National Park Service Risk Management Division and
U.S. Fish and Wildlife Service Division of Safety and Health

Heat Injury Prevention:
Cool Ideas On A Hot Topic!

Participant Guide

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How to Interact with the Instructor

We encourage you to ask questions and share your comments with the instructors throughout this TELNPS course.

If you were physically in the classroom with the instructor, you would raise your hand to let him know you had a question or comment. Then you would wait for the instructor to recognize you and ask for your question. We are all familiar with that "protocol" for asking questions or making comments.

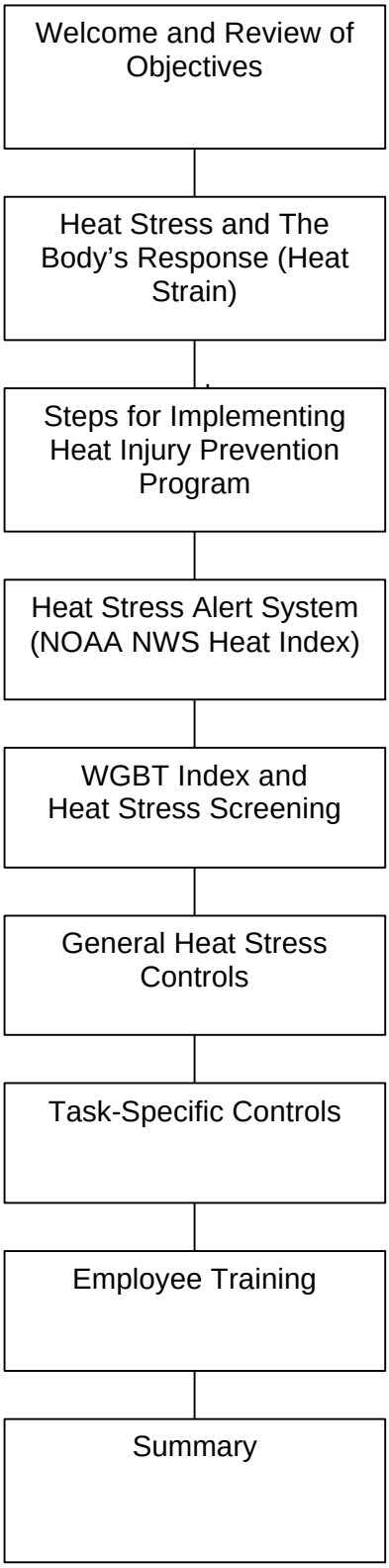
With TELNPS courses there is also a "protocol" to follow to ensure you can easily ask questions and others can participate as well. It may seem a little strange at first asking a question of a TV monitor. Remember, it is the instructor you are interacting with and not the monitor. As you ask more questions and participate in more TELNPS courses, you will soon be focusing only on the content of your question and not the equipment you are using to ask it.

As part of the TEL station equipment at your location, there are several push to talk microphones. Depending on the number of students at your location, you may have one directly in front of you or you may be sharing one with other students at your table.

When you have a question, press the push to talk button and say,
"Excuse me [instructor's first name], this is [your first name]
at [your location]. I have a question (or I have a comment)."
Then release the push to talk button. This is important.
Until you release the button, you will not be able to hear the instructor.

The instructor will acknowledge you and then ask for your question or comment. Stating your name and location not only helps the instructor, but also helps other students who are participating at different locations to get to know their classmates.

Heat Injury Prevention: Cool Ideas on a Hot Topic!
Course Map



Course Objectives

Notes

At the conclusion of this course, you should be able to:

1. Define heat stress and heat strain.
2. Describe the body's mechanisms for regulating its core temperature.
3. List heat stress factors that can put a strain on the body.
4. List the six action steps in implementing a heat injury prevention program.
5. Demonstrate how to use the National Oceanic and Atmospheric Administration's (NOAA) heat index to determine the increased risk of prolonged exposure or physical activity.
6. Calculate the WBGT index for a given set of environmental conditions.
7. Demonstrate how to use the WBGT index for Heat Stress Screening.
8. Demonstrate how to conduct physiological monitoring.
9. Determine when general heat stress controls must be implemented. Give several examples of general heat stress controls that can be implemented.
10. Determine when task-specific control must be developed and implemented. Give several examples of task-specific controls.
11. List the topics that should be included when training employees how to prevent heat injuries.

What are the conditions and factors that contribute to heat injury?

