

Final Performance Report

**Occupational Radiation and Energy-Related
Health Research Grants**

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I. ABSTRACT

Guidelines to monitor workers exposed to heat have been promulgated by the National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH) and the Environmental Protection Agency (EPA). In addition the Occupational Safety and Health Administration (OSHA) has developed a technical manual for employers. The adequacy of these guidelines to protect workers of various ages and health status needs further evaluation.

We examined the effects of heat on a group of middle-aged construction workers. In addition to monitoring heart rate, temperature and weight as recommended by existing guidelines, we examined neurobehavioral responses, urine osmolarity and pH, blood pressure and symptoms.

I. Significant Findings

Baseline characteristics of the 25 participants were that 18 were men, 7 were female; 20 were white, 3 were Hispanic and 1 was Asian, none were African-American; all had completed high school with 13 having at least some college education; age ranged from 25-56 with a mean of 40.3 years; 10 were obese (≥ 30 body mass index (BMI)), and 10 were overweight (≥ 25 BMI). There were 7 current smokers. Seven individuals indicated they never drink alcohol. Only 1 worker had ever had to be treated for problems with heat. When working in heat in the past: ten reported sometimes and 7 regularly feeling faint; 10 reported sometimes losing consciousness; 11 reported

sometimes and 2 regularly having blurred vision; 11 reported sometimes and 1 regularly having nausea and vomiting; 10 reported sometimes and 2 regularly having a growing feeling of panic. We considered the one individual who had seen a doctor for heat problems and anyone who reported any symptoms on a regular basis to have had history of problems. By this definition, 16 had no history of problems and 9 had. Twenty-three said they tolerated heat better and 2 said they more uncomfortable than most others. None said they easily and quickly get sick from heat. Ten said they knew more than most other people about the effects of heat and 15 about as much as anyone else. None said they were expert or didn't know very much about the effects of heat. Eleven participants said they had some chronic disease (5 heart disease, 2 asthma, 2 cancer, 2 high blood pressure, 2 hepatitis, 1 chest operation). Two individuals had multiple conditions. One worker reported not being in good health but reported no chronic conditions.

There was no correlation between average skin temperatures and changes in pH or specific gravity between pre and mid shift measurements or pre and post shift measurements. However, there were correlations of $r = .39$, ($P = .0468$) between the average morning wet bulb globe ambient temperature and an increase in the urine specific gravity, and a correlation $r = .47$ ($P = .007$) between the average daily wet bulb globe temperature and a decrease in the urine pH. For pre-post shift there was a significant correlation ($r = .31$, $P = .0495$) between the average afternoon wet bulb globe temperature and a decrease in the urine pH.

No correlation was found between morning or daily average wet bulb globe temperature and average morning or daily pulse, systolic or diastolic blood pressure. Similarly, there is no correlation between afternoon and daily average wet bulb ambient temperature and afternoon average pulse, systolic or diastolic pressure. Finally, there was no correlation between the morning, afternoon or daily ambient wet bulb globe temperature and the daily average pulse, systolic or diastolic blood pressure.

An inverse correlation was found with average morning and average daily skin temperature and average morning diastolic blood pressure ($r = -.47$, $p = .0114$ and $r = -.55$, $p = .001$, respectively). An inverse correlation was found with average daily skin temperature and average afternoon diastolic blood pressure ($r = -.4057$, $p = .0322$). Finally, an inverse correlation was found with average daily skin temperature and average daily diastolic blood pressure ($r = -.4057$, $p = .0322$). No significant correlations were found with systolic blood pressure or pulse and morning, afternoon or daily skin temperature.

II. Usefulness of Findings

This study was partially successful in demonstrating the ability to collect data on the potential effects of heat among an average working population. The study demonstrated it was technically feasible to collect the data but that full administrative support from the employer is necessary to carry out a study with this level of complexity of data elements.

Because of small sample and inadequate number of individuals working on hot days we are unable to demonstrate marked changes in relation to heat exposure. Changes were as expected with a correlation between measures of heat and an increase in urine osmolarity, decrease in urine pH and decrease in diastolic blood pressure. Relatively few people became symptomatic during their work in heat. Tables 1, 2 and 3 show changes in symptomatic individuals (cases) and asymptomatic individuals (controls).

Further work in assessing heat exposure in average workers under actual field conditions are needed to obtain sufficient sample size to reach meaningful conclusions about the adequacy of existing guidelines for protecting heat exposed workers.

