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MEDICAL GROUP

OPEN JOURNAL OF Pediatrics and Child Health OPEN ACCESS JOURNAL

ISSN: 2640-7612 DOI: https://dx.doi.org/10.17352/ojpch

Research Article

Extremes of Weather Conditions and Child Health

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Received: 01 July, 2024
Accepted: 05 July, 2024
Published: 06 July, 2024

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Keywords: Ambient temperature; Heat; Severe cold; Weather; Climate; Thermoregulation; Prickly heat; Heat exhaustion; Heat stroke; Dehydration; Hyperthermia; Hypothermia

Abstract

Background: The number of people exposed to extreme heat is growing exponentially due to climate change worldwide. Heat-related mortality for people over 65 years of age and young children has increased by 85% between 2000–2004 and 2017–2021. World Meteorological Organization announced that there's an 80% chance that the world will exceed the 1.5 °C temperature limit in at least one of the next 5 years.

Aim: To review the impact of extremes of climate changes on Children's health based on cases managed and reported in media.

Methods: Material & Methods: This article is a review of the impact of extremes of heat & Cold weather on children, based on personal handling of cases and media reports of the adverse effects of heat this summer, exercising /punishing children in hot and cold weather.

Key findings: Most children experience increased thirst, weakness, headache, dizziness or fainting, muscle cramps, nausea and/or vomiting, irritability, prickly heat & heavy sweating. Dehydration in children is more than just being thirsty, as it is a condition where there isn't enough fluid in the body because children lose more water than they take in. High heat stress also reduces physical work capacity and motor-cognitive performances, with consequences for school attendance for children. The cold weather itself doesn't cause illness, but it weakens the immune system, making it a lot harder for the child to fight off infections.

Conclusion: Temperatures above long-term averages during summer months and heatwaves are associated with cardiorespiratory and other diseases and mental health issues. Very young children are particularly vulnerable to the effects of heat, irrespective of income level or geographical region. Most heat-related mortality and morbidities are preventable with individual efforts like avoidance of exposure, improved community preparedness, and Public Health Advisory.

Introduction

Weather reflects short-term conditions of the atmosphere while climate is the average daily weather for an extended period at a certain location. Heat is the flow of thermal energy between objects with different temperatures, whereas temperature is a measure of how hot or cold an object is relative to another object. Heat is an important environmental and occupational health hazard. High heat stress can also reduce physical work capacity and motor-cognitive performances, with consequences for productivity, and increase the risk of occupational health problems [1]. Heat stress is the leading cause of weather-related deaths and exacerbates many underlying illnesses like cardiovascular disease, diabetes, mental health, asthma, etc. It can increase the risk of accidents and transmission of some infectious diseases [2]. The number of people exposed to extreme heat is growing exponentially due to climate change in all countries worldwide. Heat-related mortality for people over 65 years of age increased by approximately 85% between 2000–2004 and 2017–2021 [3,4].

Citation: Kishanrao S. Extremes of Weather Conditions and Child Health. Open J Pediatr Child Health. 2024;9(1):050-057.
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Exposure to high ambient temperatures causes needless suffering and death. Temperatures above long-term averages during summer months and heatwaves are associated with excess heat is one of the largest weather-related causes of death in developed countries from cardiorespiratory and other diseases, mental health issues, adverse pregnancy and birth outcomes, and increased health-care costs. Very young children are particularly vulnerable to the effects of heat, irrespective of income level or geographical region. Although excess mortality across all countries, there is greater knowledge about the burden of heat-related mortality in high-income countries. Most heat-related morbidity and mortality is preventable with improved preparedness and avoidance of exposure [1].

Ambient temperature is the air temperature of any object /person/ or environment where they are stored or live. The word ambient an adjective means "relating to the immediate surroundings". An ambient temperature is the average temperature of an environment and varies depending on the location or time of year. Ambient temperature excludes humidity and wind chill which also contribute to overall effects, as it only refers to the average air temperature. World Meteorological Organization announced that there's an 80% chance that the world will exceed the 1.5 °C temperature limit in at least one of the next 5 years [5].

