

Section 3

Use of Physiologic Status Monitoring (PSM) in the Fire Service



PSM at Hanover Park Fire Department

- Municipal department located in the Chicago metro area.
- Residential Population: 40,000
- 55 Firefighters
 - Fire/Rescue/ALS Ambulance Service
 - Fire Apparatus Staffing: 3
- MABAS Division 12
 - Hazardous Materials Rapid Response Squad
 - Rehab Response Team



Hanover Park^{USA}



PSM at Hanover Park Fire Department

- Personnel began wearing WASP technology in January 2017.
 - Shirts
 - Straps
- WASP was worn for all activities throughout the 24-hour shift.
 - Physical Fitness
 - Training
 - Emergency Response
 - Sleep
- Devices also worn by Command Staff (non-shift work).





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Physiologic Data

- To date – we have collected nearly 20,000 physiologic data files from HPFD using the Zephyr Biomodule (PUC) System.
- Each 24-hour file is about 10,000 pages if printed

SMARTER

Battalion Chief “Buggy” Equipped: *Zephyr Omnisense Live*

- Used by Incident Command to monitor operating on-scene personnel.
- Connects quickly (less than a minute).
- Connects about one block away from the scene.



Case Studies





HPFD

Call 17-1803

Residential Structure Fire

July 5, 2017

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Hanover Park units dispatched for a reported structure fire at 1636 Sycamore Avenue. Arrival on scene showed a two-story split-level single family home with smoke showing from the second-floor eaves.

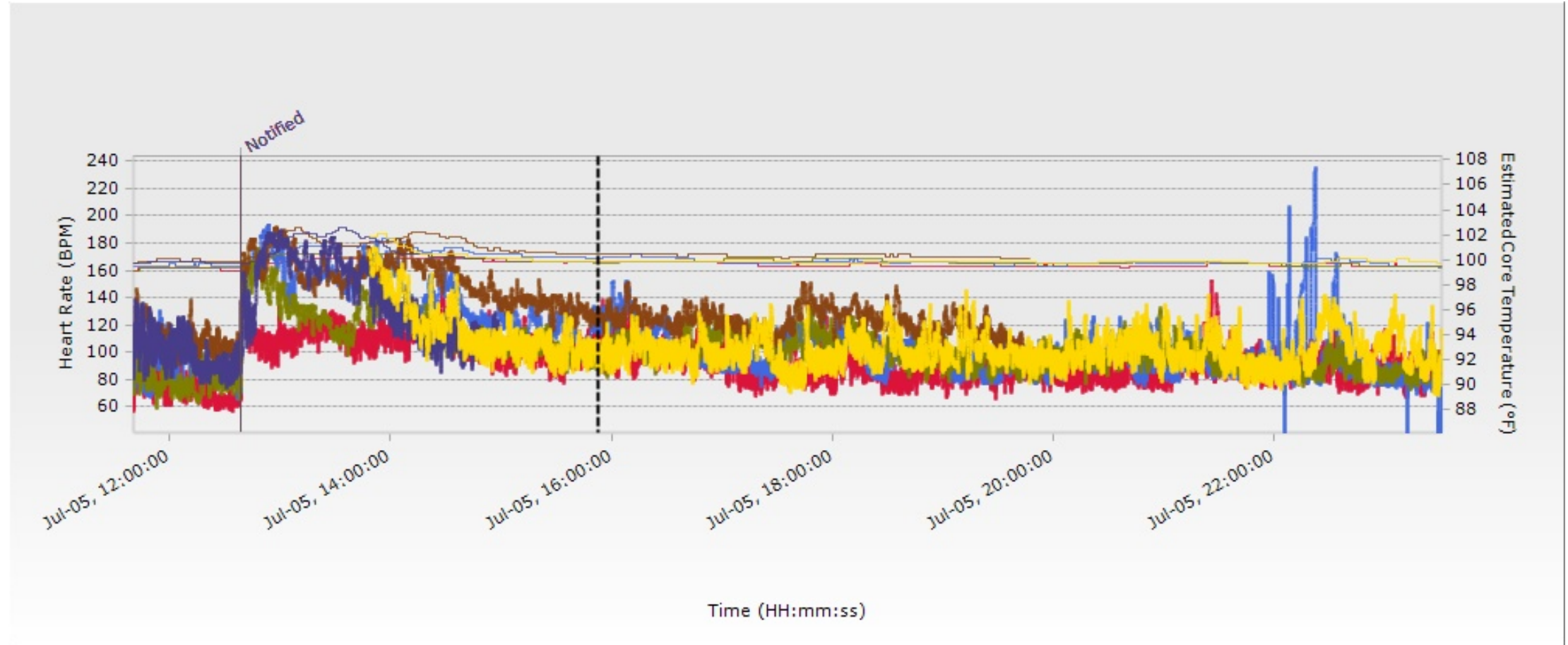
Call Narrative

Facts of the incident:

