

# It's Snow Time!

## The Ergonomics of Skiing and Snowboarding



By Tamara Mitchell

There are several different types of skiing which produce somewhat different strains and possibilities for injury, and snowboarding presents still different strains on the body. By far, the most prevalent recreational type of skiing is Alpine or downhill skiing. Cross-country skiing has gained a lot in popularity, too, and provides the opportunity for a superb aerobic workout outside the usual ski resorts. Telemarking and ski mountaineering are fairly uncommon forms of skiing and since little data exists for these types of skiing injuries, we will not cover them in this article. Snowboarders, though they are on the slopes with the downhill skiers, do not share the same type of techniques nor injuries as skiers.

In general, reporting of overuse injuries in professional sports is under reported. Injury data reported can be misleading, since most studies include data from medical facilities at ski resorts that treat primarily traumatic injuries and some research has found significant underreporting of injuries relating to tendons, ligaments, muscles, and joints by medical and technical personnel at World Cup competitions in comparison to problems reported during interviews with the athletes.<sup>1</sup> Overuse injuries are likely treated by a medical practitioner at some later time, even months or years after suffering mild discomforts of overuse. Using lost time from sports (training or tournaments) has also not been a good measure of overuse injury incidence since athletes often participate with nagging low-level, persistent pain and frequently do not report it.<sup>2</sup> Surveying or questioning athletes about their pain and pain level appears to be a much more relevant way of detecting overuse injuries, though it is rarely used.<sup>2</sup>

Proper conditioning prior to the snow season is important for all of these sports. It will increase your endurance and control, and it will decrease your chances for injury. If you plan to head to the snow this winter, plan on tuning up your body ahead of time and be ready to enjoy yourself injury-free this winter.

### Traumatic Injuries

#### *Alpine skiing traumatic injuries*

In Alpine skiing and snowboarding, trauma injuries are mainly due to falls and collisions, resulting in bruising, sprains, fractures and head injuries. Ski injuries can encompass just about every joint in the body, but the most common joints injured are the knee, shoulder, and hand.<sup>3,4</sup> Lower leg fractures are especially common among children ages 12 years or younger (17% of all injuries).<sup>4</sup> The rate for lower leg fractures among adults aged 20 or over is 3% and for children ages 13-19 years old, the rate is 5%.<sup>4</sup>



Image courtesy of AgenceSportiv.com

A disproportionate number of Alpine ski injuries were found among the “less than 16” age group by a factor of 2.2 This may be due to deficiencies in equipment for children or it may be due to the fact that most children have little fear of injury. By a large margin, joint dislocations outnumbered other types of injuries. Studies suggest that smaller, younger, lighter, and less experienced skiers are at the highest risk for injury.<sup>3</sup>

Knee injuries are very common in Alpine skiing due to the twisting of the upper leg one way, while the lower leg rotates the opposite way. This torque often causes tears to the anterior cruciate ligament (ACL) of the knee.<sup>5</sup> 32-48% of all Alpine ski injuries are related to the knee.<sup>3</sup> Females are two to five times more likely to injure their knees, with 33% more females injuring their ACL than males.<sup>3</sup> Males, however, are more likely to injure their head and shoulders than females.<sup>3</sup> 20-25% of knee injuries are to the Medial Collateral Ligament (MCL) and these commonly affect beginner and low-intermediate skiers in the "snowplow" position resulting from a fall, skis crossing, or the snowplough stance widening. Tears to the meniscus are also occur during the twisting action of the knee during skiing.<sup>6</sup>

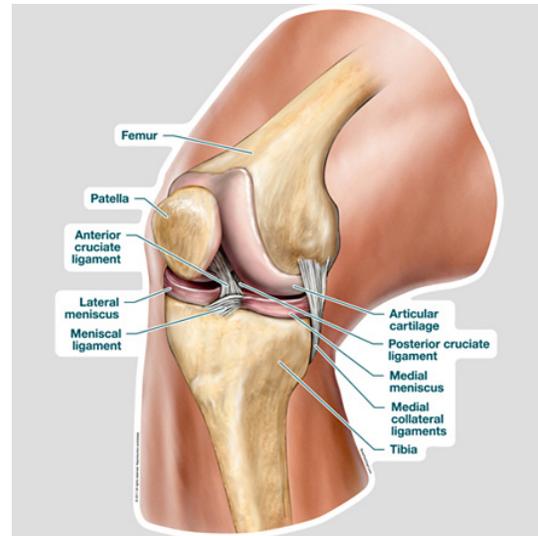


Illustration courtesy of <https://hersheyrehab.wordpress.com> Nov. 7, 2013

Inexperienced skiers have an injury rate 3 times that of expert skiers<sup>4</sup> Incidence of injury drops by one-half when beginners participate in supervised ski lessons.<sup>3</sup> Use of a helmet significantly reduces injury rates.<sup>4</sup>

