Guidelines for Competition in the Cold

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Cold weather is not usually a barrier to athletic activity, but team and individual sports played in the late fall, winter and early spring place a large number of athletes at risk for cold injury. Environmental changes as simple as sunset, a rainstorm or an increase in wind speed can shift the body's thermal balance suddenly. As part or all of the body cools, there can be diminished exercise performance, frostbite, hypothermia and even death. Frostbite and hypothermia represent 20 percent of all injuries in Nordic skiers.

Physiological Response to Cold

Cold exposure produces peripheral vasoconstriction, decreasing peripheral blood flow, and decreasing convective heat loss from the body's core to its shell. Cold exposure also elicits increased heat production through skeletal muscle activity. This occurs through involuntary shivering (which can increase heat production six-fold) and through voluntary increased activity.

Athletes exposed to cold repeatedly can exhibit cold acclimatization, in which both cold-induced vasoconstriction and shivering are blunted. Compared to heat acclimatization, cold acclimatization is less pronounced, slower to develop and less effective in defending normal body temperature and preventing thermal injury.

Cold Injury

Frostbite occurs when tissue freezes. Frostbite can be in exposed skin, e.g. nose, ears, cheeks, but also occurs in hands and feet, because vasoconstriction lowers peripheral tissue temperature significantly. Numbness or a "wooden" feeling is usually the first symptom of frostbite in the hands and feet. With frostbite to exposed facial skin, however, there can be a burning feeling. Freezing of the tissue is often relatively painless. Re-warming is accompanied by sharp, aching pain and persistent loss of light touch sensation.

The risk of frostbite increases as temperature decreases. With appropriate precautions, the risk of frostbite can be less than five percent when ambient temperature is above 5 degrees F. But increased surveillance of athletes is appropriate when the wind chill falls below minus 18 degrees F, since exposed facial skin then freezes in 30 minutes or less. At these temperatures, consideration should be given to postponing or shortening athletic events. Predetermined school policies bring neutrality to that decision and help the public to anticipate it. Several apps are available for calculation of wind chill.

Hypothermia is core temperature below 35C (95F). In mild hypothermia, an athlete feels cold, shivers, is apathetic and withdrawn, and demonstrates impaired athletic and mental performance. Coaches and athletes must recognize and respond to these early symptoms so as to avoid more severe hypothermia. The symptoms can be confused with concussion, hypoglycemia or drug use. As core temperature continues to fall, there is confusion, sleepiness, slurred speech and irrational thinking and behavior. Severe hypothermia causes cardiac arrhythmia and arrest. Efforts to resuscitate must persist until re-warming has been achieved.

Risk factors for Frostbite and Hypothermia

1) Exercising in water, rain and wind. Evaporation from wet clothing in a cold environment increases heat loss four-fold.
2) Lean athletes lack the insulation provided by fat and muscle mass and have more difficulty maintaining core temperature.
3) Fatigue, energy depletion, sleep deprivation and many endocrine disorders produce hypoglycemia. Hypoglycemia impairs muscular activity and shivering, decreasing heat production.
4) Physical fitness and strength training allow longer exercise at high intensity with prolonged heat production and maintenance of core temperature. Poor fitness thereby predisposes to cold injury.
5) Altitude greater than 8,000 feet decreases shivering and vasoconstriction response to cold.
6) Cessation of Exercise. Exercising, athletes produce heat by muscular activity and are at less risk for cold exposure injury. At the end of an event, or when exercise stops due to injury, heat is no longer being generated by exercise, but heat loss continues, and rapid cooling may result. Training alone, in remote places and at unusual hours, increases the length of exposure likely to occur before an injured athlete can be removed from the cold.

Preventing Cold Injury

1) Risk and Event Management
   a. Assess environmental heat loss risk: temperature, wind, rain, solar load, immersion, altitude. Be alert to changes

Photo provided by 20/20 Photographic, Mt. Pleasant, Michigan.

in these factors. Athletes can then be advised to modify clothing or seek shelter. And event managers can consider shortening, moving or cancelling an event. Wind chill temperature index (WCT) integrates temperature and wind to estimate cooling power. The WCT predicts the risk of frostbite to exposed facial skin in a person moving at walking speed. The wind effect of the athlete moving at higher speed (run, ski, bike, skate) is not considered in calculating WCT. The risk of frostbite in the extremities is not predicted by WCT.

b. Assess athletes' risk factors: exercise demands, fitness, fatigue, health, body fat, hydration and nutritional status.

c. Prepare appropriately: adequate training, clothing, water and food; scheduled clothing changes; provision of shelter and re-warming; planned monitoring of weather conditions and of athlete tolerance of the cold; and action plans to care for athletes, staff and spectators who are having difficulty staying warm.