- Fire found burning on two floors in the rear of the structure.
- Two unconscious dogs located during primary search – removed and resuscitated.
- Broken hydrant – hand stretch 4” supply line 600’ to next available hydrant.
- Performed both horizontal and vertical ventilation.
- Extensive overhaul required.
- Weather:
 - 81°F
 - 65% Humidity
 - Easterly wind at 13.7 mph



Notified: 12:39
Clear Time: 23:10



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HPFD

Call 17-422

Wildland Fire

February 14, 2017

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Call Narrative

Dispatched for the outside fire. Medic 16 was on the scene first and reported a grass fire across the street from the water tower, in the forest preserve grassland area. Upon our arrival, crew found the grass fire to be moving quickly due to windy conditions. Crew attempted to extinguish the fire utilizing the deck gun, but the windy conditions hampered that attempt. Crew then drove into the forest preserve where multiple hose lines were deployed. Engine 16 and Medic 16 extinguished the fire. Crew then washed down the burned vegetation area.

Incident Details

- Engine 16:
 - Notified 16:06:49
 - Arrived 16:12:24
- Medic 16:
 - Notified 16:06:49
 - Arrived 16:11:14
- Battalion 15
 - Responding with Zephyr Omnisense Equipment



Environmental Conditions

- During Fire Extinguishment
 - 45° F (37° C)
 - 56% Humidity
 - 18 MPH Wind Speed
 - No Precipitation





Responder per WASP Tracking ID

- #1100
- #1360
- #868
- #1079 (No Data - puc recording error)
- #1106

Participant 1100

- **90 seconds prior to call:**

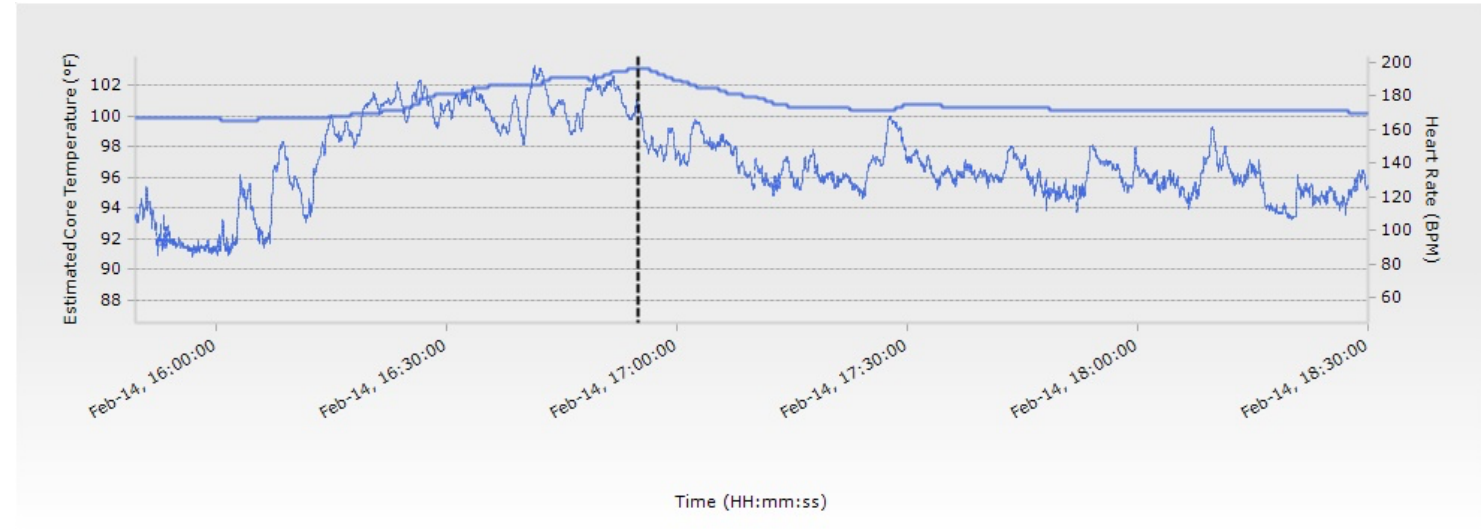
- HR: 92
- Estimated Core Temp: 99.68° F

