

Fluid and Electrolyte Balance during Winter Sports

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Fall 2014
ESAT 3410

In the middle of winter one would expect to find people sitting at home by a warm fire sipping hot chocolate. However, there is a large percentage of people who love to be outside and enjoy the snow. These people endure temperatures below 0°C because they enjoy the outdoors and the winter sports Minnesota has to offer. Winter sports include alpine skiing, snowboarding, ice hockey, speed skating, curling, downhill skiing, snowshoeing, to name a few. To be considered a winter sport, the temperature is usually below 0°C and sometimes performed at higher altitudes.

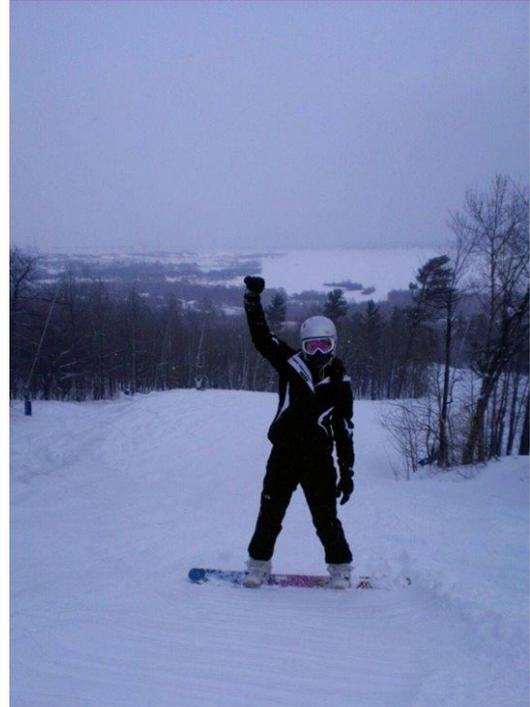
INTRODUCTION:



Skiing and snowboarding are recreational activities that involve the use of special equipment including skis, poles, and snowboards. Some other equipment used during skiing and snowboarding to endure the cold and prevent injuries includes helmets, gloves, boots, snow pants, and light or heavyweight jackets depending on the temperature. The amount of

time a person spends outdoors skiing or snowboarding is on average 4-6 hours spent on the slopes a day. This number varies and is determined by whom the athlete is skiing with, the weather conditions, and physical activity.

An athlete must balance fluids and electrolytes before, during, and after exercise. Water requirements for the body are less while exercising in colder climates but, this does not mean that there is a decreased risk for dehydration while exercising in the cold. Dehydration is a risk during any type of exercise and should not be overlooked. In the cold, dehydration is correlated with thermoregulation and hypothermia. If a skier or snowboarder is dehydrated, their body cannot maintain core temperatures. Therefore, the natural cold environment will increase the risk for hypothermia. The object of this chapter is to discuss how to maintain fluids and electrolytes during winter sports, particularly during skiing and snowboarding.



LITERATURE REVIEW:

The literature review of this chapter covers fluid loss, maintaining hydration, maintaining thermobalance, effects of cold on the body, and nutritional recommendations. During winter sports, an athlete does not have a sense of thirst which can cause problems that lead to dehydration (Kenefick et. al, 2004). Dehydration can lead to a reduced cardiovascular efficiency, extended energy requirements, and a decrease in muscle blood flow (Seifert et. al., 2006). One study showed that even though the participants drank water there was still a decrease in plasma osmolality, plasma protein, and urine osmolality (Seifert et. al., 1998). The other portion of the study shows a constant plasma osmolality will decrease the amount of urine production during rehydration (1998).

According to a study by Gibson et al. (2012), there was no direct correlation between collected urine specific gravity (USG), heart rate, percent body mass lost, and sweat rate however there seemed to be a large range in the participants regarding the individual results of fluid loss. Fluid loss is different in every athlete. The final results of the study showed that drinks which have carbohydrates and electrolytes are the best choice because both prevent a reduction in plasma osmolality (Seifert et. al., 1998). The electrolyte-water balance was related to thirst and mouth dryness in the cold environment (Mears and Shirreffs, 2014). The water intake of the subjects was less in the cold environment, compared to the warmer environment, but was still adequate to be able to prevent dehydration (Mears and Shirreffs, 2014). When an athlete is interested in being able to maintain the amount of water loss during exercise he or she may be interested in the study that showed more than twice the amount of fluid was retained with a glycerol + water hydration before exercise, than when only water was consumed (O'Brien et. al., 2005).

