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 ($\geq$ 30 body mass index (BMI)), and 10 were overweight ($\geq$ 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 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 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 glove 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 because 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

		ΔPh (pre-post)	A.M. systolic blood pressure	P.M. systolic blood pressure	Δsystolic blood pressure	A.M. diastolic blood pressure	P.M. diastolic blood pressure	Δdiastolic 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

		ΔPh (pre-post)	A.M. systolic blood pressure	P.M. systolic blood pressure	Δsystolic blood pressure	A.M. diastolic blood pressure	P.M. diastolic blood pressure	Δdiastolic 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

		ΔPh (pre-post)	A.M. systolic blood pressure	P.M. systolic blood pressure	Δsystolic blood pressure	A.M. diastolic blood pressure	P.M. diastolic blood pressure	Δdiastolic 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