Framework for Heat Stress Management --

A tour of the 2022 ACGIH® TLV® for Heat Stress and Strain

(Notice of Intended Change)

NORA Seminar Series
16 September 2022

NORTH CAROLINA
Occupational Safety and
Health Education
and Research Center

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A tour of the 2022 ACGIH® TLV® for Heat Stress and Strain (Notice of Intended Change)

Thomas E Bernard | 16 September 2022

USF Health UNIVERSITY of SOUTH FLORIDA

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Special Thanks

To those with whom I have worked

- USF, USF College of Public Health, and sponsors of my work
- CDC/NIOSH and Sunshine Education and Research Center
- ACGIH® and ISO Committees to which I contributed
- Faculty, staff, students and the many study participants
  - Candi D. Ashley and Ximena P. Garzón

Notice: All opinions are mine

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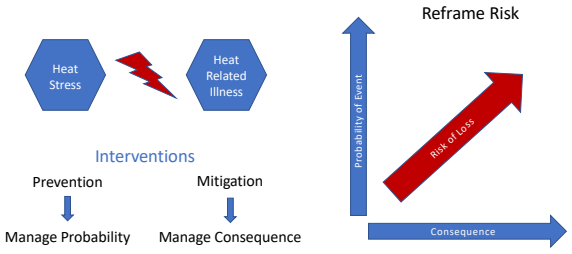
Treat Heat-Related Illness as Loss Event



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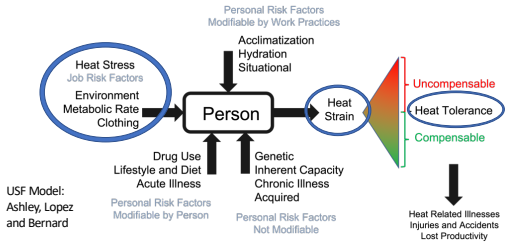
Conceptual Model for Individual Heat Tolerance



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For this webinar, I will rift on …

New TLV for Heat Stress and Strain (NIC)

My opinions about some topics

- I trust that you will be able to tell when I am offering opinion

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Updated TLV®

Principal Pieces

- The Warning
- Introduction to TLV's Key Points
- Evaluation Process
- Heat Stress Management Program

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Warning

The TLV® is based on the ability of most healthy hydrated acclimatized workers to sustain thermal equilibrium.

The Action Limit (AL) is similarly prescribed for healthy hydrated unacclimatized workers.

This TLV has a small margin of safety, and some workers may experience heat-related disorders below the TLV and the AL.

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Exertional Heat Illness

Probability of exertional heat illness increases with environmental heat and humidity

- Outdoor (mostly agriculture): 75% of heat disorders above 90 °F-HI (~28 °C-WBGT)
- Meta-analysis: Warm/Hot Work v Neutral: RR = 4
- Aluminum smelting (OR_{ModHS} = 20 and OR_{HighHS} = 80)
- Sports (OR = 7 between below and above 23 °C-WBGT)
- Outdoor work (Gulf Cleanup: OR = 1.4/°C-WBGT for >20 °C)
- Military training (OR = 4 between below and above 23 °C-WBGT)
- Emergency Department Admissions (14% increase / 1°F air temperature)

That is, there is an exposure-response relationship

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Carry-Over Effect

Previous Day

- US Marine Corps Training
- Deepwater Horizon Gulf Clean-up
- Firefighter Training

Multiple Day

- Emergency Department Cases from Five States (3- to 4-day influence)
- Aluminum Plants in Middle East (3-day weighted average)

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OSHA Activity

Notice in Federal Register about notice to initiate rulemaking

- https://www.federalregister.gov/documents/2021/10/27/2021-23250/heat-injury-and-illness-prevention-in-outdoor-and-indoor-work-settings

OSHA has established the Heat Injury and Illness Prevention Work Group of the National Advisory Committee on Occupational Safety and Health (NACOSH)

- https://www.osha.gov/heat-exposure/heat-injury-and-illness-prevention-work-group

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Introduction

Goal

The TLV

Definitions

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Goal

Sustainable Exposures for Most Healthy Workers

- Most healthy workers can maintain thermal equilibrium

Premise: Increasing core temperatures due to loss of thermal equilibrium are associated with heat exhaustion and heat stroke.