Improvements in ski equipment have reduced traumatic injuries steadily since the 1940's. In the 1950's and 1960's, there was an average of 6.6/1000 hours. In the 1970's and 1980's, that decreased to 2.8/1000 hours.<sup>3</sup> In 2000-2002, the rate of traumatic injury for Alpine skiers was just 1.1/1000 hours.<sup>4</sup>

#### *Snowboarding traumatic injuries*

Snowboarding results in significantly more injuries than either Alpine skiing or telemarking according to one study: a rate of 2.3 injuries per 1000 hours of participation.<sup>4</sup> Snowboarding is still a developing sport and the direction it is taking is toward a more extreme sport.<sup>7</sup> The prevalence of injuries depends on what research we look at. From reports of World Cup snowboarders, knee injuries comprised 17% of all acute injuries, back and chest injuries (22%), and head injuries (7%), yet head injuries comprise 26% of all recreational snowboarders.<sup>7</sup> High, severe injury rates among competitive snowboarders include head, shoulder, chest, back, knee, and ankle.<sup>8</sup>



Photo courtesy of [snowkingmountain.com](http://snowkingmountain.com)

Another report states that the most prevalent injuries are the wrist, arm, and back.<sup>4</sup> Fractures were found to be more common among snowboarders than among Alpine skiers or telemarkers.<sup>4</sup> Expert snowboarders have 1/3 the number of injuries experienced by novices.<sup>4</sup> Use of protective helmets significantly reduces the number of injuries, though it doesn't appear to reduce deaths from more major accidents.<sup>4,9</sup> The types of snowboarding done in competitions such as halfpipe, snowboard cross, and big air involves a lot more jumping and more resulting injuries to the chest and spine than the types of maneuvers generally performed on Alpine ski slopes by less experienced athletes.<sup>7</sup>

This theory was found to be the case by a thorough review of all injury research.<sup>8</sup> Beginner to intermediate snowboarders tend to hurt themselves during an isolated fall and the injuries are not severe.<sup>8</sup> The severity of World Cup injuries is equivalent to professional football players.<sup>8</sup> Injuries to the wrist are common in recreational snowboarders, but are almost absent in expert athletes.<sup>8</sup>

When snowboarding, both feet are strapped onto the same board and always point the same direction. Because of this, the knee is not twisted as it is in skiing, but the stance of snowboarding is unnatural and sideways.<sup>5,10</sup> Both boots are bound to the board and a snowboarder can do little to shift leg balance during a fall.<sup>10</sup> Snowboarding boots are softer and more supple than rigid ski boots which allows for the



Illustration courtesy of CoastalOrthopaedics.com.au

acrobatics and jumps of snowboarding, but also opens the feet and ankles up to injury.<sup>10</sup> More flexibility means less protection. The upper body takes the force of a fall.<sup>5</sup> Snowboarders fall landing on their hands, shoulders, rear-ends, or heads. Snowboarder's ankle is another traumatic injury unique to this sport which involves breaking the Talus, a small bone located between the heel bone and the two bones of the lower leg.<sup>10</sup> This injury is very difficult to diagnose, often doesn't show up in x-rays, and is commonly mistaken for a sprain.<sup>10</sup> If pain doesn't subside in a couple of weeks, a podiatric foot and ankle specialist should be consulted. Continuing to use the ankle when it is injured often leads to compensation for the pain by favoring the ankle which can lead to injuries of the knees, hip, and spine.<sup>10</sup>

### *Cross-country skiing traumatic injuries*

There are two types of cross-country skiing.<sup>11</sup> Classical cross-country skiing is still very common, where both skis are pointed straight ahead and thrust forward by pushing off from the middle of one ski while the other glides forward. Ski-skating has become increasingly popular since the mid-



Image courtesy of glisshop.de

1980's. The legs are alternately pushed outward to each side as in speed skating, rather than directly backward as in the classical stride. Injury rates for the two types of