Similarly, very cold temperatures are harmful, as children exposed to very low temperatures for too long can get frostbite or even life-threatening hypothermia. Many winter activities, such as playing in the snow or skating on ice, expose children to cold temperatures, which increases the risk of illness and death from coughs, lung and heart problems, falls, poor mental health, and carbon monoxide poisoning from poorly maintained heating appliances. Children are at an increased risk of exercise-induced asthma, and acute and chronic physiological responses. The cold weather itself doesn't cause illness, but it weakens the immune system, making it a lot harder for the child to fight off infections [6,7].

This article is a review of the impact of extremes of heat & Cold weather on children, based on personal handling of cases and media reports of the adverse effects of heat, and exercising in hot and very cold weather.

1. Case rDressing & weather changes

Three years old girls a granddaughter of our friend used to come for walking with grandparents. Since November 2023 the girl was put on multiple layers of dresses and was padded with woolen tops head gear (monkey cap) during cold mornings. She was suffering from incessant bouts of cough every 2 weeks and soon, the episodes started getting longer throughout the winter. Come April 2024, the child was padded with woolens during cold mornings, the day wore on, and it would get hot, but the woolens stayed, leaving her sweating. In the night, the opposite would happen. Thinking that it wouldn't get too cold, the child would be taken off her woolens only to be exposed to dipping temperatures.

2. Sit-ups into climate

In September 2023, the victim enrolled in the college. On June 26, 2024, this first-year student at the Dungarpur Medical College in Rajasthan said that he had been subjected to ragging by senior students who had called him to a nearby hill and forced him to perform 300 sit-ups, which had seriously injured him. At a location close to the college on May 15, seven second-year students forced the victim to perform more than 300 sit-ups at an ambient temperature of 42 °C. This put a great deal of strain on his kidney, causing an infection and malfunction, later, he had to be admitted to a private hospital in Gujarat as the pain was unbearable. A teenager forced to do intensive exercise of sit-ups in hot and humid climates in September 2023 is attributed to Kidney failure due to dehydration.

3. A case of prickly heat

By the end of the second day the girl who was playing with other kids outdoors, had sweated a lot and her parents saw some rashes in her armpits. They applied some talk powder and the baby was able to sleep. On the third day, the key day of outdoor functions of the marriage the girl's rash increased and formed blotches over the neck, chest, shoulders, and forehead [8]. They returned to Bengaluru on the 5th day and the prickly heat fully subsided within in next 2 days with no interventions.

4. A case of childe death in a parked car in Rajasthan

A couple with two daughters: Went to Jorawarpur village by car to attend a marriage in the family on 15 May 2024. While the wife and elder daughter stepped out of the car at the wedding, the husband moved to the parking area, where he locked the car and left, presuming that his wife had taken both kids with her. Both parents remained engaged in separate groups in marriage and thinking that both girls were playing together did not bother them. After about two hours, the parents found the younger girl missing and searched at the venue. The elder sister confirmed that the younger sibling was never with her after reaching the venue. Finally, they found the girl unconscious in the car and took her to the hospital to be announced as dead. In Mid-May 2024 Rajasthan was under heat wave with temperatures ranging around 45 ˚C - 50 ˚C. (http://timesofindia.indiatimes.com/Jaipur/ articles how/110190297 /17 May 2024).

Discussion

Hot climate / High heat

High heat makes everyone more irritable. High temperatures and Extreme heat have led to heat exhaustion, dehydration, heatstroke, and increased vulnerability to respiratory illnesses. Most children experience increased thirst, weakness, headache, dizziness or fainting, muscle cramps, nausea and/ or vomiting, irritability, prickly heat & heavy sweating. For children, excessive heat might be more harmful than it is for adults. Dehydration in children is more than just being thirsty, it is a condition where there isn't enough fluid in the body as children lose more water than they take in. Some of the early signs and symptoms that help parents or primary care

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physicians spot dehydration in children include a dry or sticky mouth, pale and sunken eyes, dizziness, headache, nausea, dark urine, and cramping or intense pain in the muscles. It can also cause organ dysfunction like kidney failure (as was in our second case report), and chronic issues due to congenital defects.