Not considered for TLV: Increased probability of judgment errors, acute injury, and adverse incidents.

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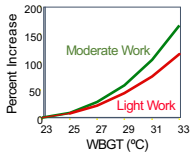
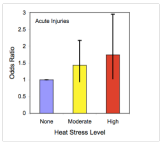
Increased Injuries

Increase in Unsafe Behaviors

Acute injuries in Aluminum Smelter

See also analysis of published papers by June Spector, et al. (2019) that demonstrates relationship between ambient heat stress and frequency of severe injury





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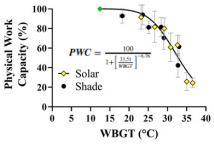
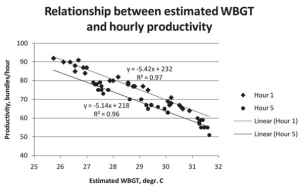
Loss of Productivity





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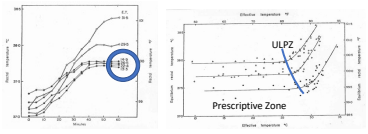
Lind's Observation (1963)

Upper Limit of the Prescriptive Zone (ULPZ): Transition from Work-Driven to Environment-Driven Core Temperature



LIND AR. A physiological criterion for setting thermal environmental limits for everyday work. Journal of Applied Physiology 18:51-56, 1963

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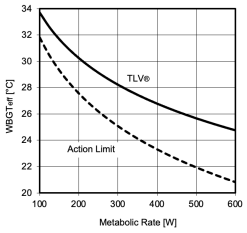
The One and Only TLV and AL

$TLV_{[°C]} = 56.7 - 11.5 \log_{10} M_{[W]}$

$AL_{[°C]} = 60.0 - 14.1 \log_{10} M_{[W]}$

$WBGT_{eff} = WBGT_{obs} + CAV$

Any other representation (e.g., a table) is an approximation at best.



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Wet Bulb Globe Temperature

$WBGT = 0.7\ T_{nwb} + 0.3\ T_g$

Except in direct sunlight,
$WBGT = 0.7\ T_{nwb} + 0.2\ T_g + 0.1\ T_{db}$

WBGT Index reflects effects of air temperature, humidity, hot surfaces and air motion. That is, C+R and E_{max}.

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Metabolic Rate Categories

Light (Reference Rate: 180 W)
- < 235 W
- sitting, standing, light hand/arm work

Moderate (Reference Rate: 300 W)
- 235 - 350 W
- walking, moderate lifting

Heavy (Reference Rate: 415 W)
- 350 - 470 W
- heavy materials handling

Very Heavy (Reference Rate: 520 W)
- 470 - 800 W
- pick and shovel work

Most Common Approach

Potential Error
- Broad Range
- Over-Estimation

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Clothing Adjustment Values (ACGIH® TLV® 2022)

Clothing Ensemble	CAV [° C-WBGT]
Work Clothes	0
Cloth Coveralls	0
Double Layer Cloth Clothing	3
Shorts and Short-Sleeved Shirt	-1
SMS Coveralls	0.5
Polyolefin Coveralls	1
Limited-Use Vapor-Barrier Coveralls with Hood	11

Note: Respirator Face Masks Have No Effect

Other CAVs Available

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Time-Weighted Average

$$\text{TWA-WBGT}_{eff} = \frac{WBGT_{eff1} \times t_1 + \cdots + WBGT_{effn} \times t_n}{t_1 + \cdots + t_n}$$

$$\text{TWA-M} = \frac{M_1 \times t_1 + \cdots + M_n \times t_n}{t_1 + \cdots + t_n}$$

Over nominal one-hour time period.

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Benefits of Acclimatization

Enhanced Cooling
- Earlier onset of sweating
- Greater rate of sweating
- More dilute sweat

Cost: Greater loss of body water

Lower Cardiovascular Strain
- Increased fluid volume
- Greater temperature gradient

Lower Core Temperature

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Notes on Acclimatization

Considered acclimatized if there were at least 2 h of work under heat stress for 5 of the last 7 days.