Image courtesy of pdxrelocate.com

cross-country skiing appear to be about the same. For recreational cross-country skiers, the injury rate is quite low: 0.65 per 1,000 hours for women and 0.40 per 1,000 hours for men.<sup>11</sup> Injury rates for competitive and elite skiers is even lower. Most of these injuries are not traumatic injuries according to research. They are overuse injuries.<sup>11</sup> It should be noted however, that since cross-country skiing

takes place wherever there is snow rather than at established resorts with groomed slopes, reporting of injuries is likely under-reported.<sup>12</sup>

Traumatic injuries seen in cross-country skiing are ankle ligament sprains and fractures, muscle ruptures, and knee ligament sprains.<sup>12</sup> Shoulder dislocation, acromioclavicular separation and rotator cuff tears are not infrequent in cross-country skiing.<sup>12</sup>

### **Overuse Injuries**

#### *Alpine skiing overuse injuries*

The most common overuse injury and pain in alpine skiers is to the lower back.<sup>13</sup> To a much lesser degree, knee, hip, and tibia overuse injury is found in World Cup slalom skiers.<sup>13</sup> Overuse injury data is severely lacking for the general population of alpine skiers.

Prevalence of low back pain in the general population is about 15% while for competitive alpine skiers, it is over 41% for women and over 33% for men.<sup>13</sup> Measurements of forces on the body in one study indicated that simultaneous spinal bending forward, back, and lateral, spinal rotation, and high peak loads while skiing may explain the prevalence of low back issues in alpine skiers.<sup>13</sup>

Research has also found that whole body vibration during slalom and giant slalom are in the range of 4 - 10 Hz which is the resonant frequency of the spine and may result in deterioration or abnormalities of the spine.<sup>14</sup> Another study measured whole body vibration for a wider variety of skiing techniques and found that all of them exceeded the limits set by the European Directive 2002/44/EC for health and safety.<sup>15</sup> Six different forms of skiing were measured: straight running, plowing, snow-plow swinging, basic swinging, short swinging, and carved turns.<sup>15</sup> Intensified vibration was measured only when skidding was involved, specifically moves where the ends of the skis glide out to the side (snow-plow swinging, basic swinging, and short swinging), rather than gliding parallel to the tips (carved turns). It appears that even elite skiers skid in carved turns (slalom and giant slalom).<sup>15</sup>

What all of this means is that likelihood of injury to the spine and low back pain is increased in the sport of Alpine skiing because of the motions involved and the simultaneous whole body vibration.

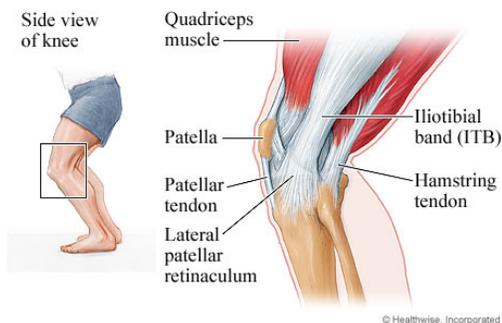
Wrist pain and tendinitis can result from repetitive flexing and rotating of the wrist as skiers withdraw their planted ski poles in deep snow. Advanced skiers may be more at risk because of their more aggressive style of pole planting.<sup>16</sup> This type of injury had an 11.9% incidence rate in one group of Alpine powder skiers.<sup>16</sup>

#### *Snowboarding overuse injuries*

There is very little research regarding overuse injuries in snowboarding. In one study of World Cup snowboarders, the most common overuse injury reported was the knee (31%) followed by back (19%), and lower leg (18%).<sup>7</sup> The foot (14%) and arm/shoulder (11%) were also somewhat frequent.<sup>7</sup> Overuse injury incidence was defined as any injury with gradual onset which influenced performance during practice or competition.<sup>7</sup> The injury rates were determined through structured interviews. The average age was 23 years in this research. As noted in the overview of traumatic snowboarding injuries, the type of injury experienced by elite athletes is likely quite different from amateur snowboarders because technique improves and the type of snowboarding maneuvers change and the sport becomes more extreme.

