Extreme Sports: Injuries and Medical Coverage

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Introduction

Most sports medicine physicians think about being a team physician in the context of traditional sports such as football, basketball, baseball, and soccer. When they think about providing medical coverage for a sporting event, football games, track meets, soccer tournaments, and marathons come to mind. However, many athletes, especially younger ones, are turning away from the more traditional activities and participating in "next-generation" activities. Participation in sports such as alpine skiing, road bicycling, and roller-skating is declining, whereas participation in snowboarding, mountain bicycling, and in-line skating continues to rise. The media also seems to be fascinated by sports that appear to place athletes at greater risks than are found in traditional sporting activities. Despite this increased risk of injury, athletes competing in these sports often have little or no formal medical coverage. This article reviews what is known about this emerging area of sports medicine to assist physicians in preparing for medical coverage of these athletes and their competitions.

The Literature

Unfortunately, the body of research on these activities is extremely limited. A Medline review of the literature on injuries and prevention in 11 of these sports (Table 1) for the years 1966 to February 2002 found only 221 articles, including 174 English language articles. Physiology and biomechanical research articles accounted for 49 (22%) articles, leaving 172 articles (including 22 case reports) that touched on injuries and prevention (Table 2). The lack of scholarly research on injuries in these emerging sports made it necessary to supplement information from the medical literature with mainstream media reports. As a result, this article is descriptive and not definitive.

Specific Sports

Skateboarding

Skateboarding, a popular activity with youth since the 1960s, has recently become a mainstream competitive sport. In competitions, the skateboarder performs a series of jumps and tricks while riding down rails, through half-and quarter-pipes, and over ramps. Naturally, recreational
skateboarders often try to recreate these actions when they skate. Unfortunately, the locations that some recreational skateboarders choose are often less than optimal and may place the skateboarders at higher risk for injury [2,3]. Both recreational and competitive skaters are at relatively high risk for head injury [3]. The use of protective equipment should be encouraged to decrease severity of injury [2].

### In-line skating

In-line skating has been one of the fastest growing recreational sports in the United States in the past decade. With its rise in popularity has come a tremendous increase in injuries [4]. The Centers for Disease Control and Prevention (CDC) estimates that more than 100,000 in-line skating injuries per year are serious enough to require emergency...
Sport-specific Illness and Injury

This places in-line skating in the top 10 sports in terms of frequency of injury from a recreational activity, along with sports such as basketball, bicycling, football, baseball, skiing, and soccer. In in-line skating, approximately two thirds of the injuries occur in the upper extremity, the wrist being the most common locus of injury [4,6,7,8]. Wearing protective equipment significantly reduces the risk of injury, but many in-line skaters wear no protective gear [5,9–11]. Competitive in-line skating events have grown with the popularity of the sport. First were endurance distance events; recent growth has been in increasingly aggressive skating events such as “big air competitions” that rate competitors on height of jump, execution of tricks, and artistic performance. The more extreme forms of in-line skating increase the potential for injury, especially the more severe types, such as head injury [12].

Mountain bicycling
Mountain bicycling has enjoyed tremendous growth in the past 20 years. Competitions include laps around narrow off-road paths, downhill races, and indoor competitions with artificial obstacles. In addition to traditional road bicycling injuries, mountain bikers are at increased risk of solo crashes caused by the terrain. Although most injuries are relatively minor, up to 10% of mountain bikers require hospitalization for injuries varying from fractures to internal injuries [13••,14]. For many, the use of protective equipment may reduce the risk and severity of injury. One injury that is relatively specific to mountain bicycling is a high rate of microtrauma to the scrotum in male bicyclists, resulting in a variety of genitourinary symptoms [15].