Noticeable loss after 4 days of no exposures to heat stress

Complete loss at 3 weeks of no exposures to heat stress

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Heat Stress Management Program

Sets Workplace Policies
- Training, heat stress hygiene practices, surveillance, physiological monitoring, emergency plan

General Controls
- Training, heat stress hygiene practices, policy on acclimatization, policies on recognizing heat-related symptoms and first aid, and emergency planning

Job Specific Controls
- Traditional hierarchy of controls

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Evaluation Process

Trigger Point

Four Methods
- Screening Criteria
- TLV Analysis
- Advanced Heat Stress Evaluation
- Heat Strain and Physiological Monitoring

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Trigger

Any one of the following
- Reports of discomfort or other symptoms associated with heat stress
- Professional judgment indicates heat stress conditions
- Heat Index or air temperature > 27 °C (80 °F)

Establish HSMP and Implement General Controls

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Evaluation Method 1

Apply Screening Criteria

Unacclimatized

%Work	L	M	H	VH
75 to 100	28.1	25.0	--	--
50 to 75	28.7	26.0	24.2	--
25 to 50	29.3	27.2	25.7	24.6
0 to 25	30.0	28.8	27.8	27.0

Acclimatized

%Work	L	M	H	VH
75 to 100	30.8	28.2	--	--
50 to 75	31.2	29.0	27.6	--
25 to 50	31.8	30.1	28.8	27.9
0 to 25	32.3	31.3	30.5	29.8

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Evaluation Method 2

Use the TLV and AL Equations or Figure
- Task Analysis
- TWAs

This is the actual application of the TLV exposure assessment

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Evaluation Method 3

Use an advanced heat stress evaluation method

Specifically mentioned
- Predicted Heat Strain (PHS) (ISO/DIS 7933.2)
- US Army Heat Stress Decision Aid

Any published method that has been validated

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Evaluation Method 4

Heat Strain and Physiological Monitoring

Unacceptable Levels
- Sustained Heart Rate > 180 – Age
- Measured or estimated body core temperature increase > 1 °C from a baseline of 37.5 °C or less
- Recovery Heart Rate at one minute after a peak exertion > 120 bpm

Regardless of physiological status, an exposure should stop with signs or symptoms of heat exhaustion or heat stroke, or with a request to stop

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Heat Stress Management Program

General Controls

Job Specific Controls

Personal Risk Factors

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General Controls

Training
Heat Stress Hygiene Practices
Policies
Environmental Surveillance
Medical Clearance and Counseling
Emergency Response Plan

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Job Specific Controls

Engineering controls to reduce or eliminate heat stress

Administrative controls to manage exposures

Personal cooling to facilitate heat dissipation

Physiological monitoring

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Personal Risk Factors

Remind workers that personal risk factors may reduce their level of heat tolerance

Inform health care providers of their exposure to heat stress and seek appropriate counseling

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Heat Stress Management

A bit more

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Heat Stress Management Topics

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Written Program

The heat stress management program ties the policy, science, and practice together.

The written program helps provide the line of sight from the organization's key person on heat stress to the front lines.

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Written Policies

Fundamental principle of occupational health and safety programs

Policies Specific to Heat Stress Management Program

- Individual Discretion over Exposure
- Acclimatization
- Early Recognition and First Aid of Heat Disorders

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Essential Interventions

- Training
- Hygiene Practices
- Surveillance — Environmental; Medical
- Heat-Related Disorders — Recognition and First Aid; Emergency Response

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Training

Training helps provide the line of sight for OHSW to the workers and supervisors.

When
- Annually, in anticipation of heat stress
- Follow-up refresher(s)

How
- Typical training program format
- Heat Stress Alert

What
- Heat stress and heat strain
- Heat-related disorders
- Heat stress hygiene practices
- Policies on self-determination and acclimatization
- Discussion of site countermeasures

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Heat Stress Hygiene Practices

- Self-Determination
- Fluid Replacement
- Lifestyle and Diet
- Health Status
- Acclimatization / Expectations

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Hygiene Practice: Health Status

Chronic Disease

- Consult with health care provider
- Clearly inform provider of heat stress exposure
- See Medical Review handout

Acute Illness

- Consider anything that may cause fever, dehydration or the use of any prescription or OTC medication (e.g., flu, vomiting, allergies, etc.)
- Stay home or report it to supervisor (presenteeism problem)
- Restricted exposures may be prudent course
- Some sort of "readiness for work" query (e.g., sleep and appetite)