III. Scientific Report

Specific Aims

1. Determine under actual working conditions of heat exposure what changes in neurobehavioral testing, blood pressure, pulse, temperature, hydration and symptoms are occurring.
2. Determine if there are correlations between neurobehavioral effects, physiological measures and symptoms.
3. Determine what factors predict changes in neurobehavioral effects, physiological measures or symptoms. The factors studied are ambient weather factors, level of protective equipment, level of work and personal factors of the workers.

Sample Selection

Volunteers were sought among unionized construction workers at the Hanford site. This was done at group meetings of the workers. The response was favorable and over 100 individuals volunteered to participate in the Spring of 1996. However, we were unable to obtain permission from the Department of Energy to begin data collection in the summer of 1996 and no data was collected until the summer of 1997. Because of difficulties in obtaining contractor cooperation, 17 workers participated in the summer of 1997, none in the summer of 1998 and 8 in the summer of 1999. Because an individual could participate on more than one day we have 48 days of data.

Data Collection

A mobile testing van was set up at Hanford near the actual work site. The instruction manual for the testing is contained in Appendix I.

Questionnaire

A baseline medical background questionnaire, and pre, mid and post shift questionnaires were developed. Copies are in Appendix II. The Army's standardized heat index questionnaire was the major source of the questions regarding symptoms.

Consent Form

The consent form used by participants is in Appendix III.

Data Analysis

The outline of the data analysis is in Appendix IV.

Add-On Study

The Occupational and Environmental Medical Program at Harborview Medical Center collected urine to measure mRNA response to heat stress.

A copy of their protocol is contained in Appendix V.

IV. Publications/Presentations

Presentations

Cameron W. Technical Meeting on Heat Stress. Los Alamos. 6/24-25/96.

Rosenman KD. United Brotherhood of Carpenters Health & Safety Fund. Science and Technical Advisory Committee Meeting. Palm Springs, California. 3/6/98.

Cameron W. United Brotherhood of Carpenter's Health & Safety Fund. Palm Springs, California. 3/22/97.

Cameron W. United Brotherhood of Carpenter's Health and Safety Fund. Washington, D.C. 11/19/98.

Cameron W, Anger K, Rosenman KD. Heat Stress. National Occupational Injury Research Symposium, Morgantown, West Virginia. 10/15-17/97.

Rosenman KD. Heat Stress Study. Sub-Tap for Worker Safety and Health. Hanford. 2/9-11/98.

Anger K, Cameron W, Rosenman KD. Physical and Neuropsychological Effects of Heat Exposure on Workers Wearing Protective Clothing

Table I – Comparison of Individuals Who Had Problems Concentrating on the Post-shift Questionnaire but not the Pre-shift Questionnaire (cases) versus Those without Chronic Problems (controls) Concentrating

		Δ Ph (pre- post)	A.M. systolic blood pressure	P.M. systolic blood pressure	Δ systolic blood pressure	A.M. diastolic blood pressure	P.M. diastolic blood pressure	Δ diastolic blood pressure
Day 1	Case	/	/	/	/	/	/	/
	Control	0.2	133.4	129.1	3.2	93.3	90.8	2.7
Day 2	Case	0.8	119.1	114.1	5.0	89.7	84.4	5.3
	Control	0.2	138.9	138.4	0.5	90.8	90.2	0.6
Day 3	Case	0.5	113.8	117.2	3.7	81.6	74.5	6.5
	Control	-0.2	142.3	147.4	-3.5	97.9	95.3	5.4

Table II – Comparison of Individuals Who Had Problems Remembering on the Post-shift Questionnaire but not the Pre-shift Questionnaire (cases) versus Those Without Chronic Problems (controls) Remembering

		Δ Ph (pre- post)	A.M. systolic blood pressure	P.M. systolic blood pressure	Δ systolic blood pressure	A.M. diastolic blood pressure	P.M. diastolic blood pressure	Δ diastolic blood pressure
Day 1	Case	-0.5	134.0	132.0	2.0	89.3	85.0	4.3
	Control	0.3	133.3	128.9	3.3	93.6	91.2	2.6
Day 2	Case	1.3	112.4	105.8	6.7	84.6	78.9	5.7
	Control	0.2	137.1	136.3	0.8	91.3	90.1	1.2
Day 3	Case	0.3	120.9	117.2	3.7	81.0	74.5	6.5
	Control	-0.1	133.4	147.4	-3.5	94.0	95.3	5.4

Table III – Comparison of Individuals Who Had Problems Thinking on the Post-shift Questionnaire but not the Pre-shift Questionnaire (cases) versus Those Without Chronic Problems (controls) Thinking