Direct & indirect effects of hot days: Hot days affect both directly and indirectly by increasing the risk to asthmatic children.

Direct effect: Hot days contribute directly to asthma attacks through Dehydration, & associated lactic acidosis and electrolyte imbalance, resulting in more severe asthma.

Indirect effects: Hot weather increases the levels of air pollutants, including ozone, fine particulate matter, and sulfur dioxide. These pollutants trigger asthma attacks and increase the need for medical care. Heat fuels the creation of ground-level ozone, or smog, formation. And if hot days are also humid, humidity can worsen lung function. Pollen is another common trigger for asthma. Over the past several decades, the pollen season has lengthened by several weeks across the world. Hot and dry weather can increase the risk of wildfires. Wildfire smoke pollutants provoke asthma symptoms. During the heat season, exposure to multiple concurrent environmental hazards, including wildfire smoke, pollen, and flooding lead to Mold, results in children facing several simultaneous asthma triggers [6].

Hot weather creates conditions that can harm children's health, especially because children have unique sensitivities to heat exposure. Children's developing minds and bodies may be more sensitive to higher temperatures than adults. Contrary to common belief Heat can worsen asthma symptoms, hot days can worsen air quality, and breathing air with AQI >100 with unhealthy ozone levels for as short as 1 day can trigger asthma attacks [6].

A new analysis has indicated that 50-80 days night temperature exceeded 25 °C in the last 5 years. Higher temperatures cause physiological discomfort and impact human health by preventing body temperatures from cooling off during the night. It impacts the quality of sleep immensely in India and across the world. This temperature rise is mainly caused by fossil fuels like firewood, coal, oil, and gas. Poor sleep affects physical and mental health, cognitive functioning, and life expectancy. Hot nights have disproportionate impacts on vulnerable populations like children and the elderly, who do not have access to proper cooling mechanisms. The week of 18-24 June 2024 saw Delhi, Kolkata, Mumbai, and Chennai recording over 35 °C temperatures. These increasing frequent night temperatures are contributing to heat stress, exhaustion, and heat stroke. The ongoing heat wave is made worse, and more frequent by climate change. The urban night temperatures are turning our cities into hot islands due to Building constructions, Vehicular movements, Air conditioners, and other infrastructure absorb and re-emit heat. Cutting trees, less rain, and trees and greeneries also contribute to the night temperature. During the day's Sun's rays reach as short-wave radiation penetrates through and heats the earth's surface which is mostly concretized and blacktopped. At night heat escapes as longwave radiation which gets trapped easily by concrete and clouds [9].

Every year a lot of children die from heat stroke and hyperthermia left unattended in closed automobiles. Two factors make children more prone to hyperthermia than adults: children have a greater surface area body mass ratio than adults and their thermoregulation is less efficient than adults. A parent may leave his/her child unattended in the car could be related to Working Memory (WM). The stress increases interference from irrelevant information, impairing selective attention and WM and influencing behavior. In 2011 & 2012 Italy reported 16 cases of child hyperthermia due to abandonment in a motor vehicle. These events are mostly unintentional, legislative efforts may be in vain, and educational programs and literature for parents regarding automobile safety must include information about the potential dangers of heat stress [10].

Hyperthermia-related deaths are poorly reported vehicular injuries in India; however, between 2011 and 2018, 16 incidents resulted in 28 fatalities across India, in the summer months. Most children (19/28) were aged 4–6 years, of whom 25 (89%) gained access to unattended vehicles and became accidentally locked in [7,11]. Only one child under 3 years was left intentionally.