- **At time of alarm (16:06)**

- HR: 138
- Estimated Core Temp: 99.86° F

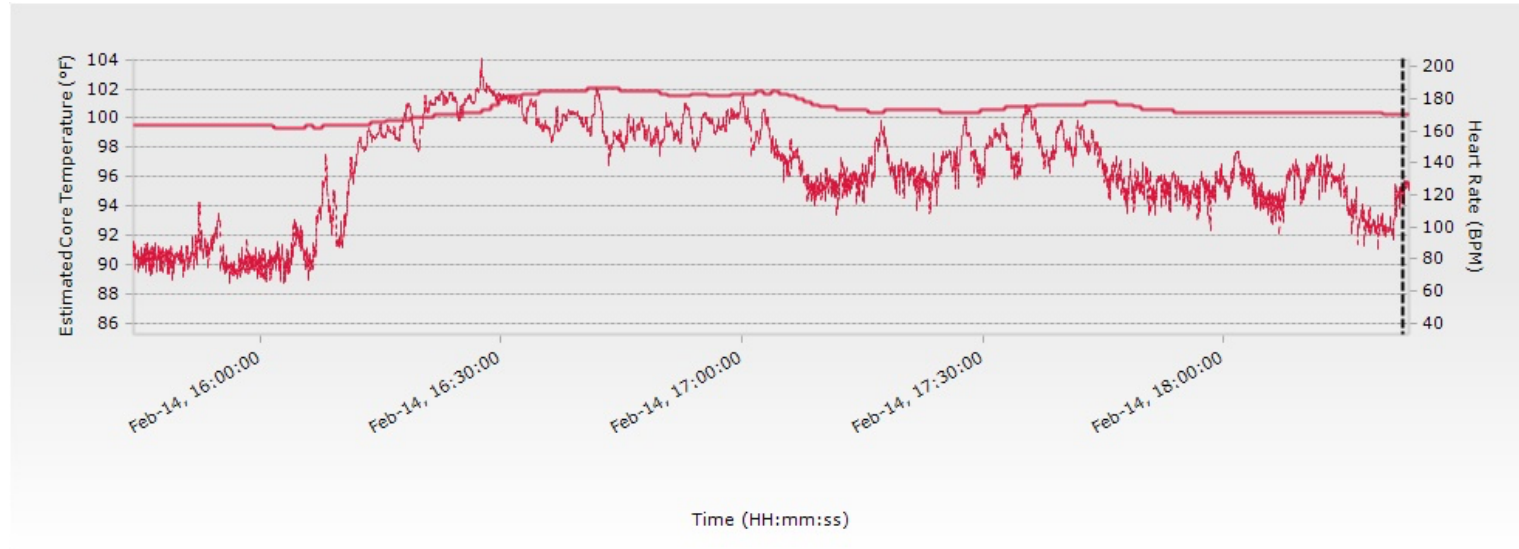
- **On Scene**

- Peak HR: 198 (16:41)
- Average HR for call duration: 143
- Peak Estimated Core Temp: 103.1° F (16:53)



Participant 1106

- **90 seconds prior to call:**
 - HR: 80
 - Estimated Core Temp: 99° F
- **At time of alarm (16:06)**
 - HR: 107
 - Estimated Core Temp: 99° F
- **On Scene**
 - Peak HR: 205
 - Average HR for call duration: 141
 - Peak Estimated Core Temp: 102.2° F



Case Study Analysis

- **Firefighter ages:**
 - Late 20's to late 30's
 - Oldest member being the Engine Company Lieutenant at 39.
- **Responders had peak heart rates from 159 to 205.**
- **Average heart rate for the length of the incident (all responding personnel) = 124.**
 - Firefighters at or near maximum cardiac output at various times during the incident.
 - Not overly concerning for personnel who are in good health and do not suffer from an underlying cardiac condition.

Case Study Analysis

- **Peak core temperatures:**

- 103.1°F
- 102.2°F

- **A generally accepted standard for heat stroke – 104°F**

- Prior laboratory research – core temperature continues to rise even after firefighters exit the hot environment and remove their PPE.
- Firefighters **very** close to meeting the clinical definition of heat stroke.
- Ambient temperature at this incident was 45°F.

- **Live feed data used by I/C:**

- Pulled the firefighter w/ highest core body temperature
 - *This may not always be possible depending on the situation.*



Live Fire Training

Comparison of Firefighters & Instructors
Physiological Response During “a full day” of
Live-Fire Training

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Live Fire Training

- Approximately 10-12% of firefighter fatalities occur during training.
 - 56% of these due to cardiac events
- The cardiovascular strain of live fire drills is well documented.
- The cardiac & thermal strain associated with a “**full day**” of burns has not been well characterized.