#### *Cross-country skiing and ski skating overuse injuries*

Overuse injuries are the predominant type of injury in cross-country skiing.<sup>11</sup> The four primary areas of overuse injury are the anterior thigh, knee, lower back, and shoulder.<sup>11</sup> Among elite Swedish cross-country skiers, medial-tibial stress syndrome, Achilles tendon problems, and lower back pain were the most common overuse injuries.<sup>Renstrom</sup> Runner's knee is quite common in cross-country skiers. It involves wearing down of the cartilage on the underside of the kneecap (chondromalacia or patellofemoral syndrome) usually due to sideways tracking of the kneecap or an increased angle between the upper and lower leg, especially in women.<sup>17</sup> Symptoms include pain under the kneecap or to the side of it, crunching, popping, grinding, or a feeling of the knee giving way.<sup>17</sup> This problem is often precipitated by skiing too much, too fast, and/or too far.<sup>17</sup> Tight hamstrings and calves, weak quadriceps muscles, and sometimes tight iliotibial band can cause the kneecap to track out of alignment.<sup>Drozid</sup>



Sesamoiditis is the inflammation of the small bones

associated with the tendons just below the big toe in the ball of the foot.<sup>17</sup> It can be either an intermittent pain or it can be an intense throbbing and swelling if it is more advanced.<sup>17,18</sup> Cross-country skiers using the classic technique rather than ski-skating are most prone to this. It occurs primarily as a result of skiing too many hills, too fast, or increasing mileage too quickly.<sup>17</sup> People with high arches are also prone to developing sesamoiditis.<sup>17</sup>



### **Injury Prevention**

*Preventing injuries in all snow sports.*

Regardless of the sport, frostbite and hypothermia are dangers. Make sure to get waterproof, weatherproof clothing and stay warm.<sup>6</sup> Delayed onset muscle soreness (DOMS) is very likely since you will be using muscles you don't usually use, even if you have worked on conditioning ahead of time.<sup>6</sup>

Exposure to cold and wind can cause injury to the exposed skin of face and hands. Frostnip, is the numbness and blue-white discoloration of exposed skin. Frostbite involves deeper skin layers and can be a precursor of hypothermia.<sup>4</sup>

Exercise Induced Bronchospasm (EIB) is quite common in athletes who participate in vigorous exercise in cold weather.<sup>17</sup> It involves constriction of the small airways in the lungs when breathing cold, dry air and often also involves a dry cough after skiing/snowboarding.<sup>17</sup> To manage EIB:<sup>17</sup>

- Warm up slowly in the cold.
- Avoid exercise in very cold weather and, if you must ski, use a face mask.
- Don't smoke and ensure that indoor air is of high quality and smoke-free.
- Avoid viral upper respiratory infections such as colds and influenza by assiduously washing hands.
- Consider using asthma inhalers before skiing if your doctor believes it is indicated.
- If you have asthma, follow your doctor's recommendations.

Please pay attention to pain of any kind. Don't just mask the pain with pain killers or ice.<sup>17</sup> Seek medical attention so you can determine the source and head off the progression of overuse injuries.

- Proper conditioning prior to snow sports of any kind is the best way to prevent injuries.<sup>6</sup>
- Warm up before heading out to the slopes or on the trail because cold muscles are more easily injured. Note, this does NOT mean stretching.<sup>6,19</sup> Take lessons from a qualified instructor to make sure you use proper form and can fall without injury.<sup>6</sup>
- Wear a helmet and other protective gear (goggles, gloves, padding) and use appropriate, well-fitting clothing and equipment.<sup>6,20</sup>
- Stay with a friend or buddy so if an emergency arises, you will not be left alone in the cold, especially if you participate in cross-country skiing where you may be in a remote area that is not patrolled regularly.<sup>6,20</sup>
- Take it easy when you become tired or at the end of the day.<sup>20</sup> Take breaks to rest throughout the day.<sup>21</sup> Injuries occur most often when people are tired.<sup>20</sup>
- Don't ski/snowboard above your ability.<sup>21</sup>
- Stay hydrated.<sup>21</sup>

### *Alpine skiing injury prevention*

Unfortunately, overuse injury has not received the attention it needs to be able to offer solid suggestions for prevention, especially with regard to lower back injury. It has been recommended that building up core strength and possibly wearing a stability corset may help reduce the likelihood of injury to the spine

resulting from the bending, twisting, turning, and whole body vibration involved.<sup>22</sup> Certainly building core strength is an excellent recommendation regardless of the sport. This pilates workout with Kristin McGee is excellent if done several times a week: <https://youtu.be/AuzsfR5J8rI> .