Very cold temperatures

A cold wave is a weather-related event characterized by a sharp drop of air temperature near the surface, leading to i) extremely low values of temperatures ii) steep rise of air pressure iii) strengthening of windspeed, and iv) associated with hazardous weather like frost & icing. In India, the cold wave Season is during winter more often in December-January. Seventeen States / UTs from north, northwest, east, and central India are in the 'Core Cold Wave Zone' and experience the highest number of cold waves/severe cold waves [12]. Vulnerable populations include the Homeless, elderly, economically disadvantaged, disabled, pregnant or lactating mothers, women, children, outdoor workers, managers of night shelters, and farmers. Children exposed to very low temperatures for too long can get frostbite or even life-threatening hypothermia. They are also at an increased risk of exercise-induced asthma, specifically acute and chronic physiological responses.

The cold weather itself doesn't cause illness, but it can weaken the immune system, making it a lot harder for the body to fight off infections. Hypothermia develops when a child's temperature falls below normal due to exposure to colder temperatures. It often happens when a child is playing outdoors in extremely cold weather without wearing proper clothing or when clothes get wet as was in our first case. When exposed to cold temperatures, a child's body begins to lose heat faster than it is produced. Prolonged exposure to cold will eventually use up a child's body's stored energy, resulting in hypothermia.

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Many winter activities, such as playing in the snow or skating on ice, can expose children to cold temperatures, increasing the likelihood of catching a cold or flu. Cold weather increases the risk of illness and death from coughs, lung and heart problems, falls, poor mental health, and carbon monoxide poisoning from poorly maintained heating appliances.

Typical cold symptoms are a runny nose, nasal congestion, sneezing, coughing, and a mild sore throat as was in our first care report. Some children may not want to eat, have a headache, or be more tired than usual and sometimes have mild fever (around 39 °C).

Manifestations of climate change, like diurnal temperature, prolonged winters, extremely hot summers, extended rainy seasons, and cloudy skies adversely impact children's health. The study predicts that approximately 175 million children will be affected by climate change-induced natural disasters every year next decade. Global warming studies suggest that disease-carrying vectors, like mosquitoes and flies, will find a greater range of habitats, particularly in tropical and sub-tropical regions [2].

Pathophysiology of human body thermoregulation

Thermoregulation is the biological mechanism responsible for maintaining a steady internal body temperature [13].

There are three mechanisms of thermoregulation:

i) **Efferent responses:** Efferent responses are the behaviors that humans can engage in to regulate their body temperature. E.g., a) Putting on a Sweater/Jacket or a coat before going outside on cold days and b) moving into the shade on hot days.

ii) **Afferent sensing:** involves a system of temperature receptors around the body to identify whether the core temperature is too hot or cold. The receptors relay the information to the hypothalamus, a part of the brain, and

iii) **Central control:** The hypothalamus acts as the central control, using the information it receives from afferent sensing to produce hormones that alter body temperature. These hormones send signals to various parts of the body so that it can respond to heat or cold in the following ways:

The human body maintains a temperature of about 98.6 °F (37 °C) using various physical processes. These include sweating to lower the body temperature, shivering to raise it, and narrowing or relaxing blood vessels to alter blood flow. If an individual is unable to regulate temperature, the body could overheat, leading to hyperthermia or the core temperature falls below a safe level, which will cause hypothermia. Both conditions are potentially life-threatening.

Thermo-sensitivity is active in neonates and children; both heat production and heat loss effector mechanisms are functional but easily exhaustible. Proportional and lasting defense against thermal challenges is difficult, and both hypothermia and hyperthermia may easily develop. Febrile or hypothermic responses to infections or endotoxin can develop, together with confusion. In small children, febrile convulsions may be dangerous.

Causes of impairment in thermoregulation

Several factors affect thermoregulation - environmental conditions, diseases, & medications.

Environmental conditions: Extreme weather significantly affects the body's ability to regulate temperature.