		Δ Ph (pre- post)	A.M. systolic blood pressure	P.M. systolic blood pressure	Δ systolic blood pressure	A.M. diastolic blood pressure	P.M. diastolic blood pressure	Δ diastolic blood pressure
Day 1	Case	/	/	/	/	/	/	/
	Control	0.2	133.4	129.1	3.2	93.3	90.8	2.7
Day 2	Case	1.3	119.3	111.2	8.2	87.7	81.7	6.0
	Control	0.2	135.2	134.1	1.1	90.7	89.2	1.5
Day 3	Case	0.3
	Control	-0.1	130.9	137.3	-1.1	91.4	88.3	5.8

Appendix I

Appendix II

<i>Filled in by Study Team</i>	
Date:	___/___/___
Participant ID#:	_____
Time Completed:	_____

HEAT STUDY
Baseline Medical Background Questionnaire

1. SEX: Male ___ Female ___

2. DATE OF BIRTH: ___/___/___
 Mo. Day Yr.

3. RACE:

White	___
Black	___
Hispanic	___
Asian	___
Other	_____

4. Have you smoked cigarettes? ___ Yes ___ No
 (yes means more than 20 packs of cigarettes or 12 oz. of tobacco in your life)
 If "no," go on to question 5. If "yes," answer questions 4a-4e

- 4a. Do you smoke now? ___ Yes ___ No
- 4b. How old were you when you started smoking regularly? _____
- 4c. If you stopped, how old were you when you stopped? _____
- 4d. How many packs per day do you smoke now? _____
- 4e. On the average, how many pack per day have you smoked? _____

5. Have you ever had to have medical treatment for heat exhaustion or heat stroke? Yes: ___ a. If "yes" how many times? ___
 b. What was the last year this happened? 19___

No: ___

6. Do you experience any of the following when you work in the heat?
- a. A period of feeling faint or dizzy? Never: Sometimes: Regularly: All the time:
 - b. Loss of consciousness? Never: Sometimes: Regularly: All the time:
 - c. Blurred vision? Never: Sometimes: Regularly: All the time:
 - d. Nausea or vomiting? Never: Sometimes: Regularly: All the time:
 - e. A growing feeling of panic? Never: Sometimes: Regularly: All the time:
7. How well do you tolerate working when it is hot? (Check the best answer)
- a. I tolerate the heat better than most other people.
 - b. I do about as well as most others in the heat.
 - c. I get more uncomfortable than most others in the heat.
 - d. I easily and quickly get sick in the heat.
8. How well informed are you about the effects of heat? (check the one best answer)
- a. I am an expert
 - b. I know more than most other people.
 - c. I know about as much as anyone else.
 - d. I don't know very much about the effects of heat.
9. Have you been told by a doctor you have:
- a. Emphysema? Yes: No: If yes, what year? 19__
 - b. Asthma? Yes: No: If yes, what year? 19__
 - c. Chest operations? Yes: No: If yes, what year? 19__
If yes, describe: _____
 - d. Chest injuries? Yes: No: If yes, what year? 19__
 - e. Angina? Yes: No: If yes, what year? 19__
 - f. Hepatitis? Yes: No: If yes, what year? 19__
 - g. Cirrhosis? Yes: No: If yes, what year? 19__
 - h. Cancer? Yes: No: If yes, what year? 19__
If yes, describe: _____
 - i. Diabetes? Yes: No: If yes, what year? 19__
If yes, how are you treated: Diet Pills Insulin
 - j. Kidney disease? Yes: No: If yes, what year? 19__
If yes, describe: _____

10. Has a doctor ever told you that you had a heart attack? Yes: ___ No: ___

11. Has a doctor ever told you that you had any other kind of heart trouble? Yes: ___ No: ___
If "yes," specify _____

12. Do you have irregular or skipped heart beats? Yes: ___ No: ___

13. Has a doctor ever told you that you had high blood pressure? Yes: ___ No: ___

14. Have you had any treatment for high blood pressure (hypertension) in the past 10 years? Yes: ___ No: ___
If "yes," please list what medication you take for this condition _____

15. List all medications you take on a regular basis (include those you can buy without a prescription). If you don't know the name, list what the pill is for (i.e., "heart pill" or "water pill," etc.): _____

List others on back of page

16. Do you drink alcohol? Yes: ___ No: ___
a. If "yes," on the average how many days a week? _____
b. If "yes," on the average when you drink how many drinks? _____
c. Do you usually drink (circle all that apply) Beer, Liquor, Wine.