The body's ability to maintain thermal balance during exercise in the cold is referred to as thermoregulation which helps in prevention of hypothermia (Castellani et. al., 1999). During thermoregulation studies results have shown that when athletes are fatigued or exhausted their vasoconstrictor responses, but not shivering, are impaired which does not allow the body to maintain thermal balance after extended cold exposure (Sawka et. al., 2001). The time to exhaustion is significantly shorter in cold climates (Sandsund et. al., 1998). Effects on thermoregulation during exercise in the cold are induced by dehydration which results in a decreased skin temperature and an increased stroke volume and cardiac output (Kenefick et. al., 2004).

*How to Properly Dress
for Exercise during
Skiing and
Snowboarding:*

<https://www.youtube.com/watch?v=7vngG2AZjvU>

DRESS WARM!!

During exercise the body is able to maintain thermal balance in a cold environment. In response to a drop in body temperature, blood is taken from the extremities. Therefore, skiers and snowboarders exercising in the cold have to wear enough clothing to keep them warm and prevent hypothermia.

WHAT IS HYPOTHERMIA?

Hypothermia is a dangerously low body temperature caused by long exposure to cold environments. The normal body core temperature is 98.6 degrees Fahrenheit and hypothermia occurs when the body core temperature drops to 95 degrees Fahrenheit or lower. During hypothermia, the heart and lungs “shut down” to preserve heat and protect the brain. As a result, brain activity, heart rate, and breathing are slowed. Confusion, fatigue, unconsciousness, and even death can occur during hypothermia.

THERMOREGULATION

During cold exposure most heat loss escapes through the skin. The body’s ability to maintain thermal balance during exercise in the cold is referred to as thermoregulation (Castellani et al., 1999). Thermoregulation helps in the prevention of hypothermia (1999). Thermoregulation is the process that allows the body to maintain its core temperature of 98.6 degrees Fahrenheit. Effects on thermoregulation during exercise in the cold are induced by dehydration which results in a decreased skin temperature and an increased stroke volume and

cardiac output (Kenefick et. al., 2004). If dehydration affects thermoregulation then the cardiovascular efficiency decreases which decreases muscle blood flow (Seifert et. al., 2006). If muscle blood flow is decreased, there is an increased risk of hypothermia. Therefore, thermoregulation uses negative feedback to maintain homeostasis while exercising in the cold.

During thermoregulation studies, results have shown that when athletes are fatigued or exhausted their vasoconstrictor responses, but not shivering, are impaired which does not allow the body to maintain thermal balance after extended cold exposure (Sawka et. al., 2001). The vasoconstrictor responses help the body take blood from the extremities to maintain core temperatures. Less blood flow to the extremities is a serious risk for hypothermia, which is why skiers and snowboarders need to wear proper clothing. Wearing gloves, hats, jackets, and snow pants keeps the skier or snowboarder warmer but causes the body to sweat. However, a study

concluded exercising in the cold reduces sweat loss (Mears et al., 2014). Both of these statements are true. The amount of sweat loss in cold environments is lower than in hot environments.

Nonetheless, adding insulated clothing will trap the heat loss escaping through the skin and will increase the sweat rate.

Sweating requires the performer to replace lost fluids.



Why do Athletes Become Dehydrated?

- 1. Poor understanding of fluid requirements*
- 2. Limited opportunity to drink or availability to drink*
- 3. Poor drinking strategies*
- 4. Poor tolerance of drinks during competition*
- 5. Inability to match excessive sweat rates*

Explanation of above list:

1. Because sweat rates vary between individuals, the person does not realize how much fluid he or she needs to replace
2. During skiing and snowboarding, the athlete does not take enough breaks to replenish fluids
3. The event prevents the athlete from drinking
4. Some athletes blame nausea on sports drink; however nausea can be caused by dehydration itself. The sports drink may also be too concentrated for the athlete which causes poor tolerance.
5. The athlete does not consume enough fluids compared to the amount of sweat lost during exercise (sweat loss is greater than fluid replacement).

PREVENTING DEHYDRATION

Fluid loss occurs during exercise. During winter sports, such as skiing and snowboarding, fluid loss and dehydration have multiple effects on the performer.