Hot weather: Extended exposure to the sun can cause the body to overheat. Instead of losing more heat than it can produce, the body heats up faster than it can cool itself down. Anyone can also develop hyperthermia in warm temperatures due to, drinking insufficient fluids, wearing heavy, insulating clothing, Infections, visiting overcrowded places, and exerting themself physically, especially outside in the sun (Table 1).

Cold weather: Hypothermia occurs when a person is exposed to extremely cold temperatures for an extended period as the body loses heat quickly, and heat production cannot keep up, causing a dip in body temperature. Hypothermia can also occur in cool temperatures if sweat, rain, or submersion in cold water chills the body [14] (Table 1).

When a person has an infection, harmful microorganisms invade the body and multiply, thrive at typical body temperatures, but an increased temperature makes it more difficult for some of them to survive. For this reason, part of the immune response to infections is often a fever, which occurs when the body raises its temperature to kill infection-causing organisms. That's the reason why most doctors recommend letting a fever run its course so that the body can adequately protect itself, However, problems can arise if the body temperature becomes too high, hindering necessary functions. If someone has a fever above 105 °F (40.5 °C) that does not decrease with medication, must seek urgent medical attention.

Age: Infants and older adults have a higher risk of thermoregulation disorders due to a lower muscle mass, a decreased shiver reflex, and lower immunity. Older adults tend to have a lower body temperature and may not develop fevers when they contract a viral or bacterial illness. Sometimes, they can develop hypothermia instead.

Gender: A recent study published in the journal Lancet found that women's core body temperatures can run 0.4 °F higher than men's on average. And women's hands can be

Table 1: Response to Extremes of Heat & Cold among Children [8].

Response to heat	Response to cold
sweating	shivering, or thermogenesis
dilated blood vessels, known as vasodilation	constricted blood vessels, known as vasoconstriction
decrease in metabolism	increase in metabolism

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significantly colder 82.7 °F on average, compared with 90 degrees F for men. Females tend to be smaller than males, which gives them a higher skin surface-to-volume ratio causing them to lose heat more quickly through the skin. Women are also five times more likely to experience Reynaud's disease, in which the blood vessels that supply blood to the extremities spasm and excessively constrict in response to cold or stress. Fingers and toes can turn white and then blue from the lack of blood and oxygen. After the cold parts of the body warm up, normal blood flow returns in about 15 minutes [2].

Skin temperatures: The perception of cold begins when nerves in the skin send impulses to the brain about skin temperature. So, we feel chilled, often due to a drop in temperature in the fingers, toes, and other peripheral and exposed parts of the body.

Body composition and size: Compared to men, women have less muscle, which is a natural heat producer. They also have 6 to 11% more body fat than men, which keeps the inner organs toasty but blocks the flow of blood carrying heat to the skin and extremities.

Cutaneous circulation & thermoregulation: There are specialized blood vessels in the skin that react to temperature changes called "thermoregulatory" vessels, located near the surface of all areas of the skin, but denser in the fingers and toes. They are primarily controlled by the sympathetic nervous system. Normally, these vessels that supply blood to the skin constrict or narrow in response to cold temperatures known as "vasoconstriction." This decreases blood flow to the skin, which helps to minimize heat loss by shunting blood into deeper tissues and therefore preserving a normal internal or "core" temperature. In warm temperatures, these same blood vessels dilate, increasing the flow of blood to the skin surface, thus allowing heat to leave the body, & keeping the core body temperature from rising to a dangerous level. The same system that reacts, when we are stressed or upset emotionally. This is the reason why both cold and emotional stress can trigger vasoconstriction of these blood vessels, causing cold fingers and toes [15].

Endocrine disorders: The endocrine system, such as the pancreas, thyroid, pituitary gland, and adrenal glands produce hormones, if something interferes with hormone production, it affects body temperature. E.g., Hypothyroidism can lead to a lower body temperature, while hyperthyroidism, can cause a higher body temperature.