Live Fire Training – Purpose

Compare the physiologic response of firefighters and instructors.

- Training occurred over ~ 7-hour period
 - Three drills:
 - Transitional Fire attack w/ventilation and search
 - Standpipe
 - Vent/Enter/Isolate/Search
 - Following each drill:
 - Debrief/Critique
 - Clean-up and Reset



Participant Demographics

Table 1. Descriptive characteristics of all participants

Group	Instructors	Students
Age (years)	36 ± 15	35 ± 19
Height (m)	1.78 ± .10	1.80 ± .08
Mass (kg)	95.68 ± 24.65	91.33 ± 12.13

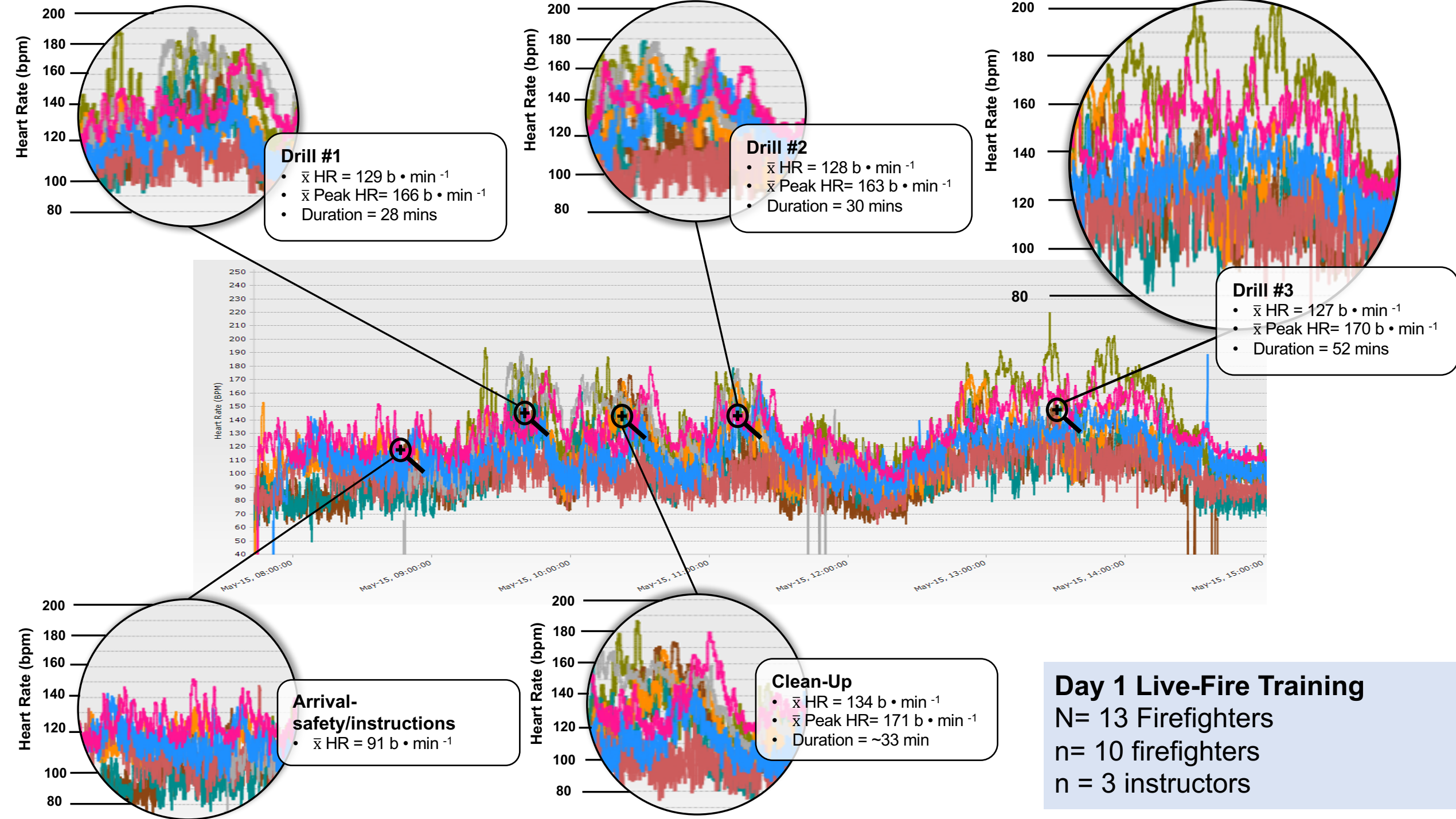
Values are means SD; N=35; Instructors=6; Students=29