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Alternative Acclimatization Schedule Plus-Up on Observed WBGT

		Day 1	Day 2	Day3	Day 4
Unacclimatized	New employee; Away for a week or more due to illness; Absent for 3 weeks	+2.5 °C	+1.5 °C	+1.0 °C	Practically Acclimatized
Mostly Unacclimatized	Away for less than a week due to illness; Absent for 2 weeks	+1.5 °C	+1.0 °C	Acclimatized	Acclimatized
Somewhat Unacclimatized	Absent for 1 week	+1.0 °C	Acclimatized	Acclimatized	Acclimatized
Some Caution	Absent less than 1 week	Reduce Expec-tations	Acclimatized	Acclimatized	Acclimatized

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Surveillance

Environmental
- Provide some guidance on trigger points for different actions

Medical
- Chronic Disease: At least advice to seek counselling from health care provider (see handout)
- Acute Illness: Report it to supervisor who may restrict exposures

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Medical Surveillance

Review Illness and Injury Logs
- Look for sentinel events

Acute Illness: Have a plan to deal with presenteeism
- Good public health practice

Chronic
- Individuals advise their personal healthcare provider of exposure to heat stress as part of the job

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Monitoring for Signs and Symptoms

Bernard (and Tustin): Many reported cases of heat-related illness may be a mix of job and personal risk factors.
- Someone has to be the least tolerant of heat stress in your workforce; and it may not be the same person each day.
- And on that day that person may also have personal risk factors
- It is hard to know who this person might be on that day

Monitoring of signs and symptoms is the essential backstop.

Never work without a buddy; and both must be able to easily communicate with the other.

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Notes on Recognition and Treatment

Act early and error to the side of thinking there is a problem where none exists.

Heat stroke depends on early recognition of signs.
- The person will not come up to you and say they have heat stroke.

Any time a worker experiences a fainting spell or other form of collapse, medical approval for return to work is advised.

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Just Thinking …

Given: In military, sports, and occupational settings, the rate of heat-related incidents goes up with environmental conditions.

Why, under conditions of well-managed heat stress, does the rate of heat-related illnesses increase?
- More of the less heat tolerant population are experiencing heat-related disorders
- Carry-over effects reduce the effectiveness of interventions

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Special Thanks

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Medical Review for Employees Exposed to Heat

During the medical and physical examination, specific concerns related to heat tolerance are

- water and electrolyte management (renal, endocrine and gastrointestinal functions)
- cardiac output and distribution to musculature and skin
- sweating (skin integrity and sweat gland function)
- thermal regulation (CNS and peripheral nervous system)
- previous episodes of heat-related disorders

Health History

- Cardiac
- Vascular
- Respiratory
- Neurologic
- Renal
- Hematologic
- Gastrointestinal
- Endocrine
- Skin (e.g., chronic damage, anhidrosis)
- Heat-related disorders (based on follow-up questions: single case of heat stroke (some people will report experiencing heat stroke when it is heat exhaustion), repeated episodes of heat exhaustion, or general reports of not tolerating heat well)

Prescription Medications (see annex for possible mechanism)

- Psychotropics
    - Phenothiazines
    - Tricyclic antidepressants (e.g., imipramine, amitriptyline, protriptyline)
    - Lithium
    - Amphetamines, cocaine, ecstasy
    - Haloperidol
    - Anticonvulsants
    - Others (e.g., MAOIs, benzodiazepines)
- Anticholinergics (e.g., benzotropine, trihexyphenidyl)
- Antispasmodics
- Antihistamines
- NSAIDs (long term and/or high dose)
- Diuretics
- Laxatives
- Calcium channel blockers (e.g., amlodipine, verapamil)
- Beta blockers (atenolol, betaxolol)
- Levothyroxine
- Anticholinergics (e.g., benzotropine, trihexyphenidyl)
- Narcotics
- Barbiturates
- Ergogenic stimulants (e.g., ephedrine/ephedra)

OTC Medications and Supplements

- Antihistamines

- Analgesics (high dose and/or long-term use) (e.g., acetaminophen (impaired liver function); aspirin and NSAIDs (impaired renal function))
- Laxatives
- Ergogenic stimulants (e.g., ephedrine/ephedra)