Dehydration means the body does not have enough water and other fluids. The physiological effects of dehydration range from a desire of thirst, fatigue, drowsiness, and in severe cases, death. There are countless studies, media exposure, and public awareness when dehydration is paired with heat exposure, but the amount of research and results regarding dehydration in cold environments are not well known by the general public. Skiers and snowboarders tend not to realize how much they are sweating and the extent of the fluid loss they have accumulated. How long the athlete is exercising has a large effect on the amount of sweating and fluid loss. The performer needs to be conscious of factors contributing to fluid loss and how to prevent dehydration.

One study proved that the water intake of the subjects was less in the cold environment, compared to the warmer environment, but was still adequate to be able to prevent dehydration (Mears and Shirreffs, 2014). Due to the results of this study one could make the assumption that there does not

need to be the same amount of water intake during exercise in the cold compared to exercise in the heat. Even though the body's physiological response is to ingest less fluid during skiing and snowboarding, dehydration still occurs during exercise in the cold. Results from a study showed that dehydration can lead to a reduced cardiovascular efficiency, extended energy requirements, and a decrease in muscle blood flow (Seifert et. al., 2006). The results of the study lead to the idea that dehydration can cause unnecessary energy expenditure causing further dehydration.

Signs and Symptoms of Dehydration:

- Extreme thirst
- Little or no urination
- Dry mouth
- Confusion
- Dizziness
- Weakness

STUDIES ATTEMPTING TO PREVENT DEHYDRATION

During exercise our kidneys generally concentrate urine in order to conserve water and further prevent dehydration. Considering this normal physiological function, a study found that the urine output collected in the samples showed it exceeded the water intake (Seifert et al., 2006). Although, the results from a study by Gibson et al. (2012) show

The Bodies Response to Dehydration:

A loss of 2% bodyweight causes an increase in perceived effort and claims to reduce performance by 10-20%. A fluid loss exceeding 3-5% bodyweight reduces aerobic exercise performance and impairs reaction time, judgment, concentration, and decision making. This is important to understand because in long-duration activity fluid loss is critical.

no direct correlation between collected urine specific gravity (USG), heart rate, percent body mass lost, and sweat rate; there seemed to be a large range in the participants regarding the individual results of fluid loss. This explains that individuals lose fluids at different rates. Another study showed that even though the participants drank water, there was still a decrease in plasma osmolality, plasma protein, and urine osmolality. Constant plasma osmolality will decrease the amount of urine production during rehydration (Seifert et al., 1998). The result of this study leads to the assumption that drinking water alone is not always enough when maintaining fluid balance in the human body.

WHICH DRINKS ARE BEST FOR MAINTAINING FLUID BALANCE?

When maintaining fluid balance during exercise an athlete also needs to consider maintaining electrolytes and carbohydrates. The results of a study that was performed showed that drinks that have carbohydrates and electrolytes are the best choice because both prevent a reduction in plasma osmolality (Seifert et. al., 1998). The optimal carbohydrate concentration depends on physiological demands of the sport, environmental condition, and the athlete's tolerance. A few popular drinks, such as Gatorade



Nutrition Facts

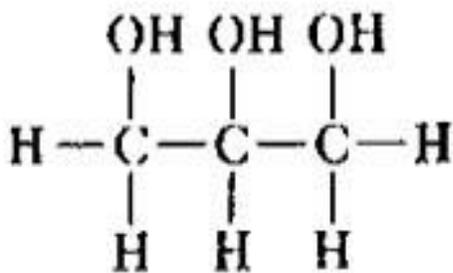
Serving Size: 8 oz	
Amount Per Serving	
Calories 50	Calories from Fat 0
% Daily Value*	
Total Fat 0 g	0%
Saturated Fat 0 g	0%
Trans Fat 0 g	
Cholesterol 0 mg	0%
Sodium 110 mg	5%
Potassium 30 mg	1%
Total Carbohydrate 14 g	5%
Dietary Fiber 0 g	0%
Sugars 14 g	
Sugar Alcohols 0 g	
Protein 0 g	
Vitamin A 0 IU	0%
Vitamin C 0 mg	0%
Calcium 0 mg	0%
Iron 0 mg	0%