Central Nervous System (CNS) disorders: The CNS includes the brain, spinal cord, and nerves. Conditions that affect the CNS can interfere with thermoregulation by impairing afferent sensing and central control. Some examples include brain injuries, spinal cord injuries, neurological diseases, such as Parkinson's or multiple sclerosis, and tumors.

Medications: Certain medications can disrupt thermoregulation as a side effect, causing a temporary rise in body temperature known as "drug fever." e.g., antibiotics, nonsteroidal anti-inflammatory drugs (NSAIDs), first-generation anticonvulsants, and antidepressants. Usually, thermoregulation quickly returns to normal when a person stops taking the drug.

Thermoregulation disorders [13,15,16]

1. Hyperthermia

Hyperthermia occurs when the body's heat-regulating mechanisms fail, and the body temperature becomes too high. There are several types of hyperthermia, including:

a) **Heat cramps:** Which present as heavy sweating and muscle cramps during exercise.

b) **Prickly heat:** Children and teenagers fair in color show pinkish rashes while for children with dark skin, the spots or blisters might look brown, purple, or grey. The number of spots or blisters varies and might cover a large area of the body or a small area like a skin fold. They most commonly appear over the face, neck, and torso. Usually heat rash goes away by itself. Sometimes, may need medical care if blisters get infected indicated by filled with yellow pus, spots, blisters that last more than 3 days, or a rash and generally unwellness, a fever, or aren't feeding or eating well.

Treatment for heat rash or prickly heat for i) Babies and young children- Avoid too many layers when you wrap your baby or dress your child, Change wet nappies regularly, gently dry child's skin folds after each bath, ii) All ages- a) in a hot climate, use air conditioning or keep your child in a comfortably cool place if possible, b) ensure bedrooms are cool and ventilated, c) choose light, loose-fitting & breathable clothing, d) remove sweaty clothes often, e) give a bath in lukewarm water to help with itchiness, f) Avoid soap because this can irritate the skin g) use a soap-free wash or a moisturizing lotion or bath oil if needed [16].

c) **Heat exhaustion:** Which is more serious and causes a range of symptoms. Ids often show signs and symptoms of milder heat illnesses such as heat cramps and heat exhaustion. Often occurs after a child has been exercising or playing in the heat and becomes dehydrated from losing excessive fluids and salt from sweating. The signs of heat exhaustion in children may include a) an elevated body temperature, usually between 100° and 104 °F b) Cool, clammy skin despite the heat c) Goosebumps, d) Fainting, dizziness, or weakness, e) Headache, f) Increased sweating, g) Increased thirst h) Irritability i) Muscle cramps j) Nausea and/or vomiting.

Overweight or obese children, children who are taking certain medicines, have a sunburn, and are sick are at a higher risk for heat exhaustion. Immediate remedial measures include bringing the child to a cool, shaded place – preferably in an air-conditioned building or vehicle, encouraging him or her to drink cool fluids that contain salt, applying a cold wet towel or sponge to the skin & gently stretching or massaging [5].

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d) **Heat stroke:** This is a medical emergency, that causes similar symptoms, but with some important differences. Heat stroke is a severe type of heat illness that occurs when a child's body creates more heat than it can release. This results in a rapid increase in core body temperature, leading to brain damage or death if not promptly treated.

Signs of heat stroke in children may include: i) A body temperature that rises dangerously high – above 104 °F ii) Absence of sweating iii) Confusion, disorientation, iv) Flushed, hot, and dry skin (skin may be wet) v) Loss of consciousness, vi) Nausea, vomiting, diarrhea, vii) Rapid heartbeat and breathing, viii) Severe headache ix) Seizures x) Weakness and/or dizziness. Person close by must- a) Bring the child indoors or into the shade and undress him or herb) Begin rapid cooling by immersing him or her in a bathtub of cold water c) If a bathtub is not available, apply cold towels over much of the body replacing them frequently iv) Avoid pushing fluids unless the child is conscious, alert, and seek immediate care [15].