Physiologic Characteristics

Table 1. Physiologic Characteristics

Variable	Instructors (n=6)	Firefighters (n=29)
HR Peak (b·min-1)	183 ± 15	188 ± 19
HR Avg (b·min-1)	114 ± 14	116 ± 11
EST Tco Peak (°C)	38.3 ± .35	38.6 ± .53
EST Tco Avg (°C)	37.7 ± .39	37.8 ± .32

Values are means ± SD; EST= estimated



Clean up & Reset

	Drill 1	Drill 2	Drill 3	Cleanup (After Drill 1)
HR Peak (BPM)	166.4	163.7	170.1	171.3
HR x (bpm)	124.6	128.6	127.3	134.1
T _{co} Peak (°F)	100.5	100.7	100.7	100.9
T _{co} x (°F)	100.2	100.4	100.2	100.4
Duration of Drill (min.)	~28	~30	~52	~33

Clean up & Reset

	Firefighter	Instructor
Peak HR (bpm)	175.4	158.7
HR x (bpm)	136.5	116.0
T _{co} Peak (°F)	100.5	100.0

Clean up & Reset

- The physical exertion during cleanup activities can be as physically demanding as the live fire drills.
- When considering the physiologic strain, the work of cleanup should also be considered.



Bailout Training

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Bailout Training

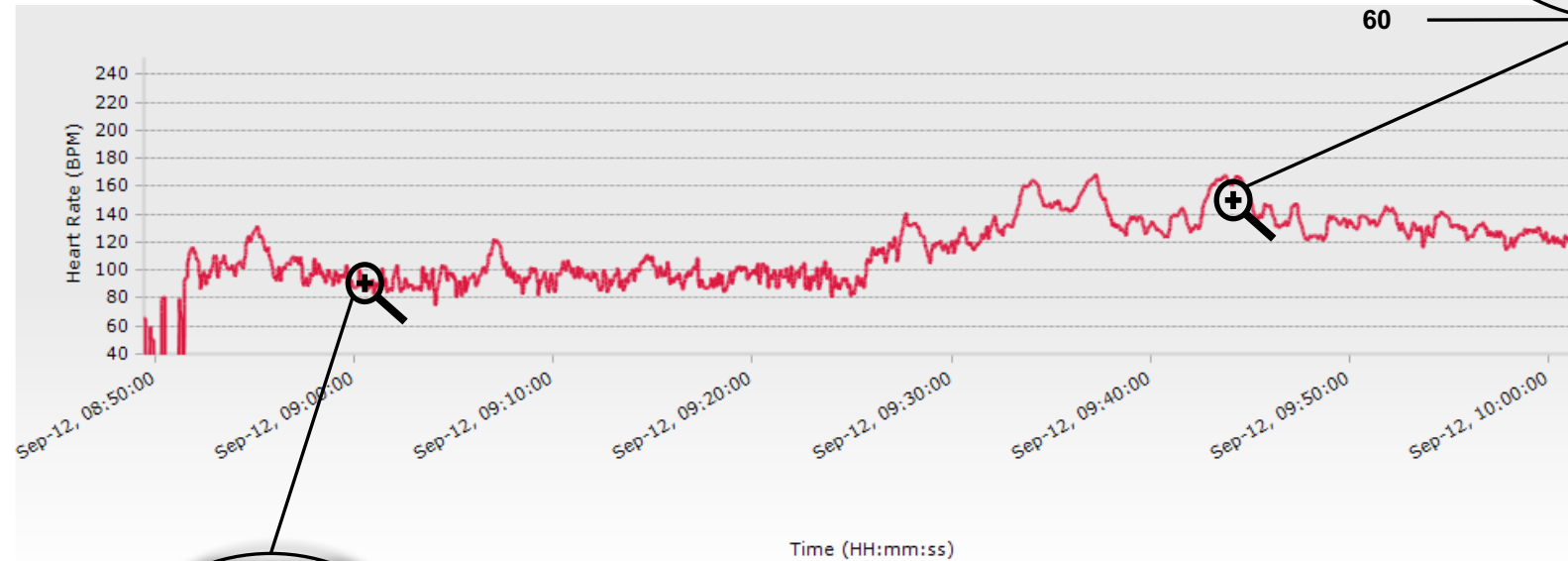
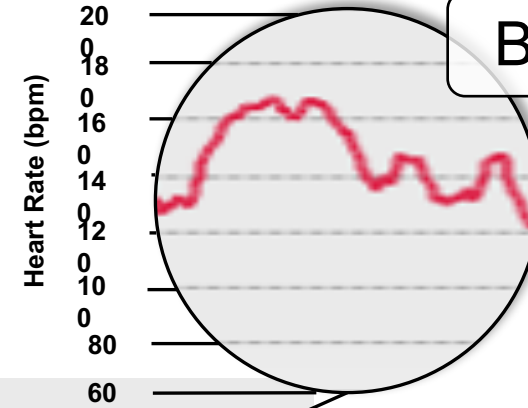
- Previously considered a low-intensity drill
- PSM data revealed that all participants reached at least 74% of HRM
 - Sympathetic Nervous System Activation