Gatorade provides carbohydrates and the necessary electrolytes such as sodium to aid in water absorption for maintaining fluid balance. CHO-electrolyte drinks usually contain 4-8% CHO which is absorbed quicker than water and provides fuel for muscle performance.

and Powerade, are important for athletes to help maintain fluid balance in the body because they provide required carbohydrates and electrolytes, specifically sodium. Drinking plain water causes bloating, suppresses thirst, and stimulates urine output. However, during exercise when a high fluid intake is required, it is a poor choice to drink only water. Gatorade and Powerade provide the electrolyte sodium balance which stimulates water absorption, but the most important feature of any sports drink is palatability because the drink has no value if it tastes awful and cannot be consumed in large volumes. The benefits of carbohydrates in sports drink delays fatigue and helps maintain mental alertness and judgment. Deciding what, when, and how much an individual athlete should consume is not straightforward because sweat rates vary among athletes. The amount of carbohydrate that should be consumed is based on the tolerance of the athlete because some athletes may find sports drinks with 4-8% CHO as heavy and need a weaker, more diluted solution.

WAYS TO IMPROVE WATER ABSORPTION

When an athlete wants to maintain the amount of fluid loss during exercise he or she may be interested in the study that showed more than twice the amount of fluid was retained with a glycerol + water hydration before exercise, than when only water was consumed alone (O'Brien



Chemical structure of Glycerol.
Glycerol helps aid the body in absorbing water to stay hydrated (Glycerol increases retention of water)

et. al., 2005). Hyperhydration with glycerol is more effective than hyperhydration with water (2005).

Hyperhydration is an excess of water in the body.

Glycerol increases retention of water to eliminate

dehydration (2005). Glycerol is another name for sugar.

After discovering the benefits of adding glycerol to water

one might think they do not have to drink as much to

replace the fluid loss. In the cold there are no set guidelines on how to replace and maintain fluid balance. Results show the electrolyte-water balance was related to thirst and mouth dryness in the cold environment (Mears and Shirreffs, 2014). The idea of drinking water when there is a desire of thirst is an easy concept to follow but it also leads to a problem. During winter sports, a skier or snowboarder does not have a sense of thirst which can (Kenefick et. al, 2004). Therefore, an athlete cannot rely on feeling thirsty as a reminder to replace lost fluids. Exercise suppresses thirst which directly leads to dehydration. An additional study by Kenefick et al. (2008) reported up to a 40% decrease in thirst during rest and exercise when subjects were exposed to cold air (4 degrees Celsius).



Drinking water throughout exercise tends to decrease dehydration. A study was performed that showed dehydration typically occurs during the beginning and first few hours of exercise (Seifert et al., 2006). Even though the skiers were allowed to drink water during the midday break they could not replenish the lost fluid (2006). Athletes that tend to drink a lot of fluids in one sitting do not replenish the fluids that were

previously lost. In the same study a different group of participants were given a back mounted hydration system (BMHS) while exercising (2006). The group that was allowed to use the BMHS prevented dehydration (2006). This goes to show that participants who had the

convenience of a BMHS drank water when they felt necessary to allow them to avoid dehydration. Drinking water more often is better for the body than drinking a large amount of water at one time. While on the mountain, a skier or snowboarder will take breaks to ingest large amounts of water at one time before returning to exercise. However, that is a bad idea because it will not replenish the fluids properly. A back mounted hydration system might be a wise purchase for an avid skier or snowboarder.