Snowboarding
Snowboarding has also had the distinction of having one of the fastest evolutionary rates of any competitive event. Originally, competitions consisted of the more traditional events such as individual alpine-style races. These original events have become more mainstream with their inclusion in the Winter Olympics and World Cup competitions, but over time some have been replaced with more extreme sports, such as snowboarder-cross. In cross-type activities, multiple athletes, usually four to six, race simultaneously over an obstacle-filled course that includes bumpy slopes, jumps, ramps, and gaps. Finish time is not the goal in these races because only the first riders (usually the first two to three) to complete the course advance to the next round. Even the traditional half-pipe competition is slowly being replaced with more extreme variations. One such innovation is “big air” events, in which competitors launch themselves off of large ramps and are judged on height of jump, performance of tricks, and landing technique. Another is “slopestyle” events, in which the competitors perform a series of tricks over fixed obstacles such as modified stair-rails, pipes, and picnic tables. Once again, each new type of competition usually places athletes at greater risk for injury [19].

An injury specific to snowboarding is “snowboarder’s ankle,” a fracture of the lateral process of the talus that may be difficult to see on a standard ankle radiograph series. This fracture may comprise up to 15% of ankle injuries requiring medical evaluation in snowboarders. The mechanism of injury is forcing the ankle into dorsiflexion and inversion, usually during a landing from an aerial maneuver or a jump, and especially with over-rotation of the landing [18]. Physicians should maintain a high index of suspicion for these injuries in a snowboarder with a severe ankle sprain that is persistently painful, has limitation of motion, and fails to improve with appropriate management.

Extreme skiing
Although freestyle skiing events, including moguls and aerials, have been present for many years, recently skiers have been adding many snowboard-inspired events such as big air, slopestyle, half-pipe, and skier-cross. Naturally,

**Table 2. Medline review of the scientific literature on extreme sports, 1966–2002**

<table>
<thead>
<tr>
<th>Sport</th>
<th>Total articles†</th>
<th>Case reports</th>
<th>Review articles</th>
<th>Research, injury</th>
<th>Research, physiology</th>
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<tbody>
<tr>
<td>Extreme martial arts</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Extreme skiing</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Indoor football &amp; soccer</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>In-line skating</td>
<td>47</td>
<td>4</td>
<td>4</td>
<td>28</td>
<td>11</td>
</tr>
<tr>
<td>Mountain bicycling</td>
<td>20</td>
<td>4</td>
<td>1</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Rock climbing</td>
<td>36</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
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<td>2</td>
<td>8</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
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<td>Ultra-endurance races</td>
<td>22</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>12</td>
</tr>
</tbody>
</table>

†Total includes articles that could not be classified, primarily foreign language articles.
‡Articles on multiple sports (eg, comparison of in-line skating with skateboarding injuries) were counted under both categories.
each of these events places the athlete at increased risk of injury because of the placement of obstacles and the requirements for increased jump heights. In addition, competitive athletes usually wear their bindings extremely tight to prevent premature release of their skis. However, tight bindings also decrease the chance of ski release after a crash. The attached ski creates a long lever that increases forces on the lower extremity, increasing the risk of injury.

Rock climbing
Rock climbing is another sport that has recently moved from being a recreational activity to a competitive sport. Rock climbing places athletes at risk for unusual overuse injuries of the upper extremities, including stress fractures, proximal interphalangeal collateral ligament injury, and flexor digitorum tendinitis [20••,21,22]. An injury specific to the sport, found in up to 26% of climbers, is the disruption of the A2 pulley, or "climber's finger" [20,21]. This injury usually presents with pain to palpation of the A2 pulley region or to resisted finger flexion. In some cases, bowstringing of the tendon can be seen. Rock climbers who do not use a properly belayed safety line, such as free soloing climbers, are at substantially greater risk for potential catastrophic injury.

A more recent twist to rock climbing is ice climbing on frozen waterfalls. This is considered more dangerous then traditional rock climbing because of the increased risk of falling. Ice climbing competitions have resulted in at least 35 deaths in the past 4 years [23]. In addition to ice, other types of rock surface can influence the sport by increasing the risk of falls, being struck by falling rocks, and severity of abrasions.