"How hot is it outside?" is the first thing many people ask to determine if there is danger of heat injury. However, there are other factors that contribute to a situation where an employee may be at serious risk of suffering a heat injury. List the things that you think could contribute to a heat injury.

_____

_____

Heat Stress and the Body's Response

National Institute for Occupational Safety and Health (NIOSH) Heat Strain Study

Could this have been your park?

- "Every ranger had heat strain, which means that their heart rates and/or body temperatures were so high during parts of their work shifts that they were in danger of becoming seriously ill."
- "There were not enough rangers to work when other rangers needed to rest or get used to the heat."
- "There is no formal heat stress management program at the park."

Heat stress is the net heat load to which a worker may be exposed from the combined contributions of metabolic heat generated during work, environmental factors (air temperature, humidity, air movement, and radiant heat) and clothing requirements.

Heat Strain

Heat stress can create a strain on the body. Heat strain is the overall physiological response resulting from heat stress.

Heat Stress and the Body's Response (cont)

Notes

Heat Balance Equation
(What factors affect your body's ability to regulate its temperature?)

Heat Gain/Loss = Metabolic Heat
– Evaporation
± Convective Heat
± Conductive Heat
± Radiant Heat

What is Metabolic Heat?

Working muscles generate heat (metabolic heat). When the body uses carbohydrates, fats, or proteins for energy, about 75% of the energy stored in these compounds is released as heat.

If metabolic heat is not removed the temperature of the body core will rise.

Evaporation

- Evaporation of sweat is primary method for removing heat in humans
- Your body may be able to sustain sweat rates as high as 1 liter/ hour for 8 hours
- Complete evaporation of 1 liter of sweat in 1 hour would result in ____ kcal of heat loss
- High humidity reduces evaporation

Convection

- Transfer of heat by the flow of some fluid (liquid or gas)
- Convection heat loss in the body through blood circulation or water/air across the skin
- Transfer is dependent on difference in temperature – a thermal gradient

Conduction

- Direct transfer of heat when a hotter and colder object are in contact
- Dense materials such as metals are best conductors of heat
- Example: Water, much more dense than air, is 23 times more conductive than air

Radiation

- Electromagnetic transfer of energy without direct contact
- The sun transfers heat to the body through radiation
- The body will lose heat through radiation

Heat Stress and the Body's Response (cont)

Notes

The following table has examples of heat generated during work (metabolic heat):

Activity	Kcal/Hour
Keyboarding, standing quietly	108
Seated writing	120
Driving tractor	150
Sheet metal work	198
Carpet sweeping, wallpapering	200
General carpentry	210
Welding	210
Raking	222
Mopping floors	252
Scraping and painting	260
Vacuuming	264
Feeding animals	264
Tapping and drilling	265
Laundry	270
Planting seedlings	288
Using chain saw	305
Plastering	320
Walking, smooth road	325
Shoveling grain	348
Erecting mine supports	360
Forestry hoeing	372
Drilling rock	384
Walking 4 mph	396
Shoveling coal	438
Mowing	456
Trimming Trees	528
Felling Trees	540
Barn Cleaning	552
Digging Trenches	594
Hiking, steep terrain, fast pace	660
Fast Choping with Ax	1212

Heat Stress and the Body's Response (cont)

Notes

Heat Exhaustion - Symptoms

- Fatigue, nausea, headachy, giddines
- Skin clammy and moist, complexion pale
- May faint on standing
- Rapid pulse and low blood pressure
- Oral temperature normal or low but rectal temperature usually elevated
- Urine volume small, concentrated

Heat Exhaustion - Predisposing Factors

- Sustained exertion in heat
- Lack of acclimatization
- Failure to replace water lost in sweat dehydration
- Depletion of circulating blood volume
- Competing demands for blood flow to skin and to active muscles

Heat Stroke – Symptoms

- Failure of sweat mechanism
- Hot dry skin (red, mottled or cyanotic)
- Rectal temperature 104 or greater
- Confusion, loss of consciousness, convulsions
- Rectal temp continues to rise
- Fatal if treatment delayed

Heat Stroke – Predisposing Factors

- Sustained exertion in heat by unacclimatized workers
- Lack of physical fitness and obesity
- Recent alcohol intake
- Dehydration
- Individual susceptibility
- Chronic cardiovascular disease

Heat Stroke – Treatment

- Immediate and rapid cooling
  - immersion in chilled water
  - wrapping in wet sheet with vigorous fanning
- Avoid overcooling
- Treat shock if present

Hyponatremia

- Water intoxication
- Loss of electrolytes
- Hyperhydration
- Symptoms include dizziness, muscle cramps, nausea and altered mental status

Who Is At Greater Risk?