17. Do you get any physical exercise other than that required to do your job? Yes: ___ No: ___
a. If "yes," what activities _____
b. If "yes," on the average how many days a week? _____
c. If "yes," on the average, when you exercise, how many minutes do you exercise? _____

18. How many years have you been working at your current job or similar type of work? _____

19. How many years have you been using a respirator? _____

20. How many years have you been wearing impermeable protective clothing? _____

21. Do you consider yourself to be in good health? Yes: ___ No: ___
If "no," state reasons: _____

Filled in by Study Team

Date: ___/___/___

Participant ID#: _____

Time Completed: _____

PRE-SHIFT QUESTIONNAIRE

1. Did you drink alcohol yesterday? Yes: ___ No: ___
If yes, what type? Beer (glasses, cans, or bottles)? Yes: ___ No: ___
If "yes," how many? _____
Liquor (shots)? Yes: ___ No: ___
If "yes," how many? _____
Wine (glasses)? Yes: ___ No: ___
If "yes," how many? _____

2. List any medicines you took yesterday or today (include those you can buy without a prescription). If you don't know the name, list what the pill is for (e.g., "heart pill," water pill," etc.) _____

3. Do you have a cold today? Yes: ___ No: ___
If "yes," do you have a fever? Yes: ___ No: ___
If "yes," took temperature with a thermometer? Yes: ___ No: ___
Results: _____
If "no," last cold ended:
This week: ___ This month: ___ More than a month ago: ___

4. Have you been having diarrhea more than a month? Yes: ___ No: ___
If "yes," how many times a day are you moving your bowels? _____
If "yes," how many days have you had diarrhea? _____

5. How do you feel now?
Great: ___ Good: ___ OK: ___ Rundown: ___ Awful: ___

6. Do you have a skin rash now? Yes: ___ No: ___
If "yes," where is the rash on your body? _____

7. a. Are you having problems remembering things now?
Yes: ____ No: ____
- b. Are you having problems concentrating now?
Yes: ____ No: ____
- c. Are you having problems thinking now?
Yes: ____ No: ____
8. How much sleep did you get last night?
Less than usual Usual More than usual (circle one)

Filled in by Study Team

Date: ___/___/___

Participant ID#: _____

Time Completed: _____

MID-SHIFT QUESTIONNAIRE

1. How do you feel?

Great: ___ Good: ___ OK: ___ Rundown: ___ Awful: ___

2. Do you have a skin rash now? Yes: ___ No: ___

If "yes," is it the same as pre-shift? _____

3. a. Are you having problems remembering things now? Yes: ___ No: ___

b. Are you having problems concentrating now? Yes: ___ No: ___

c. Are you having problems thinking now? Yes: ___ No: ___

4. Would you consider your work since the last questionnaire?

No physical work: ___ Light: ___ Moderate: ___ Heavy: ___

5. How much fluids have you drank since the last questionnaire? ___ glasses

6. HOW YOU HAVE BEEN FEELING DURING YOUR WORK SINCE THE LAST QUESTIONNAIRE. PLEASE ANSWER EVERY ITEM. If you did not have the symptom, check not at all.

a. I felt lightheaded.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

b. I had a headache.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

c. I felt dizzy.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

d. I felt faint.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

e. My coordination was off.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

f. I was short of breathe.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

g. It was hard to breath.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

h. My heart was beating fast.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

i. I had a muscle cramp.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

j. I had stomach cramps.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

k. I felt weak.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

l. I felt constipated.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

m. I felt warm.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

n. I was sweating all over.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

o. Parts of my body felt numb.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

p. My vision was blurry.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

q. I lost my appetite.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

r. I felt sick.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

s. I was thirsty.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

t. I felt tired.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

u. I felt irritable.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

v. I felt restless.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

During the work period you just completed (since you filled out the last questionnaire in this test room), please rate:

“How hard did you work?”

ON AVERAGE:

Very, Very Light _____

Very Light _____

Light _____

Moderate _____

Heavy _____

Very Heavy _____

Very, Very Heavy _____

AT YOUR PEAK:

Very, Very Light _____

Very Light _____

Light _____

Moderate _____

Heavy _____

Very Heavy _____

Very, Very ~~Light~~ _____

Heavy

Check one row in each column _____

<i>Filled in by Study Team</i>	
Date:	___/___/___
Participant ID#:	_____
Time Completed:	_____

POST-SHIFT QUESTIONNAIRE

1. How do you feel?
Great: ___ Good: ___ OK: ___ Rundown: ___ Awful: ___

2. Do you have a skin rash now? Yes: ___ No: ___
If "yes," where is the rash on your body? _____

3. a. Are you having problems remembering things now? Yes: ___ No: ___
b. Are you having problems concentrating now? Yes: ___ No: ___
c. Are you having problems thinking now? Yes: ___ No: ___