Drugs of Abuse

- Ethanol
- CNS stimulants such as amphetamines, cocaine, ecstasy
- CNS depressants such as barbiturates

Drug Annex

Prescription Drugs

Drug	Effect on Heat Tolerance
Phenothiazines	Impaired sweating, (possibly) disturbed hypothalamic temperature regulation
Tricyclic antidepressants (e.g., imipramine, amitriptyline, protriptyline)	Impaired sweating, increased motor activity and heat production
Lithium	Nephrogenic diabetes insipidus and water loss
Amphetamines, cocaine, ecstasy	Increased psychomotor activity, activated vascular endothelium
Haloperidol	Tachycardia, altered central temperature regulation, and hyponatremia
Other psychotropics as a general class (e.g., anticonvulsants, MAOIs, benzodiazepines)	Impaired thermoregulation
Antispasmodics	Impaired sweating
Anticholinergics (e.g., benztropine, trihexyphenidyl)	Impaired sweating
Antihistamines	Impaired sweating
Analgesics (e.g., acetaminophen, aspirin, NSAIDs) (long term use)	Liver or kidney damage
Diuretics	Salt (sodium and/or potassium) depletion and dehydration
Laxatives	Dehydration
Calcium channel blockers (e.g., amlodipine, verapamil)	Reduced skin blood flow and reduced blood pressure
Beta blockers (atenolol, betaxolol)	Reduced skin blood flow, reduced blood pressure, and impaired sweating
Levothyroxine	Excessive sweating, salt depletion and dehydration
Anticholinergics (e.g., benztropine, trihexyphenidyl)	Impaired sweating
Narcotics	Excessive sweating, salt depletion and dehydration
Barbiturates	Reduced blood pressure
Ergogenic stimulants (e.g., ephedrine/ephedra)	Increased heat production

Other-the-Counter Medications and Supplements

Drug	Effect on Heat Tolerance
Antihistamines	Impaired sweating
Analgesics (e.g., acetaminophen, aspirin, NSAIDs)	Liver or kidney damage
Laxatives	Dehydration
Ergogenic stimulants (e.g., ephedrine/ephedra)	Increased heat production

Other Drugs and Drugs of Abuse

Drug	Effect on Heat Tolerance
Ethanol	Diuresis, possible effects on intestinal permeability, impaired thermoregulation
CNS stimulants such as amphetamines, cocaine, ecstasy	Increased psychomotor activity, activated vascular endothelium, impaired thermoregulation
Central nervous system depressants such as barbiturates	Reduced blood pressure, impaired thermoregulation

Heat Illness Response Guideline

Presented in order of decreasing urgency. One or more indicators in a category indicate a positive determination for that category.

Observations	Determination and Action
Severe Fatigue or Vomiting – Watch for other signs of heat stroke while starting treatment for severe heat exhaustion. *You may see* Obvious Fatigue Erratic / Irritable Behavior Confusion / Disorientation Garbled / Gibberish Speech Hysteria / Delirium / Apathy Collapse Convulsions Unconscious	**Heat Stroke** ***Emergency Response*** Begin aggressive cooling (cover in ice or place in cold/ice water bath). If ice is not available, other methods of cooling are flushing water over person from hose or shower; or keep the skin wet and fanning. Call emergency services and advise them that it is a heat stroke case. Note: You need to know where you are and how to get EMS there.
You may see Unsteady Walking Slow Reaction Times Obvious Fatigue Severe Muscle Cramps Vomiting *Person may say they have* Severe Fatigue Loss of Appetite Nausea Headache	**Severe Heat Exhaustion** Move to air-conditioned space, encourage water/electrolyte drink if able, and allow to lay down. Optional: Cover head and shoulders with a towel soaked in cold water. Watch for signs of heat stroke. If recovery is not progressing in 15 min, arrange for medical treatment and continue to watch for possible heat stroke.
Person may say they feel Tired / Fatigued Thirsty Weak Dizzy or lightheaded, particularly with change in posture to upright position or prolonged standing Muscle cramps	**Mild Heat Exhaustion** Inform supervisor Recovery in cool area Drink water with salty snack and/or electrolyte drink If symptoms persist after 15 min, treat as severe heat exhaustion

31 May 2022