Notes

Glenn

Glenn is a gardener at a park in the Southeast Region. Today he is outside pruning shrubberies, mowing grass areas (with push mower), and using a gas powered weed trimmer. He is wearing a summer work uniform with lightweight trousers and long-sleeved shirt for protection against scratches from the shrubs. He has been working outside for 3 hours and is sweating profusely. He is well acclimatized to the environmental conditions.

Sky Conditions: Partly Cloudy
Temperature: 88° F
Relative Humidity: 80%

Water Consumption: ½ liter in 3 hours

Karl

Karl is a park protection ranger at a park in the Intermountain Region. Today he is hiking up and down steep terrain at a brisk pace to check on park visitors along a popular trail. He is wearing a summer work uniform with short-sleeved shirt and shorts. He has been hiking for 3 hours and is sweating moderately. He is not acclimatized to the environmental conditions, having just transferred to the park within the last week. His previous job was working in a visitor's center at a park in the Pacific West Region.

Sky Conditions: Clear and sunny
Temperature: 94° F
Relative Humidity: 20%

Water Consumption: 1 liter in 3 hours

Does Glenn or Karl face a greater risk of heat injury?

Using the thermo-balance equation and what we have discussed about heat illness, determine who you feel is at greater risk of heat injury. What factors did you consider in deciding? Be prepared to share your answers.

_____

_____

Implementing Heat Injury Prevention Steps

Notes

1. Establish a “Heat Stress Alert System”
2. Conduct heat stress screening
3. Conduct physiological monitoring
4. Implement general heat stress controls
5. Implement task-specific controls
6. Train employees

Heat Stress Alert System

Notes

- Alerts employees to potential heat stress and need to initiate actions
- Allows parks to easily identify and anticipate conditions that may result in increased heat stress potential
- National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Heat Index of 105° F or higher requires general heat stress controls

Why it feels hotter HEAT INDEX > Air temperature + relative humidity = apparent temperature

HEAT INDEX (apparent temperature)

Air Temperature (°F) \ Relative Humidity (%)	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	121	126	132					
94	97	100	103	106	110	114	119	124	129	135			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	96
80	80	80	81	81	82	82	83	84	84	85	85	86	87

With Prolonged Exposure and/or Physical Activity
Possible heat disorders for people in higher risk groups

- EXTREME DANGER > Heat stroke or sunstroke highly likely
- DANGER > Sunstroke, muscle cramps, and/or heat exhaustion likely
- EXTREME CAUTION > Sunstroke, muscle cramps, and/or heat exhaustion possible
- CAUTION > Fatigue possible

Source: National Oceanic & Atmospheric Administration

Glenn and Karl – What is the Heat Index?

Refer to the weather conditions for Glenn and Karl (page 8). Using the NOAA Heat Index chart, determine what the heat index is for each situation. Based on the heat index, which worker is at greater danger with prolonged exposure and physical activity?

Glenn: Heat Index = _____

Karl: Heat Index = _____

Wet Bulb Globe Temperature (WBGT) Index and Heat Stress Screening

Notes

- Step 1 Measure Environmental Heat
- Step 2 Determine Metabolic Heat
- Step 3 Determine Worker Acclimatization.
- Step 4 Determine Whether Screening Criteria Have Been Exceeded

Step 1: Measure Environmental Heat

WBGT Index = 0.7 Tnwb + 0.2 Tg + 0.1 Tdb + Clo

Tnwb = natural wet bulb temperature

Tg = globe temperature

Tdb = dry bulb (air) temperature

Clo = clothing value

Table B1. Additions to WBGT Values for Some Clothing Ensembles

Clothing Type	WBGT Addition
Summer work uniform*	0
Cloth (woven material) overalls	Add 6 ^{o}F
Double-cloth overalls	Add 9 ^{o}F

*Traditional work uniform consisting of a long-sleeved shirt and pants. Adjustment to the WBGT Index have been determined for some clothing ensables. For example, shorts or seminude -2C/4F; permeable water barrier +6C/11F; Gortex +6C/11F; Tyvek full suit +10C/18F.