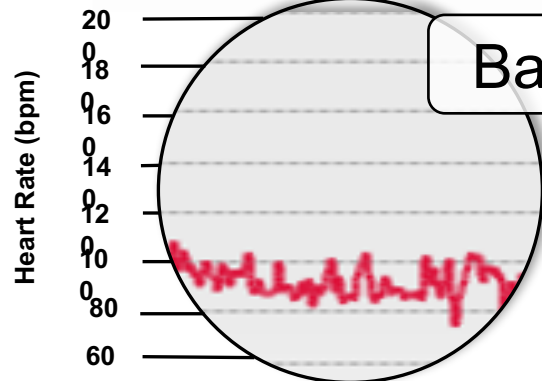
Training Overview

- \bar{x} HR = 116 b • min⁻¹
- Peak HR= 169 b • min⁻¹
- \bar{x} Tco = 37.70°C

Bailout Drill



Baseline



A firefighter is silhouetted against a bright orange and yellow fire background. The firefighter is positioned on a ladder, which is visible as a diagonal line with red and white reflective stripes. The overall scene is dramatic and high-contrast.

Insights & Perspectives

Related to Fire Service Deployment

Wearability

- As a regular duty base layer shirt that will be worn throughout the shift?
 - Generally uncomfortable for extended periods of wear
 - Uncomfortable for sleep
 - Chaffing and rash in the monitor area is a major complaint
- Keeping the electrode contact points moist is a challenge.
- Movement/data collection can be problematic.



Wearability

- PSM “strap” has generally the same complaints.
 - Challenge in keeping the strap in position if worn without shoulder straps.

If given the choice, personnel would **NOT** wear the devices.



Wearability

- Impractical for usage by volunteer/POC Departments
 - Need to don prior to response to call
 - Need to charge/download the PUC

PSM during training is realistic using existing technology.