2) Clothing: Exercise intensity and ambient temperature determine clothing (insulation) requirements during exercise. Hats are useful, as up to 50 percent of heat loss at rest is from the head. Layering is dressing with an inner layer that wicks perspiration to the outer layers for evaporation, a middle insulating layer that allows moisture transfer, and an outer layer, worn when necessary, to repel wind and rain but capable of transfer of perspiration to the air. Layering allows adjustment in insulation to prevent overheating and sweating, while remaining dry in wet conditions. Glove liners provide wicking and insulation for the hands. Mittens provide significantly more insulation than gloves. Clothing that constricts fingers or toes predisposes to peripheral cold injury. Wet clothing should be removed quickly and replaced, including socks and gloves.

3) Food and Fluid Intake: Exercise in cold environments increases energy expenditure and fluid loss. Insufficient carbohydrate reserves to maintain core temperature risks cold injury. Dehydration affects neither shivering nor vasoconstriction, but significant loss in circulating volume decreases perfusion. In cold as well as other temperatures, carbohydrate availability and dehydration are limiting factors in performance. Athletes can sustain exercise in cold by ingesting 6-12 percent carbohydrate beverages. Carbohydrate-rich foods are appropriate for prolonged exercise in the cold.

Wind–Chill Chart

ESTIMATED WIND SPEED MPH	ACTUAL THERMOMETER READING F											
	CALM	50	40	30	20	10	0	-10	-20	-30	-40	-50
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	
10	40	28	16	4	-9	-21	-33	-46	-58	-70	-83	
15	36	22	9	-5	-18	-36	-45	-58	-72	-85	-99	
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	
35	27	11	-4	-20	-35	-49	-67	-83	-98	-113	-129	
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	
	LITTLE DANGER FOR PROPERLY CLOTHED PERSON				INCREASING DANGER			GREAT DANGER				

*Wind speeds greater then 40 MPH have little additional effect

DANGER FROM FREEZING OF EXPOSED FLESH

Field Treatment of Cold Injury

Frostbite: Seek shelter and insulation to maintain core temperature. Reverse vasoconstriction by re-warming. Re-warming is best accomplished with 1) body heat – the victim's or someone else's body heat (e.g., placing the cold hand into the axilla) or 2) warm water 104-109 degrees F (40-43 degrees C). Warmer water produces greater injury, swelling and tissue death. Once re-warming begins, avoid additional freezing. It is better to tolerate some additional time with frozen tissue during extrication from the cold than to re-warm and then suffer refreezing during extrication. Rubbing the injured

part tends to add mechanical damage to thermal damage, and is to be avoided.

Hypothermia: a) Conscious, hypothermic persons should have wet clothing removed and should be insulated with whatever warming material is available. If possible, evacuate to a warm building/car/shower. Encourage the drinking of large volumes of warm, sweet liquids to improve circulating volume and available energy for exercise. Encourage exercise to promote heat production by muscular activity. Such athletes usually respond to peripheral re-warming, but transport to medical care as a precaution against deterioration. b) Comatose, hypothermic athletes should be insulated and transported emergently. Field re-warming and field CPR are usually ineffective and only delay transport to a medical facility for rapid core re-warming and comprehensive care.

Cold-induced Bronchoconstriction

Exercise-induced bronchoconstriction (EIB) is a transient narrowing of the airways that is provoked by exercise. Cold weather athletes have an increased prevalence of EIB: Twenty-three percent of Olympic winter athletes and 33-50 percent of cross country skiers. High intensity exercise, high ventilation rate and exercise in indoor rinks predisposes. The EIB with cold exposure is believed to be due to a combination of breathing dry air and reflex response to facial cooling. Impaired air quality in indoor rinks is implicated as an additional factor.

Cold Environment Modifies Trauma Protocols

The assessment and management of the injured athlete in a cold environment follows Basic Trauma Life Support protocols. Depending on the severity of the cold, the risk it represents to the injured athlete and to the rescuers, and the availability of warm shelter, evaluation and resuscitation may be delayed in order to extricate the athlete from the cold. Evacuation of the winter athlete from the scene of injury can be a challenge requiring special equipment, training and protocols, such as those developed by the National Ski Patrol.

As seasons change, extra beauty, exhilaration and challenge are brought to the excitement of athletic competition in the cold. Despite the serious risks of cold injury, thoughtful planning and preparation can ensure that safe outcomes accompany athletic success.

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