4. Would you consider your work since the last questionnaire?
No physical work: ___ Light: ___ Moderate: ___ Heavy: ___

5. How much fluids have you drank since the last questionnaire? ___ glasses

6. HOW YOU HAVE BEEN FEELING DURING YOUR WORK SINCE THE LAST QUESTIONNAIRE. PLEASE ANSWER EVERY ITEM. If you did not have the symptom, check not at all.
 - a. I felt lightheaded.
Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

 - b. I had a headache.
Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

 - c. I felt dizzy.
Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

 - d. I felt faint.
Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

e. My coordination was off.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

f. I was short of breathe.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

g. It was hard to breath.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

h. My heart was beating fast.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

i. I had a muscle cramp.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

j. I had stomach cramps.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

k. I felt weak.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

l. I felt constipated.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

m. I felt warm.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

n. I was sweating all over.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

o. Parts of my body felt numb.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

p. My vision was blurry.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

q. I lost my appetite.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

r. I felt sick.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

s. I was thirsty.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

t. I felt tired.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

u. I felt irritable.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

v. I felt restless.

Not at all: ___ Slight: ___ Somewhat: ___ Moderate: ___ Quite a bit: ___ Severe: ___

During the work period you just completed (since you filled out the last questionnaire in this test room), please rate:

“How hard did you work?”

ON AVERAGE:

Very, Very Light _____

Very Light _____

Light _____

Moderate _____

Heavy _____

Very Heavy _____

Very, Very Heavy _____

AT YOUR PEAK:

Very, Very Light _____

Very Light _____

Light _____

Moderate _____

Heavy _____

Very Heavy _____

Very, Very ~~Light~~ _____

Heavy

Check one row in each column _____

Appendix III

HEAT STRESS CONSENT FORM

I volunteer to be tested for the effects of heat. The purpose of this investigation is to learn more about the effects of heat. I will benefit from the activity because I will be informed of the results which may identify medical problems I need to address.

I understand that I will complete a medical history questionnaire, my physical fitness level and body density will be measured, neurological testing will be performed, my urine will be measured for signs of dehydration and I will complete a questionnaire on how I am feeling. This testing will be done at the beginning, throughout, and at the end of the day. Testing will be done on 3-4 working days and perhaps on one non-working day. There is minimal risk for the tests. There is no risk for the questionnaire, neurological, urine, pulse, ear, oral, skin temperature or body density testing. The neuralgic testing will consist of me sitting in front of a computer and performing activities such as tapping my finger, or remembering numbers. I will also be asked to squeeze a gauge to measure hand strength and to stand on a platform to measure balance. The urine testing will measure my hydration before, during and after work. If I agree to a supplementary urine test by signing a separate consent form, my urine will also be tested for the activity of proteins that are altered by heat. Urine samples will not be used for any other purpose. Body density will be measured with small calipers that measure skin fold thickness. The skin will be pinched between the calipers on my arm, back, and chest for males, and the arm, hip and abdomen for females. There is no pain or risk from this measurement. To test my physical fitness, I will be asked to ride an exercise bicycle. This test, which is similar to tests conducted at the YMCA, will be done to a submaximal level, and will be stopped if I develop chest pain or other symptoms. As with any exercise, there is the risk of precipitating a heart attack.

I agree to participate with the understanding that:

1. I will be paid my contractual rate of pay for all work time that I spend on this study, including extra time before or after my normal work shift. If I participate on non-working days I will receive an amount equal to one and one-half times my regular hourly rate for each hour that I participate.
2. I will receive a copy of my results in a timely manner.
3. My results will be kept confidential.
4. My participation is voluntary and I am free to discontinue my participation at any time with no negative consequence to me.
5. The information from my test and those of others will be summarized and issued as reports. These reports will be written to keep all information about me and others confidential.

6. This testing is limited and does not replace a general medical exam.

7. I can contact Buck Cameron at (206) 935-7748 at any time to ask questions about this project and its current status.

8. If I am injured while participating in the study, I need to seek emergency care as I normally would with a job-related injury. The study has no funds to provide emergency or long-term care.

My Name is (Print)

Witness Name (Print)

My Signature

Witness Signature

Date

Date

Supplemental Heat Study Consent Form

As part of an investigation of the activity of proteins affected by heat I agree to allow researchers at the University of Washington to take cells from the urine sample which I will already have provided for the United Brotherhood of Carpenters'(UBC). No additional samples will be taken.

Currently there is no health benefit to knowing the activity level of these proteins, known as heat shock proteins, and therefore individual results will not be available to me. I understand that these investigators will never know my identity. They will not be able to connect any information about my urine cell proteins to my name.

