Assessing and managing thermoregulatory responses to heat loss: a research journey

Dr. Barbara J. Holtzclaw– University of Oklahoma, USA

Assessing and Managing Thermoregulatory Responses to Heat Loss: A Research Journey

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June C. Abbey, PhD, RN, FAAN
Research Mentor

Ralph T. Geer, MD
Clinical Research Collaborator

Objectives of the research presentation

How this research project grew out of original interest in thermoregulation

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Objectives of the research presentation

How an interdisciplinary collaboration yielded the opportunity and outcomes to apply methods and principles to future research on shivering

Objectives of the research presentation

How the study findings relate to the nursing concerns of any patients who are shivering from any cause

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How the study findings relate to the nursing concerns of any patients who are shivering from any cause

- Why nurses should care?
- What are consequences for patients?
- What principles of care can be addressed all of them?

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The human’s thermostat

During masters preparation in physiological nursing, decided to explore the neurological control of body temperature

“The Human’s Thermostat”

- Core temperature range: 36.3 – 37.8 °C | 97.3 – 100 °F
- Heat loss
- Heat gain

Thermoregulatory mechanism

- Core temperature range: 36.3 – 37.8 °C | 97.3 – 100 °F
- Heat loss
- Heat gain

Thermoregulatory sensors:
- Sweat
- Vasodilation

Hypothalamic comparator
- Set-point range: 36.3 – 37.8 °C | 97.3 – 100 °F

Thermal sensors: the warning system

Core temperature range: 36.3 – 37.8 °C | 97.3 – 100 °F

Sensed threats to the set-point range are transmitted from central and peripheral temperature sensors to the central controller

Brain, spinal cord, gut

Skin and superficial tissue

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Dr. Abbey’s multi-site study

- Surface cooling causes uncontrolled shivering; drugs unsuccessful in management of shivering
- Blankets used to reduce swelling from brain trauma/surgery to lower metabolic rate & O₂ demand
- Violent shivering that ensues from fall in core temperature negates any potential gain from blankets
- Shivering at its neurological sources:
  - Predominance of heat loss sensors on hands and feet
  - Highly selective areas of temp, sensitive skin seem to lead other body responses
  - Gradual heat loss could diminish “perception” of heat loss and influence shivering

Thermoregulatory “Pearls”

- Sensors lead the body temperature change in an anticipatory manner related to rate of skin temperature fall

- Nerve endings that are highly selective to temperature stimuli are located in the skin

- Gradual heat loss can diminish the perception of heat loss

The intervention that modified shivering

- Insulation of the patient’s extremities of with 3 layers of terry cloth towels before the cooling began. A light blanket covered the trunk
- Wrappings formed long mittens and booties that kept skin of hands and feet warm as heat was lost from the trunk to the cooling blanket
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Shivering severity measurement

- Abbey’s first structured shivering severity index (SSI) published in 1973 (drawing on Hemmingway’s classic observations):
  - Shivering progression is cephalad to caudal recruitment of muscle groups
  - A 5-point scale (0-4) based on visible muscle involvement (progressing from masseter to full body & extremities)

Shivering follows cephalad to caudal progression

0. No shivering
1. Undetected tremors in masseters
2. Visible face/neck contractions
3. Visible chest/abdominal contractions
4. Extremity contractions

Discovery at the bedside: The mandibular hum

I. Observation of rewarming postop patients

II. Unexplained patterns on the ECG, patient in no distress

[Diagram showing intermittent muscle tremor artifact typical of shivering]
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Discovery at the bedside: The mandibular hum

I. Observation of rewarming postop patients
II. Unexplained patterns on the ECG, patient in no distress
III. Subtle vibrations felt over rim of mandible on either side
IV. Shivering ensues within 5-10 minutes

Research collaboration

Ralph Taggart Geer, MD.
Cardiovascular Anesthesiologist and Faculty
University of Pennsylvania College of Medicine

Measuring metabolic rate

Total body oxygen consumption (VO₂) and minute ventilation were measured. 
Inspiratory and expiratory air delivered to the metabolic cart from a piece 
attached to the ventilator tubing.

Calibrated metabolic cart
(Sensormedic, Fullerton CA, 1986)

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**Effects of increased oxygen consumption during rewarming after open heart surgery**

- **Purpose(s):**
  1. Describe changes in hemodynamic function related to changes in oxygen consumption following open heart surgery and hypothermic cardiopulmonary bypass during rewarming in the ICU.
  2. Determine how changes in oxygen consumption were related to the severity and duration of shivering during rewarming.

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**Effects of increased oxygen consumption during rewarming after open heart surgery**

- Descriptive: With correlational & comparative analyses
- 24 Patients having open heart surgery with HCPB: 39 to 86 years old
- ICU post-operative recovery unit

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**Effects of increased oxygen consumption during rewarming after open heart surgery**

- **Study objectives and variables:**
  - Hypothermia reduces oxygen requirement while heart is stopped.
  - Hypothermia also blocks thermoregulation so temperature falls further.
  - Anesthetic and neuroleptic agents block shivering and circulatory warming responses until they are reversed.
  - Although blood is warmed by bypass pump after surgery, it cannot replace lost heat when redistributed to hypothermic body tissue.
  - Ensuing shivering exerts a metabolic and cardiorespiratory toll.

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Correlates of shivering at different stages

- Mean age of SH was higher (66.8 vs. 54.4 years) than NS
- After 3 hrs, mean RT and PT higher in SH (37.2 vs. 36.3 °C)
- SH significantly increased VO2 (254 vs. 423 ml/min)
- Energy expenditure was positively correlated with PT

SH = shivering patients
NS = non-shivering patients
RT = rectal temperature
PT = pulmonary artery temperature

Study summary and conclusions

- Shivering is an important determinant of O2 consumption and metabolic rate in cardiac surgery patients after hypothermic bypass that is not compensated with cardiac output
- Findings suggest these changes lead to hemodynamic instability
- The validity of the shivering severity scale was supported by metabolic correlates during predictable progression of recruited muscle activity

Thermoregulatory implications considered

- Critical temperature levels for cardiac arrhythmias
- Effects of slower rewarming from hypothermia
- Loss of thermoregulatory function at hypothermic levels
- Awareness of shivering’s metabolic toll
- Awareness of clinical conditions that induce heat loss
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Evolving the research

Can you map out a research trajectory?

- Does a topic arouse your interest?
- Is there a potential mentor around to teach and test you?
- Is the topic researchable?
- Are you ready to take a deep dive into uncharted waters?

Relevant publications


AACN Advanced Critical Care. 16(2), 267-279.