Questions Grouped by Theme

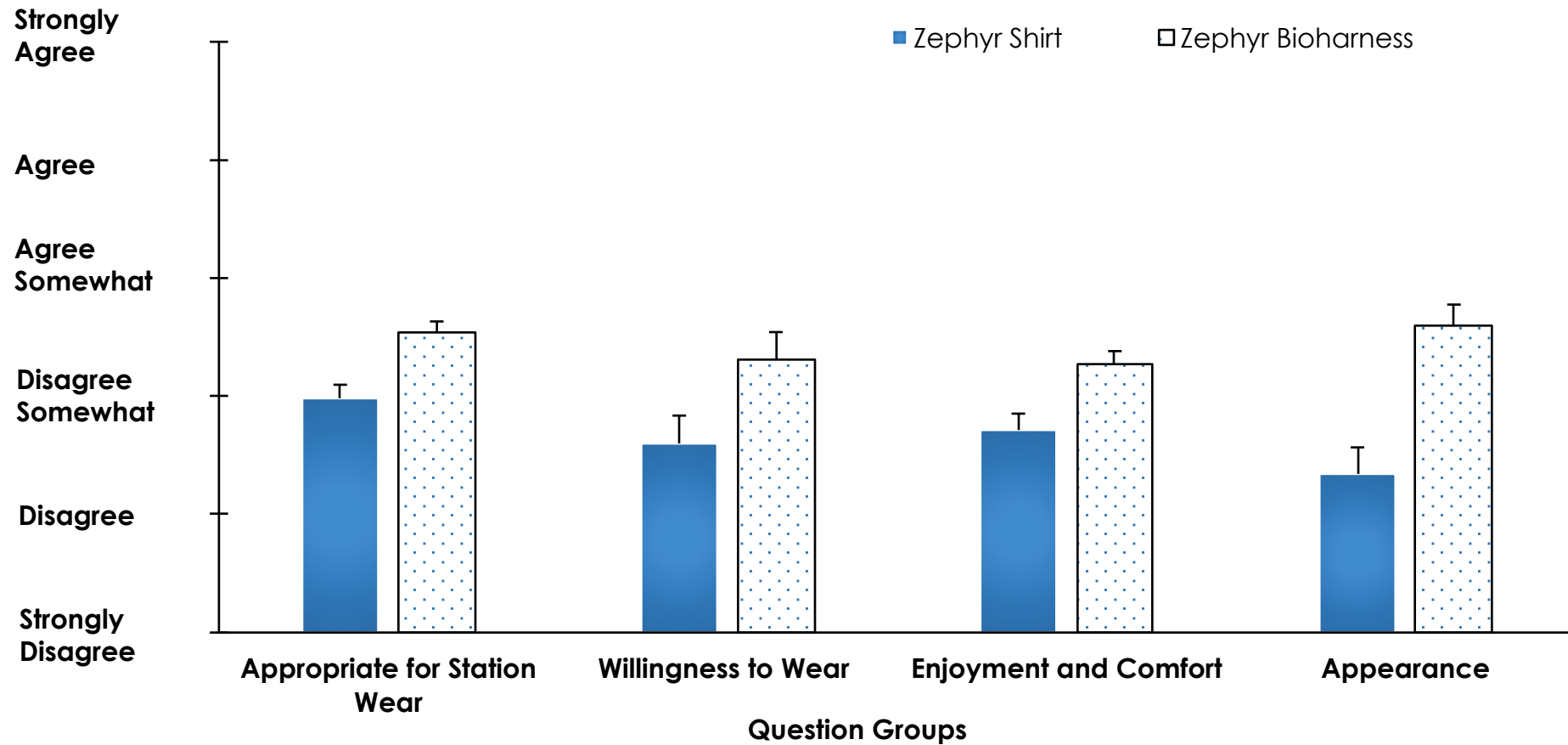


Figure 2. User Ratings of Zephyr Shirt and Bioharness (n=35 for zephyr shirt, n =44 for zephyr bioharness)

Survey Question: Please rank your experience wearing the Zephyr Product during: (four activities)