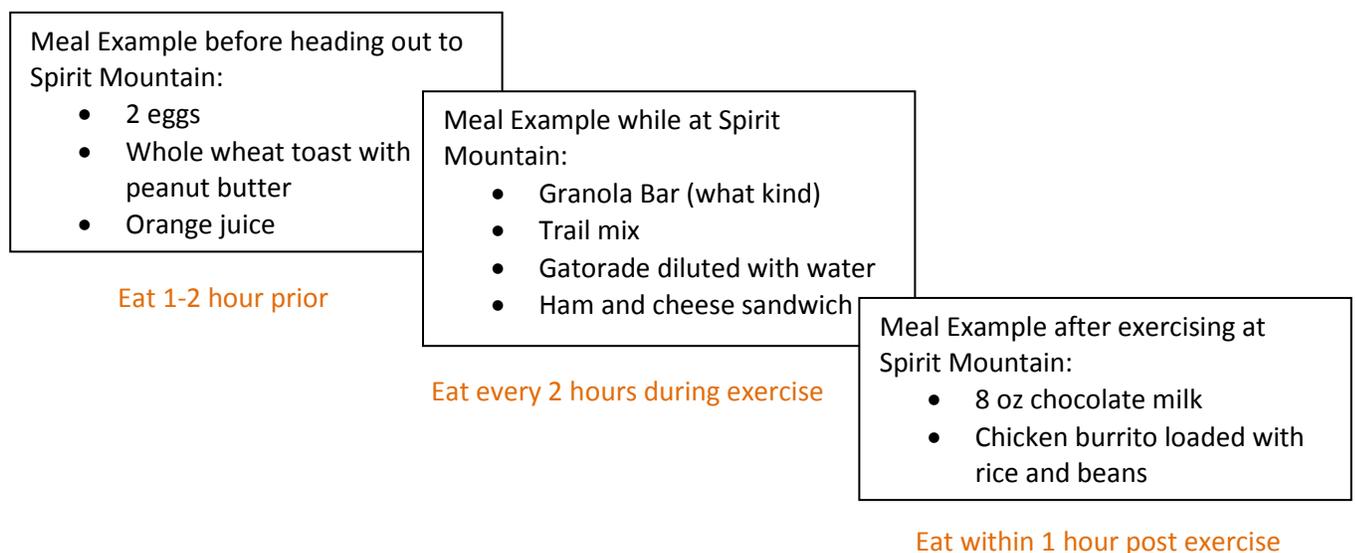


RECOMMENDED NUTRITION

Proper nutrition for skiing and snowboarding starts before hitting the slopes. One of the biggest recommendations for a college student living on a college budget is to eat a meal before heading to Spirit Mountain or another resort.

Consuming carbohydrates is the most important nutritional recommendation for skiing and snowboarding. Replenishing and maintaining carbohydrates during long periods of intense exercise is essential. Not only is it wise to eat a meal high in carbohydrates but it is also cost efficient! The prices in the chalet can be on the steep side and not many college students can afford it. Packing a light snack that contains a carbohydrate and a small protein such as trail mix or a granola bar will not only save money but also help minimize muscle damage. On the topic of being a college student, alcohol is not a good choice for a “carbohydrate” because it can further lead to dehydration. Alcohol is not a good idea for a skier or snowboarder because it will further reduce their ability to recognize the need for water and electrolytes. It is important to

remember to take a short break from the slopes and make a trip back to the vehicle to drink a Gatorade. Gatorade is cost efficient and replenishes lost electrolytes! The results from Palmer et al. (2010) conclude while ingesting carbohydrate electrolyte substances, such as Gatorade or Powerade, during exercise sodium intake increased, sodium balance overall improved, and athletes were able to obtain carbohydrate fuel sources better compared to ingesting only water. The study proves that Gatorade is the proper drink to maintain carbohydrates and electrolytes during exercise. Gatorade improves sodium balance which will help the body absorb more water because water follows salt. If sodium, electrolytes, and water are balanced then the athlete will be able to perform at maximal ability. Powdered sports drinks are best because they can be diluted to suit the climate and the individual. If possible, packing a BMHS is a great way to avoid dehydration while skiing and snowboarding. The combination of Gatorade and the BMHS provides adequate fluid replacement with carbohydrates. The meal after skiing or snowboarding should be eaten within an hour. A large glass of chocolate milk and perhaps a chicken burrito loaded with rice and beans would help your body replace the extra carbohydrates not replenished by Gatorade and provide proteins which are needed for muscle recovery.



CONCLUSION

Skiing and snowboarding require a lot of preparation that an individual would not generally think of beforehand. Living so close to Spirit Mountain in the city of Duluth is truly a blessing. Not only is skiing and snowboarding a great workout, fun activity with friends and family, and a way to enjoy the outdoors but it also teaches an individual important life lessons. Whether someone does the research on fluid intake, dehydration, electrolytes, and thermoregulation or they find out the hard way through personal experience, there is a learning curve. A skier or snowboarder needs to be consciously aware of the effects the cold environment can have on the body. For safe exercise in cold environments, skiers and snowboarders must constantly maintain fluids and thermal balance while preventing dehydration and hypothermia. The purpose of this chapter was to educate people on fluid and electrolyte maintenance during winter sports such as skiing and snowboarding.

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