Wet Bulb Globe Temperature (WBGT) Index and Heat Stress Screening (cont)

Notes

STEP 2: Determine Metabolic Heat

Table B2 Metabolic Heat

Categories	Example Activities	Metabolic Rate kcal/hr
Resting	Sitting quietly	100
Light	Sitting with moderate arm movements Sitting with moderate arm and leg movements Standing with light work at machine or bench while using mostly arms Using a table saw Standing with light or moderate work at machine or bench and some walking about	113-140 140-160 140-160
Moderate	Scrubbing in a standing position Walking about with moderate lifting or pushing Walking on level at 3.5 mph while carrying 3 kg weight load	165-190 250-350
Heavy	Mowing with push mower Carpenter sawing by hand Shoveling dry sand Heavy assembly work on a noncontiguous basis Intermittent heavy lifting with pushing or pulling (e.g. pick-and-shovel work)	380-500
Very Heavy	Hiking, steep terrain at moderate to fast pace Shoveling wet sand	500-600

STEP 3: Determine Worker Acclimatization

- Refers to physiological adjustment to heat stress conditions
- Full acclimatization requires up to 3 weeks
- Loss may begin within 4 days
- Considered acclimatized if recent history of heat-stress exposure, such as 5 of the last 7 days.

Wet Bulb Globe Temperature (WBGT) Index and Heat Stress Screening (cont)

STEP 4: Determine Whether Screening Criteria Have Been Exceeded

Table B3. WBGT Index (ºF) Screening for Heat Stress Exposure

	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	85.1	81.5	78.8	Conduct physiological monitoring	81.5	77	72.5	Conduct physiological monitoring
75% Work 25% Rest	86.9	83.3	81.5	Conduct physiological monitoring	84.2	79.9	76.1	Conduct physiological monitoring
50% Work 50% Rest	88.7	85.1	83.3	81.5	86	82.4	79.9	77
25% Work 75%Rest	90.5	87.8	86	85.1	87.8	84.2	82.4	79.5

Glenn and Karl – Who Exceeds the Screening Criteria?

Review the information on Glenn and Karl (page 8). Using the following additional information (temperatures in deg F), determine if either employee exceeds the screening criteria.

Glenn Tnwb = 78 Tg = 92 Tdb = 88

Karl Tnwb = 70 Tg = 115 Tdb = 94

Physiological Monitoring

Notes

- Direct monitoring of heat strain
- Uses heart rate, recovery heart rate and core body temperature as key measurements
- Additional measurements include weight loss and skin temperature
- Monitoring equipment available
- Sustained heart rate >180 bpm
- Recovery heart rate > 110 bphCore body temperature > 101.3° F
  - healthy, unmedicated, acclimatized workers
- Core body temperature > 100.4° F
  - unacclimatized workers
- Sudden and severe fatigue, nausea, dizziness or light headedness

General Heat Stress Controls

Notes

Must be implemented when:

- Heat stress is elevated and risk of excessive heat strain exists
- The Heat Index is 105° F or greater
- WBGT heat stress screening criteria are exceededProvide verbal and written instructions
- Encourage drinking of water
- Permit self-limitation of exposures
- Encourage co-worker observation
- Proper worker acclimatization
- Counsel and monitor medicated workers
- Encourage healthy life-styles
- Adjust expectations of returning workers
- Pre-placement medical screeningRequired for workers in environments that exceed WBGT screening criteria
- Performed under direction of licensed physician or health care provider

Glenn and Karl –
What general heat stress controls would you use?

Review the information on Glenn and Karl (page 8). Select either Glenn or Karl and then identify some general heat stress controls that you feel would be effective in helping to prevent heat injury. What is it about the controls that you chose that makes you feel they will be effective?

Be prepared to share your answers.

Task-Specific Heat Stress Controls

Notes

Must be implemented when:

- Workers are at high risk of increased heat stress due to work environment
- Workers are at high risk of increased heat stress due to required PPE
  i.e. HAZMAT emergency responders, firefighters
- Engineering controls that reduce metabolic rate, provide air movement, reduce process heat and shield radiant heat
- Administrative controls that set acceptable exposure times
- Effective personal protection

- Cool the general work environment
- Reduce humidity
- Increase air velocity
- Lower metabolic rate
  - Slower work rate
  - Mechanical assistance
- Adjust clothing
- Add micro-environmental cooling
- Provide radiant shielding
- Provide cool location/spot-cooling for rest breaks
- Provide plenty of fluids

Employee Training

Employee training must include the following topics:

- Recognition of the signs and symptoms of heat strain (Appendix B)
- Personal care procedures
- Effect of non-occupational factors such as alcohol use, medication, obesity and other health factors
- Proper care and use of heat protective equipment and clothing