If I leave a name and mailing address below, Dr. Takaro, the Principal Investigator at the University of Washington will provide summary information at the conclusion of the study describing what was learned about protein activation under heat stress with the information pooled from all participants. Leaving my name below will not affect the confidentiality agreement in the paragraph above.

I agree that my urine, discarded following analysis for the UBC Heat Study may be used for the heat shock protein investigation noted above and for no other purpose. I understand that I may withdraw this consent at any time.

My name is (please print)

Witness's name (print)

My signature

Witness's signature

Date

Date

Optional: Please mail summary results to me at this address:

Street address or P.O. Box

City, State, Zip

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Appendix IV

Outline of Plan for Data Analysis

For the purpose of data analysis we will be grouping the data in the following manner:

Risk Factors

Ambient Temperature

1. Average for period worked
2. Maximum for period worked
3. Average for the 1 hour immediately preceding testing
4. Maximum for the 1 hour immediately preceding testing

Skin Temperature

1. Average for period worked
2. Maximum for period worked
3. Average for the 1 hour immediately preceding testing
4. Maximum for the 1 hour immediately preceding testing

Ear Temperature

1. Average for period worked
2. Maximum for period worked
3. Average for the 1 hour immediately preceding testing
4. Maximum for the 1 hour immediately preceding testing

Oral Temperature

Difference between pre and mid; and pre and post shift temperature

Work Load

Time weighted averages measured in calories will be calculated from observations of work recorded every 15 minutes.

Protective Equipment

Wearing impermeable clothing - yes versus no
Wearing respirator - yes versus no

Outcomes

1. Differences in scoring on behavioral tests performed pre and mid shift, and pre and post shift on hot work days versus control days.
2. Differences in urine osmolarity and ph done pre and mid shift; and pre and post shift on hot work days versus control days.
3. Differences in average pulse and maximum pulse on hot work days versus control days.
4. Differences in average and maximum systolic blood pressure on hot work days versus control days.
5. Differences in average and maximum diastolic blood pressure on hot work days versus control days.

6. Outcomes from questionnaires

- A. Differences between pre and mid; and pre and post shift on hot work days versus control days for the following questions:

How do you feel
Skin rash
problems remembering
problems concentrating
problems thinking

- B. Differences on mid-shift between hot work days and control days

Number of symptoms indicated severe
Number of symptoms indicated quite a bit
Number of symptoms indicated moderate
Number of symptoms indicated somewhat
Number of symptoms indicated slight

- C. Differences on post-shift between hot work days and control days

Number of symptoms indicated severe
Number of symptoms indicated quite a bit
Number of symptoms indicated moderate
Number of symptoms indicated somewhat
Number of symptoms indicated slight

Confounders

Obesity - Body Mass Index > 30 versus ≤ 30

Physical fitness - 3 categories: Above average-excellent versus average versus very poor-below average

Base Line Questionnaire:

1. Current Cigarette Smoker
Question 4a yes versus no
2. History of Problems Working in Heat
Question 5 yes, or 6a,b,c,d,e
regularly or all the time versus
Question 5 no or 6a,b,c,d,e
never or sometimes
3. Tolerate Heat
Question 7 - c or d versus a or b
4. Knowledgeable about Heat
Question 8 - c or d versus a or b
5. Chronic Disease
yes on Question 9a or b or c or d or e or f or g or h
or i or j or Question 10 or Question 11
or Questions 13
6. Drink Alcohol
Question 16 yes and 16 a 3 or more, versus
Question 16 yes and 16 1-3 versus
Question 16 no

7. Job Experience
Question 18 - ≤ 1 year, versus 1-5
years versus > 5 years
8. Overall Health
Question 21 yes versus no

Pre-Shift Questionnaire

9. Drink Alcohol Yesterday
Question 1 yes versus no
10. Cold
Question 3 yes versus no
11. Diarrhea
Question 4 yes versus no
12. Overall Health
Question 5 yes versus no
13. Sleep
Question 8 less than usual versus
usual or more than usual

Appendix V

**OCCUPATIONAL & ENVIRONMENTAL
MEDICINE PROGRAM**

325 9th Ave., MS 359739
Seattle, WA 98104

Office: (206)731-3005
Fax: (206)731-8247



18 July 1996

Dear Ken:

The attached is our protocol for this summer's pilot project. Please let me know if there are areas which need further clarification.

I sent you some e-mail re: the human subjects issue. The UW IRB will most likely only require a supplement to your MSU human subjects application. I will draft a separate consent form for the UBC as you requested. Please send a copy of your HS application and protocol so we can coordinate this effort. My Seattle address is attached.

