Statens arbeidsmiljøinstitutt

Work in cold environments

19.05.11

National institute of occupational health,
Norway

Heat loss

Radiation
All objects emit electromagnetic waves (radiation).

Conduction = Heat transmission
Skin in direct contact with medium with large heat transmission ability (conductivity). Water has 25 X higher heat transmission ability (conductivity) than air. This is the background for much quicker cooling in water.
Holding a tool made of metal, one loses heat through the tool.

Convection = Transport of heat by movement in surrounding medium
Layer near skin is heated by conduction. When this layer is transported away, it is replaced by cold air (or water if submerged) which is heated. Heat is lost.

Heat loss by evaporation of sweat
Evaporation of water or other liquid requires energy.
If vapour transported away (convection), energy is lost, i.e. one loses heat.

Heat loss in respiration
Inspiratory air is heated in the airways to body temperature (37°C), expiratory air emits heat to the environment.

Statens arbeidsmiljøinstitutt

ADAPTATION RESPONSES

Response patterns: built-in programs ready for action

1. Alters attention and vigilance	
2. Readiness for emergency action	
3. Greater endurance	Energy supply priority
4. Specific responses	Cold Heat Hemorrhage Diving

Adaptation to cold

Reduce heat loss

Stop sveating

Reduce skin temperature
Close temperature regulating vessels in skin.

Produce heat

Shivering
Rapid, rythmic muscle contractions which produce heat.

Adrenalin-stimulation of heat production in muscles
The contribution of this mechanism not decided in humans.

Activation of brown fat
Sympathetic nervous activity activates brown fat or similar enzyme in muscle.

Thyroxine (T4) or T3 increases metabolic rate
The brain (hypothalamus) produces TSH which stimulates the thyroid gland to produce T4 and T3.

Statens arbeidsmiljøinstitutt

Background: Effects of working in cold envrionments

- Effects of local cooling
- Effects of general cooling - Hypothermia

Statens arbeidsmiljøinstitutt

Background: Effects of working in cold envrionments

Research on adaptation to cold:
Physiology: mechanisms for adaptation
Animal experiments

Young healthy humans: submersion in water
cold air, light clothing
cold water in face/splash

Medicine/physiology: mechanisms and treatment to increase the survivial of cells in conditions with low oxygen

Statens arbeidsmiljøinstitutt

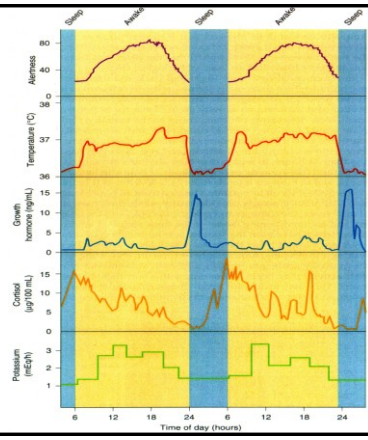
Background: Effects of working in cold envrionments

Work in petroleum industry

- Work periods last > 8 hrs - employees are not rested
- Work at night - Shift work
- Not all employees are healthy and young (students/soldiers)

Statens arbeidsmiljøinstitutt

Diurnal rythms
(Circadian rythms)



Effects of working in cold environments

Methods for searching and evaluating the research literature

work (work OR workload OR work'* OR worka* OR worke* OR worki* OR workl* OR workp* OR occupation* OR job*)

AND

cold (cold temperature OR frostbite)

LIMIT (human) for search until 2008, no limit for 2008-2010

RESULT: 1895 scientific articles
280 of which seemed relevant and were studied
50 articles contained relevant investigations

Statens arbeidsmiljøinstitutt

Effects of working in cold environments

Methods for searching and evaluating the research literature

Cold and cognitive function:

Cold cognitive function

RESULT: 338 scientific articles
The most relevant articles were studied

2 reviews with meta analysis

Statens arbeidsmiljøinstitutt

Cold tolerance during long-lasting work periods

Only 2 articles found:

Soldiers (mean 20 yrs age): 4 groups:
Sleep 2 hrs/day: Low *vs* high level physical activity
Sleep 6 hrs/day: Low *vs* high level physical activity
Results: Reduction Thyroid Stimulating Hormone

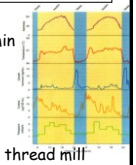
Students: Climate chamber 15 °C for 1-5 days
Results: Reduction Blood volume, Reduction exercise performance

Conclusion: There is no knowledge of cold tolerance during long-lasting work periods.