Appendix A: Helpful Resources

NPS Risk Management
http://www.nps.gov/riskmgmt/

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Appendix B Recognition, Medical Aspects and Prevention of Heat Illness

Illness	Recognition, Clinical Features	Predisposing Factors	Physiological Basis	First Aide and Treatment	Prevention
Heat Stroke	Hot dry skin usually red, mottled or cyanotic; rectal temperature 104 or >; confusion, loss of consciousness, convulsions, rectal temp continues to rise, fatal if treatment delayed	Sustained exertion in heat by unacclimatized workers Lack of physical fitness and obesity Recent alcohol intake; Dehydration; Individual susceptibility; Chronic cardiovascular disease	Partial or complete failure of sweat mechanism leading to loss of evaporative cooling and uncontrolled rise in body temperature	Immediate and rapid cooling by immersion in chilled water with massage or by wrapping in wet sheet with vigorous fanning with cool dry air, avoid overcooling, treat shock if present	Medical screening of workers, selection of workers for tasks based on health and physical fitness, acclimatization, monitoring of workers during sustained work in severe heat.
Heat syncope	Fainting while standing eret and immobile in heat	Lack of acclimatization	Pooling of blood in dilated vessels of skin and lower parts of body	Remove to cooler area, ret in recumbent position, recovery prompt and complete	Acclimatization, , intermittent activity to assist venous return to heart
Heat exhaustion	Fatigue, nausea, headachy, giddiness; skin clammy and moist, complexion pale, muddy, or hectic flush; may faint on standing with rapid thready pulse and low blood pressure; Oral temperature normal or low but rectal temperature, usually elevated; water restriction types: urine volume small, highly concentrated; salt restriction type: urine less concentrated	Sustained exertion in heat; lack of acclimatization ; and failure to replace water lost in sweat	Dehydration form deficiency of water; depletion of circulating blood volume; circulatory strain from competing demands for blood flow to skin and to active muscles	Remove to cooler environment, rest recumbent position, administer, fluids by mouth, keep at rest until urine volume indicates that water balances have been restored	Acclimatize worker using a break-in schedule for 5-7 days, supplement dietary salt only during acclimatization, ample drinking water to be available at all times and to be taken frequently during work day
Heat Cramps	Painful spasms of muscles used during work (arms, legs, or abdominal); onset during or after work hours	Heavy sweating during hot work; drinking large volumes of water without replacing salt loss	Loss of body salt in sweat, water intake dilutes electrolytes, water enters muscles, causing spasm	Salted liquids by mouth or more prompt relief by IV infusions	Adequate salt intake with meals; in unaclimatized worker supplement salt intake at meals
Heat rash	Profuse tiny raised red vesicles (blister-like) on affected areas pricking sensations during heat exposure	Unrelieved exposure to humid heat with skin continuously wet with unevaporated sweat	Plugging of sweat gland ducts with retention of sweat and inflammatory reaction	Mild drying lotions, skin cleanliness to prevent infection	Cool sleeping quarters to allow skin to dry between heat exposures
Anhidrotic heat exhaustion	Extensive areas of skin which do no sweat on heat exposure, but present gooseflesh appearance, which subsides with cool environments; associated with incapacitation in heat	Weeks or months of constant exposure to climatic heat with previous history of extensive heat rash and sunburn	Skin trauma (heat rash; sunburn) causes sweat retention deep in skin, reduced evaporative cooling causes heat intolerance	No effective treatment available for anhidrotic areas of skin, recovery of sweating occurs gradually on return to cooler climate	Treat heat rash and avoid further skin trauma by sunburn, periodic relief form sustained heat
Heat Fatigue—transient	Impaired performance of skilled sensorimotor, mental, or vigilance tasks, in heat	Performance decrement greater in unacclimatized and unskilled workers	Discomfort and physiologic strain	Not indicated unless accompanied by other heat illness	Acclimatization and training for work in the heat
Heat fatigue—chronic	Reduced performance capacity, lowering of self-imposed standards of social behavior (e.g. alcoholic over-indulgence). Inability to concentrate	Workers at risk come from temperate climates, for long residence in tropical latitudes	Psychosocial stresses probably as important as heat stress, may involve hormonal imbalance but not positive evidence	Medical treatment for serious cases, speedy relief of symptoms on returning home	Orientation to life in hot regions (customs, climate, living conditions, etc.)