The weather here in Richland is nice and cool the past two days. No doubt the summer has more hot days ahead. We are looking forward to working with you.

Regards,

Tim Takaw

Tim

cc: Buck Cameron

PROTOCOL FOR HEAT STRESS INDUCED mRNA RESPONSE

The purpose of this project is to determine the feasibility of measuring mRNA response to heat stress in a working population under exertion. Uro-epithelial cells would be harvested from routine urine collections and the mRNA activity analyzed in the Kavanagh lab at the University of Washington. Subjects would be workers at the Hanford Nuclear Reservation's Tank Farms, with urine collected for a NIOSH/DOE study on heat stress. This summer's pilot would involve approximately 20 workers.

BACKGROUND

Cellular heat response can be characterized by either direct protein damage or by the up regulation of protein synthesis including aberrant proteins. Families of heat shock proteins (HSPs) have been described, which are now generally categorized as a subset of stress proteins(1). New techniques in molecular biology have made study of gene regulation of HSPs possible, opening up an exciting area of cellular toxicology. mRNA induction can be used as a fingerprint of both physical (heat) and chemical exposure with characteristic gene responses for each class of exposure. This "fingerprinting" is best characterized for chemical exposure(2).

Previous techniques to quantify mRNA induction have relied upon somewhat tedious and expensive techniques (Northern hybridization, slot blot or reporter gene expression) which do not allow many simultaneous mRNA species to be analyzed. Our technique utilizes restriction landmark cDNA scanning (RLCS) on a two-dimensional gel similar to that described by Suzuki, et al (3).

STUDY POPULATION & METHODS

The study population has been organized by Dr. Ken Rosenman at Michigan State University with cooperation from the United Brotherhood of Carpenters. The workers are from the United States Department of Energy's Hanford Reservation tank farm. This desert steppe along the Columbia River often has summer temperatures above 90 degrees Fahrenheit. Because of the extremely hazardous contents of these tanks, and their poor characterization, fully self-contained occlusive suits are often worn during work in this area.

Voided urine samples will be collected before and after the work shift. Following measurement of specific gravity and pH the sample will be centrifuged and the cell pellet collected and resuspended in a solution containing RNase inhibitors. The resuspended cells would then be frozen on dry ice.

Ideally this preparation step will occur immediately following the void in the field. Cells can remain viable in fresh urine for a short period (30-60 min.) so that transport under refrigeration to a near-by laboratory may be possible.

Frozen cells then will be transported by express mail to the Kavanagh Lab in Seattle for sorting and analysis. Commercially available and locally produced cDNA stress response gene probes will be used to characterize induction of the stress response in uro-epithelial cells. The probes will include genes coding for the heat stress proteins of the Hsc70 family and more general stress response genes such as thiol glutathione, Gadd43, Gadd153 and p21(Waf1). Because there is wide variation in the species and quantity of mRNA induction depending upon cell type, we hope to identify the stress genes which are most responsive in the transitional uro-epithelial cells harvested in a routinely voided urine sample.

While the small number of samples in this pilot may preclude obtaining statistically significant comparisons, we will analyze any intra-individual differences before and after the workshift. We will also look for a relationship between the extent of exposure and the degree of mRNA induction. Because many oxidizing and alkylating chemicals also cause stress response induction, we will attempt to establish whether chemical exposures confound the heat response in this population. We are hopeful that this pilot project will lead to a larger study of mRNA induction of HSPs next year allowing for more meaningful analyses.

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1. Hightower, LE, Heat shock, stress proteins, chaperones and proteotoxicity. Cell 66: 191-197, 1991.
2. Todd MD, Lee MJ, Williams JL, Nalezny JM, Gee P, Benjamin MB and Farr SB, The CAT-Tox(L) assay: a sensitive and specific measure of stress-induced transcription in transformed human liver cells. Fundamnetals of Applied Tox.. 28: 118-28, 1995.
3. Suzuki H, Yaoi T, Kawai J, Hara A, Kuwajima G and Wantanabe S, REstriction landmark cDNA scanning (RLCS): a novel cDNA display system using two-dimentional gel electrophoresis. Nucleic Acids Res. 24: 289-296, 1996.