Heat stroke in babies is rare but very dangerous. Allowing a baby or child to stay outside too long in hot weather, ride in a hot car, or sit in a parked car can cause his or her body temperature to rise quickly. Since babies & very young children can't tell the attendant needs to watch if the baby is Restlessness, Rapid breathing, Lethargic, Irritability, and Vomiting and seek immediate medical care [16].

2. **Hypothermia**

Hypothermia occurs when the body loses heat faster than it can produce it. Prolonged exposure to cold temperatures can cause hypothermia. The symptoms include- Shivering, confusion, exhaustion or feeling very tired, fumbling hands, slurred speech, drowsiness, and memory loss. In young children and babies, hypothermia causes cold skin, which may be bright red in those with light skin tones [13].

3. **Physiological response to exercise in extreme Heat & Cold [17]**

Children often exercise or play in hot environments for reasons of recreation, vocation, & survival. The magnitude of physiological strain imposed by exercise-environmental stress depends on the individual's i) metabolic rate and ii) capacity for heat exchange with the environment. Muscular exercise increases metabolism by 5 to 15 times the resting rate to provide energy for skeletal muscle contraction. Depending on the type of exercise, 70% to 100% of the metabolism is released as heat and needs to be dissipated to maintain body heat balance. The effectiveness of the thermoregulatory system in defending body temperature is influenced by the individual's i) acclimatization state, ii) aerobic fitness, and iii) hydration level. Aerobically fit children who are heat acclimatized and fully hydrated have less body heat storage and perform optimally during exercise-heat stress.

To regulate body temperature, heat gain and loss are controlled by the autonomic nervous system's alteration of (a) heat flow from the core to the skin via the blood and (b) sweating. Thermoreceptors in the skin and body core provide input to the hypothalamic thermoregulatory center, where this information is processed, via a proportional control system, with a resultant signal for heat loss by the thermoregulatory effector responses of sweating and alterations in skin blood flow. Muscular exercise and heat stress interact synergistically and push physiological systems to their limits in simultaneously supporting the competing metabolic and thermoregulatory demands. During muscular exercise, core temperature initially increases rapidly & subsequently increases at a reduced rate until heat loss equals heat production, to achieve steady-values. At the initiation of exercise, the metabolic rate increases immediately; thermoregulatory effector responses for heat dissipation respond more slowly. The thermoregulatory effector responses, which enable sensible (radiative and convective) and insensible (evaporative) heat loss to occur, increase in proportion to the rise in core temperature. Eventually, these heat loss mechanisms increase sufficiently to balance metabolic heat production, allowing the achievement of a steady-state core temperature.

Metabolic rate: The total metabolic rate & percentage contribution of aerobic and anaerobic metabolism during exercise at different ambient temperatures indicate that maximal oxygen uptake is reduced in hot compared to temperate environments. Acute heat stress increases resting metabolic rate, but the effect of heat stress on an individual's metabolic rate for performing a given submaximal exercise task is not yet so clear.

Skeletal muscle metabolism: Several investigations found that greater plasma lactate levels & increased muscle glycogen utilization and muscle triglyceride utilization were reduced during exercise in the heat as compared to the cold. Serum glucose concentration increased, and serum triglyceride concentration decreased during exercise in the heat, compared to the exercise in the cold. During exercise in the heat, the increased muscle glycogen utilization was attributed to increased anaerobic glycolysis resulting from local muscle hypoxia, caused by reduced muscle blood flow.

Evaporative heat loss: When ambient temperature increases, there is a greater dependence on insensible (evaporative) heat loss to defend core temperature during exercise. Respiratory evaporative cooling is small in humans when compared to total skin evaporative cooling. The use of skin provides the advantage of having a greater surface area available for evaporation. The eccrine glands secrete sweat on the skin surface, which is cooled when the sweat evaporates. The rate of evaporation depends on the wetted area, air movement, and the water vapor pressure gradient between the skin and the surrounding air, the wider the gradient, the greater the rate of evaporation.