Proper warm-up and stretching can improve flexibility and reduce the chances for pulls and strains. Conditioning calves, gluteus muscles, hamstrings and quadriceps in preparation for the ski season is a good idea to improve muscle control. Also, strengthening the abdominal and core muscles will help you get up after a fall. This is an example of a great 30-minute conditioning workout video to prepare you specifically for the explosive movements involved in skiing: <https://youtu.be/pKnP88kWTkA> .

Take lessons from a qualified instructor. Injuries are much more likely for novices who have not had any instruction in skiing. If you ski occasionally, it is best to brush up on your technique before hitting the slopes.

Wearing a helmet can prevent head injuries, which can be fatal. Design of helmets for skiing and snowboarding is improving, making them more comfortable and popular for all ages. Anticipate the maneuvers of other skiers and snowboarders around you. For instance, snowboarders make wider-arch turns than skiers.

Be very careful late in the day when you are fatigued, even if you don't feel tired. Many people injure themselves during the last run of the day. Take your last run slowly and use it as a cool-down for your body. Do not use alcohol or drugs. And avoid off-limits areas where there may be avalanches, drop-offs, cliffs, trees and unseen rocks and underbrush. Skiing off the designated ski runs can be hazardous. People may not know where you are and safety teams do often not patrol them. Weather patterns may be erratic and you may be caught in an unknown area during a whiteout. It's best to stay on runs and areas which are designated for skiing.

#### *Snowboarding injury prevention*

Preparing the body through conditioning and warm-up prior to snowboarding help avoid muscle and ligament strains and tears. By the time you walk from your car to the hill with all of your equipment, you are probably adequately warmed up. Do some shoulder rolls, waist twists, and toe touches to limber up, but do not do stretches prior to hitting the slopes. Research has shown that stretching prior to exercise actually decreases performance and increases the chances of muscle injury.<sup>19</sup>

Though skiing and snowboarding are very different sports, they do use similar muscles. Strengthen the core muscles of the abdomen and back, calves, glutes, hamstrings, and quadriceps in preparation for the snowboarding season. This is an excellent 28-minute workout video tailored to preparing your body for snowboarding: <https://youtu.be/SfekYZS00-Y> .

Don't forget your ankles and feet! The flexible boots used in snowboarding mean that you need to strengthen your ankles and feet to withstand the demands of the sport. Wobble boards or stability discs are excellent for strengthening ankles and improving balance.<sup>10</sup> Foot and ankle rolls and exercises on a tennis ball or Franklin ball can help improve ankle flexibility and balance also. This video is a good example of exercises using Franklin balls: <https://youtu.be/wmss2G95ens> . Marble toe pickups, calf raises, and ankle rotations are also excellent exercises for strengthening the ankles and feet and improving flexibility.<sup>10</sup>



Wrist guards, such as those used for in-line skating, may be helpful. Elbow guards can ease the force of falls on the elbows. Knee pads and tailbone pads can help protect the knees and tailbone during a fall, too.<sup>5</sup>

Learn to tuck and roll when you fall to distribute the force of the fall. Falling with all of your force on one body part, such as your wrist, causing greater injury.

Make sure you have properly fitting equipment in good working order.<sup>10</sup> Use orthotics inside the flexible snowboarding boots and stiff inner boot to help stabilize the foot and ankle, improve overall foot function, and prevent injuries.<sup>10,23</sup>

As with skiing, taking lessons from a qualified instructor is likely to decrease your chances of injury.<sup>23</sup> And just because you may be an excellent skier, you may be a novice on a snowboard.<sup>5</sup> They are very different sports. Snowboarding has a steep learning curve, which means that, though beginners may feel frustrated at first, they soon find it gets easier. Novice snowboarders can advance much faster than inexperienced skiers.

Wearing a helmet can prevent concussion, brain injury, or fatalities in both skiing and snowboarding.<sup>6</sup> Stay in control and be aware of other snowboarders and skiers around you. The long-arch turns of snowboarders differ from the shorter-arch turns of skiers. Avoid collisions with others by anticipating their maneuvers. Check blind spots before turning, especially on backside turns. Don't sit down in traffic areas or anywhere you can't be easily seen.

Attach a security strap to your front foot. Detach your right foot from its bindings while using lifts or tows.

As with skiing, be very careful late in the day when you have been snowboarding all day and are fatigued. Never use alcohol or drugs when snowboarding. Stay on designated slopes and areas.