Memorandum

Date: April 30, 2001

From: Roy M. Fleming, Sc.D., Director, Research Grants Program Rmf
Office of Extramural Programs, NIOSH, D30

Subject: Final Report Submitted for Entry into NTIS for Grant 5 R01 CC317874-03.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment

cc: Sherri Diana, EID, P03/C13

List of Publications

NIOSH Extramural Award Final Report Summary

Title: Study of Heat Stress and Performance in Carpenters at DOE Sites
Investigator: Wilfrid Cameron
Affiliation: Center to Protect Worker's Rights
City & State: Washington, DC
Telephone: (206) 935-7748
Award Number: 5 R01 CC317874-03
Start & End Date: 9/30/1995–9/29/2000
Total Project Cost: \$545,446
Program Area: Not NORA
Key Words:

Abstract:

Guidelines to monitor workers exposed to heat have been promulgated by the National Institute for Occupational Safety and Health (NIOSH), the American Conference of Governmental Industrial Hygienists (ACGIH) and the Environmental Protection Agency (EPA). In addition the Occupational Safety and Health Administration (OSHA) has developed a technical manual for employers. The adequacy of these guidelines to protect workers of various ages and health status needs further evaluation.

We examined the effects of heat on a group of middle-aged construction workers. In addition to monitoring heart rate, temperature and weight as recommended by existing guidelines, we examined neurobehavioral responses, urine osmolarity and pH, blood pressure and symptoms.

Baseline characteristics of the 25 participants were that 18 were men, 7 were female; 20 were white, 3 were Hispanic, 1 was Asian, and none were African-American; all had completed high school with 13 having at least some college education; age ranged from 25-56 with a mean of 40.3 years; 10 were obese (≥ 30 body mass index (BMI)), and 10 were over-weight (≥ 25 BMI). There were 7 current smokers. Seven individuals indicated they never drink alcohol. Only 1 worker had ever had to be treated for problems with heat. When working in heat in the past, ten reported sometimes and 7 regularly feeling faint, 10 reported sometimes losing consciousness, 11 reported sometimes and 2 regularly having blurred vision, 11 reported sometimes and 1 regularly having nausea and vomiting, and 10 reported sometimes and 2 regularly having had a growing feeling of panic. We considered the one individual who had seen a doctor for heat problems and anyone who reported any symptoms on a regular basis to have had history of problems. By this definition, 16 had no history of problems and 9 had. Twenty-three said they tolerated heat better and 2 said they more uncomfortable than most others. None said they easily and quickly get sick from heat. Ten said they knew more than most other people about the effects of heat and 15 about as much as anyone else. None said they were expert or did not know very much about the effects of heat. Eleven participants said they had some chronic disease (5 heart disease, 2 asthma, 2 cancer, 2 high blood pressure, 2 hepatitis, 1 chest operation). Two individuals had multiple conditions. One worker reported not being in good health but reported no chronic conditions.

There was no correlation between average skin temperatures and changes in pH or specific gravity between pre and mid shift measurements or pre and post shift measurements. However, there were correlations of $r = .39$, ($P = .0468$) between the average morning wet bulb globe ambient temperature and an increase in the urine specific gravity, and a correlation $r = .47$ ($P = .007$) between the average daily wet bulb globe temperature and a decrease in the urine pH. For pre-post shift there was a significant correlation ($r = .31$, $P = .0495$) between the average afternoon wet bulb globe temperature and a decrease in the urine pH.

No correlation was found between morning or daily average wet bulb globe temperature and average morning or daily pulse, systolic or diastolic blood pressure. Similarly, there is no correlation between afternoon and daily average wet bulb globe temperature and afternoon average pulse, systolic or diastolic pressure. Finally, there was no correlation between the morning, afternoon or daily ambient wet bulb globe temperature and the daily average pulse, systolic or diastolic blood pressure.

An inverse correlation was found with average morning and average daily skin temperature and average morning diastolic blood pressure ($r = -.47$, $p = .0114$ and $r = -.55$, $p = .001$, respectively). An inverse correlation was found with average daily skin temperature and average afternoon diastolic blood pressure ($r = -.4057$, $p = .0322$). Finally, an inverse correlation was found with average daily skin temperature and average daily diastolic blood pressure ($r = -.4057$, $p = .0322$). No significant correlations were found with systolic blood pressure or pulse and morning, afternoon or daily skin temperature.

This study was partially successful in demonstrating the ability to collect data on the potential effects of heat among an average working population. The study demonstrated it was technically feasible to collect the data but that full administrative support from the employer is necessary to carry out a study with this level of complexity of data elements.

Because of small sample and inadequate number of individuals working on hot days we are unable to demonstrate marked changes in relation to heat exposure. Changes were as expected with a correlation between measures of heat and an increase in urine osmolarity, decrease in urine pH and decrease in diastolic blood pressure. Relatively few people became symptomatic during their work in heat.

Further work in assessing heat exposure in average workers under actual field conditions are needed to obtain sufficient sample size to reach meaningful conclusions about the adequacy of existing guidelines for protecting heat exposed workers.

Publications

No publications to date.