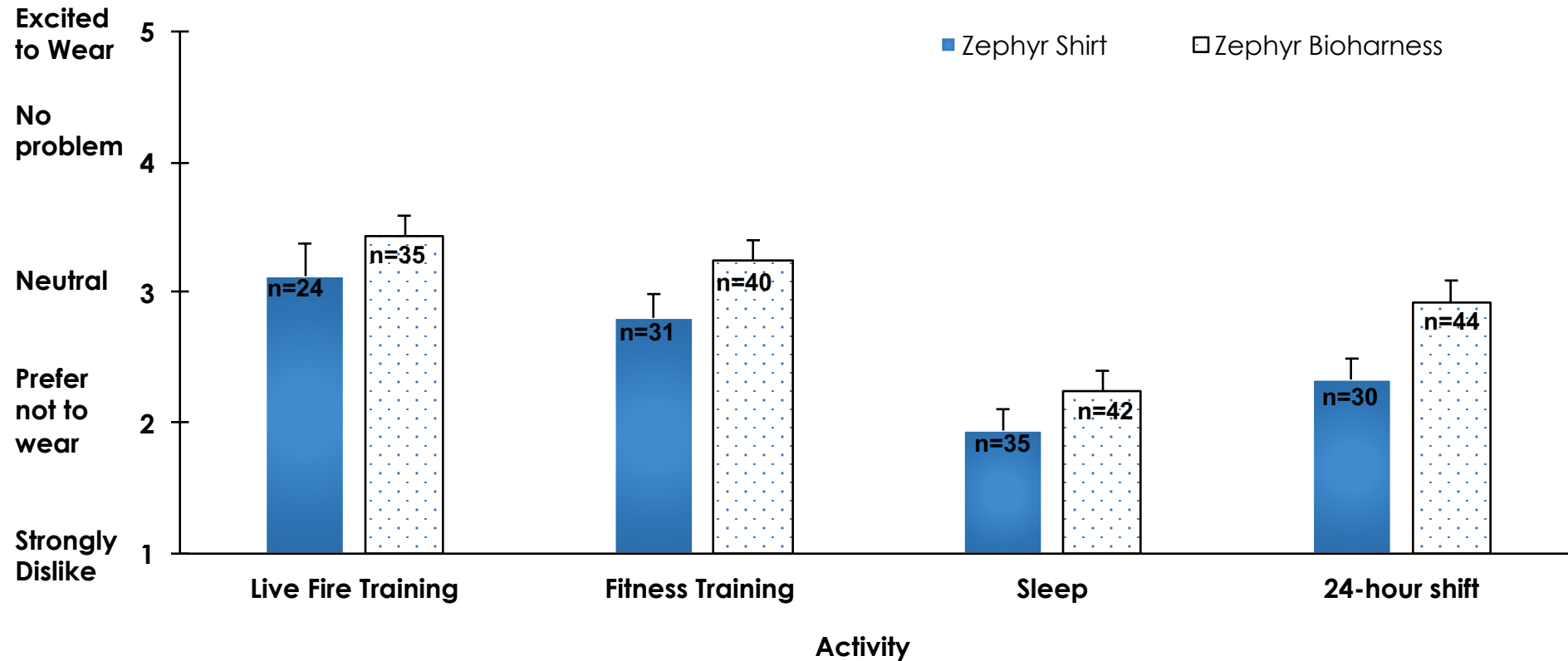


Figure 1. User rankings of experiences using Zephyr shirts and bioharnesses during activities

WASP System Workflow

Steps

Technology
Configuration
and
Assignment

Data
Collection
(Firefighters Wear
Technology)

Data
Extraction

Technology
Reconfiguration
and Call Log
Processing

Data
Compilation,
Cleaning, and
Analyzing

Dissemination of
Results

Supplies

computer,
software, and
WASP system with
accessories

computer,
software, WASP
system, and, if
recording live,
transmission
device

computer,
software, WASP
system, and
accessories

computer,
software, call logs,
and WASP
system with
accessories

computer and
software

computer,
software, and
printing
materials

Personnel

research team
and fire
department
leadership

participants,
research team,
and fire service
personnel

research team
and fire service
leadership

research team
and fire service
leadership

research team

research team

Field Use

Research Use

Data Management

- Managing of the PUC downloads: 3 – 4 Hours Daily
- Program management is hugely labor intensive
- Once you have the data – now what?
 - Analysis?
 - Getting it into a usable format
 - Decision making?
 - Expertise of reviewers (physiologists)



Usefulness in “Field” Decision Making

- Decision making while companies are operating – **limited**.
 - In most instances I/C will not be able to stop a “push” due to physiologic data seen at a command post.
 - May be able to add staffing/company to a task to reduce the workload based on what is seen.



A photograph of firefighters at night. A fire truck is visible with its rear open, and several firefighters in reflective gear are standing around it. The scene is illuminated by red emergency lights. The text 'BATTALION' is visible on the side of the truck. A firefighter's name 'RICE' is visible on their gear. A fire department emblem is also visible on the truck.

Usefulness in “Field” Decision Making

- Questions related to decision making:
 - What are the threshold limits?
 - Do they vary from individual to individual?
 - Do you need a base level understanding of each firefighter in order to interpret readings?
- Data overload...
 - Incident Command staff needs to be robust in order to evaluate all information available.

Usefulness in “Field” Decision Making

Use during rehab as PSM –
High Potential.

- Ease in firefighter assessment
- Continuous read of PSM
- Ease in data collection w/less errors or omissions





So what...

Future of PSM – There is Promise


- As a research tool
- During training
- Field use capabilities – Need further R & D
 - Wrist watch style device?
 - Must be usable by volunteer/POC aspect of fire service



Theory: Non-structural PPE

- Based on elevated core body temperatures:
 - Does it make sense to reduce the thermal load by wearing different PPE when not engaged in “fire suppression” work?
- Use of PPE that has not been exposed to products of combustion limits contamination:
 - Wearer
 - EMS patients
 - Apparatus





Theory: Policy Changes on Cleanup and Reset

- Increased Focus: “Put the firefighter back into service.”
 - Ensure that Rehab takes place (at minimum company level rehab)
 - Joining crews to assist with company reset?
 - Hold companies on-scene longer to assist with clean-up and reset?



SMARTER Getting Attention: *Innovation of the Year Award*

- Presented by Intergovernmental Risk Management Association (IRMA)
- Award presented to:
 - Hanover Park Fire Department
 - IAFF Local 3452

A photograph of a fire training exercise. In the center, a small wooden structure is on fire, with thick white smoke billowing from it. Four firefighters in full gear are present. One firefighter in the foreground is kneeling, with "B. NEVAREZ" on his back. Another firefighter to the right is holding a wooden board. A third firefighter stands to the left. A fourth person is visible on the roof of the building. The scene is set in a paved area next to a large brick building with red doors and windows. A red fire truck is partially visible on the left. The word "Questions?" is overlaid in large white text.

Questions?