#### *Cross-country skiing injury prevention*

Cross-country conditioning should emphasize aerobic and anaerobic conditioning, but also should employ strength training for ski-specific motions.<sup>11</sup> Proper warm-up and cool-down exercises, as well as endurance and strengthening exercises, are necessary to avoid overuse injuries. Ski-skating relies on the hip adductors and rotators, which are muscles not routinely involved in preseason conditioning, such as running.<sup>4</sup> Roller skiing can be a good strategy in pre-season conditioning and training.

Cross-country skiing is physically demanding from not only the standpoint of requiring aerobic fitness, but also requires strength in the core and legs. There are several excellent workouts on YouTube, but this one with just three exercises really targets the core and the legs including the lateral movements used in ski skating: <https://youtu.be/cgOsgc1lxnc> .

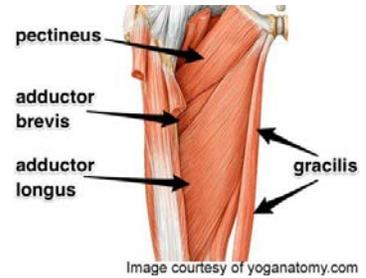
This routine on roller skis is really good conditioning before the snow season starts to get your technique and strength built up for sports-specific injury prevention:

<http://www.silentsports.net/2016/10/06/fall-roller-ski-drills-to-develop-specific-strength/> .

Another good pre-season drill to work on balance, core strength, hip and adductors strengthening, and upper body drills with exercise band/bungee cord: <http://www.silentsports.net/2015/11/01/prep-your-body-for-snow-and-free-your-mind/>

This discussion covers finding the right balance between endurance and intensity in your workouts and conditioning routine. Each person has a different balance that is right for them :

<http://www.silentsports.net/2016/11/06/endurance-and-intensity-find-your-own-balance/>



If you are starting to experience pain under the kneecap, runner's knee should be suspected, it is important to reduce the distance you are skiing *immediately*. Increase mileage only 10% each week if you ski daily and back off if you feel any pain. Avoid other activities that stress the knee such as walking or running on downward slopes and going down stairs.<sup>Drozd</sup> Try orthotics in shoes and ski boots.<sup>Drozd</sup> Exercises to stretch the hamstrings and calves and strengthen the quadriceps can help take pressure off the kneecap and keep it in place.<sup>Drozd</sup> This three-phase strengthening and stretching routine from Loyola University is an excellent program for helping to reduce kneecap tracking problems: <https://youtu.be/XMfZT9Hysnc> .

To prevent Sesamoiditis:<sup>17,18</sup>

- Be sure to have properly fitting footwear for training, walking, and, most importantly, for skiing.
- Consider buying new ski boots if your old ones are worn and overly flexible at the ball of the foot. Increase padding under the area of the sesamoid bones and/or wear orthotics.
- Combi boots can be used for both classic and skating technique and have a relatively stiff sole.
- Cross-train by ski skating. Skating boots are much less likely to aggravate the condition due to their stiff soles reducing flexion at the MTP joint.
- Get arch supports or custom orthotics to reduce pressure on the sesamoid bones by distributing pressure more evenly on the foot.
- Use ice treatments and anti-inflammatory medications such as ibuprofen or naproxen to reduce pain.
- Deep massage in the hands of a massage professional who understands sports medicine.
- Cut down on duration of skiing or even stop skiing for a time if symptoms are present.

Attention to equipment is very important in injury prevention. Equipment should be in good repair and fit you well. Wear layered clothing, adequate hydration (carry water with you), and protective eyewear help prevent cold and wind related injuries. It is best to stay on marked trails and let someone know where you are going. There are miles of cross-country trails many of which are lightly patrolled by safety teams, especially in comparison to heavily populated downhill ski areas. If you become injured, it can take quite a while to get help to you. Weather conditions can change rapidly, so be aware of your location and trail branching. It is very wise to take a course in winter survival offered by ski patrol or forest service in some areas. Make up a small survival pack to carry that contains a space blanket, trash bag (for cover/tent), waterproof matches, compass, and mirror or reflector. Most importantly, if you get lost, stay

where you are. It will be far easier for rescue teams to find you if you don't get farther off the track and deeper into the woods. Panic is very common and it is important to remain calm and conserve energy.

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This article and all of our articles are intended for your information and education. We are not experts in the diagnosis and treatment of specific medical or mental problems. When dealing with a severe problem, please consult with a healthcare or mental health professional and research the alternatives available for your particular diagnosis prior to embarking on a treatment plan. You are ultimately responsible for your own health and treatment!

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