calls; means SE
pNN50

3 Participants; 365 calls; 29 sleep events; means SE
Low Frequency/High Frequency Ratio

3 Participants; 365 calls; 29 sleep events; means SE
Heart Rate: Non-Fire vs. Fire Calls

3 Participants; 29 fire calls vs. 335 non-fire calls; means SE
Heart Rate Response to Fire and Non-Fire Alarms

![Heart Rate Graph](image-url)
Heart Rate Response - Time of Day

3 Participants;
Daytime: 0600-2259,
Night: 2330-0559;
307 Day time calls;
57 night calls;
means SE
Thank you