Skin blood flow and circulatory responses in heat

Blood flow from the deep body tissues to the skin transfers heat by convection. When core and skin temperatures are low enough sweating does not occur. Raising skin blood flow brings skin temperature nearer to blood temperature, and lowering

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skin blood flow brings skin temperature nearer to ambient temperature. This phenomenon allows the body to control sensible (convective and radiative) heat loss by varying skin blood flow and thus skin temperature. In conditions in which sweating occurs, the tendency of skin blood flow to warm the skin is approximately balanced by the tendency of sweating to cool the skin. Therefore, there is usually little change in skin temperature & sensible heat exchange after sweating has begun, and skin blood flow serves primarily to deliver to the skin the heat that is being removed by sweat evaporation. Skin blood flow and sweating thus work in tandem to dissipate heat under such conditions [17].

Prevention: The Union Health Ministry in India has released an advisory for the public to stay safe from the impact of health as shown in the flier (Figure 1).

Recommendations

For Children, parents must:

- Make sure that the child is getting enough water.
- Send them out to play only fully hydrated. Even when they are playing, ensure that they take regular breaks to drink fluids.
- Try to give them as much plain water as possible instead of sugary soft beverages as these drinks can lead to more dehydration.
- When it is sunny outside, let the child get used to the heat slowly-acclimatization.
- Ensure that the kid wears loose and comfortable cotton clothing to avoid overheating
- For mild dehydration in children, encourage them to take frequent small sips of oral rehydration solution during fluid breaks.

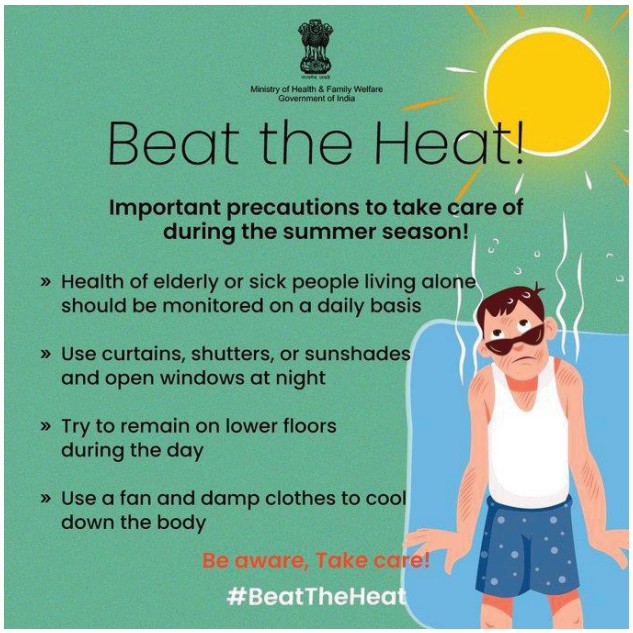

Figure 1: Beat the Heat GOI Guidelines (Source, GOI- [6]).

- If they are drinking enough fluids, it is completely fine if they wish to eat a few solid foods when they are dehydrated.
- As the child starts to feel better and their appetite increases give less oral rehydration solution and more of their usual food and drink.

Conclusion

Temperatures above long-term averages during summer months and heatwaves are associated with cardiorespiratory and other diseases and mental health issues. Very young children are particularly vulnerable to the effects of heat, irrespective of income level or geographical region. Most heat-related mortality and morbidities are preventable with individual efforts like avoidance of exposure, improved community preparedness, and Public Health Advisory.

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Citation: Kishanrao S. Extremes of Weather Conditions and Child Health. Open J Pediatr Child Health. 2024;9(1):050-057.
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Citation: Kishanrao S. Extremes of Weather Conditions and Child Health. Open J Pediatr Child Health. 2024;9(1):050-057.
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