Statens arbeidsmiljøinstitutt

Cold tolerance during night work or shift work and the importance of diurnal rhythms for cold tolerance

Only 4 articles found:
Young healthy men: Climate chamber – 25 °C for 3-20 min
Night (03-05) *vs* Afternoon (15-17)
Results: Night exposure: Reduction perceived cold
Reduced manual dexterity
Elevated skin temperature



Healthy subjects (mean 27 yrs): Climate chamber 0 °C: thread mill
Sleep deprivation 50 hrs *vs* normal sleep.
Results: Rectal temp lower after sleep deprivation, but increased more during exercise.

2 studies on working in the arctic region studied sleep problems only.

Conclusion: There is no knowledge of cold tolerance during night- or shift work.

Statens arbeidsmiljøinstitutt

Adaptation during long-term cold exposure
Seasonal variations

Only 8 articles were included:
Cold-room workers (– 20 °C)
Results: Faster skin response to cold.

Cold-room exposure 1 hr per day for 11 days:
Results: No change in neuroendocrine response to cold.
Cold-room exposure 2 hrs per day for 11 days:
Results: Reduced cold perception, reduced skin temperature.

Studies on seasonal variations show variaton in thyroid hormones and little systematic variation in effects of cold on cognitive function.

Conclusion: There seems to be some adaptation of cold perception.
Cold adaptation may be slightly better in the summer.
There is little knowledge of adaptation during long-term cold exposure.

Statens arbeidsmiljøinstitutt

Cold tolerance in senior workers

Only 3 articles were relevant:

Men 62-70 yrs vs 20-29 yrs: Cold water exposure fingers (10 °C):
Results: Older group exhibited slower skin response to cold.

Members Antarctic expedition (n=12, 26-52 yrs): 2 hrs at 10 °C:
Results: Larger heat loss with increasing age.

Inuits, hunterers:
Results: Reduced repiratory function > 40 yrs old.

Conclusion: The cold tolerance is lower in increasing age.
There is no knowledge of the age at which cold tolerance is reduced.

Statens arbeidsmiljøinstitutt

Sex differences in cold tolerance

9 articles were somewhat relevant:

Different studies of different exposures and populations have produced seemingly conflicting results.

There may be effects of hormones and menstrual cycle.

It seems that cooling is faster in women, probably due to larger body surface/weight.

Men may tolerate handling cold tools better than women do?

Conclusion: The possiblity that there may be sex differences should be tested systematically.

Statens arbeidsmiljøinstitutt

Cognitive functions

Definition: Processing of information.
Attention and perception, ability to process information, ability to make decisions (choice), memory, problem solving.

What is investigated (measured)?

- Ability to maintain attention (vigilance)
- Pattern recognition
- Working memory
- Ability to process information through several senses concomitantly
- Ability to process conflicting information
- Ability for logical reasoning
- Ability for parallell processing of information

Method problem: Many tests require use of hand(s).
Cold can affect muscle nerves and muscle function.

Statens arbeidsmiljøinstitutt

Cognitive functions in cold environment

Moderate short-lasting cold

Sympathetic nerve activity + adrenalin	⬆
Ability to maintain attention (vigilance)	⬆
Ability for fast reactions	⬆
General effects on the central nervous system	?
Effects on nerves + muscles: abiliy for tasks demanding precisie movements	⬇
Distress ("freeze") influence attention and concentration	⬇
Shivering influence attention and concentration	⬇

Strong long-lasting cold producing hypothermia

Ability for parallell processing of information	⬇
Severe hypothermia: general judgement	⬇ Confusion

Conclusion: Inadequate knowledge to conclude of the temperature and duration of cold exposure for cognitive functions to be reduced.

Statens arbeidsmiljøinstitutt

Cold tolerance in persons with medical conditions

Raynaud's fenomen:
Cold exposure precipates pain.

Angina pectoris:
Cold temperatures may lower threshold for attack.

Coronary heart disease:
Cold may lower threshold for myocardial infarction?

Statens arbeidsmiljøinstitutt

Effects of working in cold environments

General conclusions:

Cold exposure produces biphasic effects on cognitive function.

Inadequate knowledge to draw conclusions on:

- Temperature and duration of cold exposure for cognitive functions to be reduced
- Cold tolerance during long work periods
- Cold tolerance during night work
- Cold tolerance during shift work
- Age when cold tolerance is reduced
- Sex differences in responses to cold exposure