Indoor (American) football and soccer
Moving traditional outdoor sports indoors creates a new risk of injury by collision with walls at the edges of the playing surfaces. Furthermore, changes in rules, such as severely restricting substitution, lead to increased risk of injury, in this case as a result of increased fatigue. Indoor soccer and football players are at risk for artificial turf injuries. The few studies on indoor soccer have shown that, although injuries are similar to those of outdoor soccer, the rates of occurrence may be higher [24–26]. Unlike indoor soccer, indoor football play results in frequent collision with the side-boards. Thus, in addition to the usual football injuries, other injuries are more similar to those caused by boarding in hockey.

Martial arts
Official sporting associations in traditional martial arts have been working to reduce injuries by emulating amateur boxing, requiring protective equipment such as headgear. However, newer forms of competitive fighting have emerged to recreate the original spirit of the traditional events by minimizing or even eliminating protective gear. Kickboxing is growing in popularity, and creates more scoring opportunities by allowing the use of both the hands and the feet. Some forms also allow for elbow and knee strikes. The more recently developed mixed martial arts fighting allows any maneuver except eye gouging, hair pulling, groin strikes, and finger bending.

Medical coverage at these events is often minimal or completely absent. A medical student with whom I have worked is a former kickboxer who gave up competing and started providing medical coverage after one match at which he was asked to evaluate several injured fighters. He realized that if he got injured, no one would be available to evaluate him. He also notes that this lack of medical coverage may result in misleading injury statistics. For example, three major national and international kickboxing-sanctioning organizations report that 31.3% of 1606 matches have ended as a result of a concussion (George Buse, Personal communication). However, in the student's experience covering 74 of these events, only 20.2% were stopped because of concussion. He believes that this discrepancy may be the result of counting all technical knockouts (TKOs) as concussions, even though other problems such as abdominal injury may be the cause of the TKO ruling (George Buse, Personal communication).

Ultra-endurance sports
Some extreme ultra-endurance sports were created by moving traditional endurance events to more challenging locations (eg, the recent South Pole Marathon). Other events are created by adding length, such as the Ice Age 50 Mile Trail Run. Combining both more difficult terrain and greater distance are events such as the Western State Endurance Run, which requires runners to complete a 100-mile course through the Sierra Nevada mountains with a net elevation change of 41,000 feet in less than 30 hours. Increasing race distances place athletes at increased risk for environmental injuries ranging from sunburn to dehydration, as well as less common, but potentially life-threatening, conditions such as hyponatremia [27••,28,29].

A more recent trend is the creation of multiday endurance events. These events can place athletes at risk for sleep deprivation, which in turn places them at risk for poor judgment, and leads to accidents and traumatic injuries. Recently, a team participating in a multiday ultra-endurance event attempted to complete the final 3 days without sleep. They later found that they had lost their maps and a significant portion of their water, although they could not remember dropping them. In addition, they had one teammate who kept wandering off during the final 45-mile leg. Members of other teams also reported having hallucinations from sleep deprivation, despite taking a few short naps [30]. The latest development is the creation of the self-supported ultra-endurance events, such as the Marathon des Sables. This 6-day running event requires participants to cross 150 miles of the Sahara desert while carrying any necessary supplies that they will need (eg, food, sleeping bag, and first aid kit) except water, which is supplied by the race organizers.
Recommendations and Suggestions for Planning Medical Coverage of Extreme Sports

When covering extreme sports teams, the medical staff must consider potential mechanisms for both overuse and traumatic injuries. The sports should be analyzed for repetitive motions that may place the athletes at risk for overuse injuries. Environmental factors to consider include weather exposure, water and sun exposure, and types of fauna and flora in the competition venue. Traumatic injury risks include sporting surface, obstacles, and potential fall distance.

Many ultra-endurance events place the athletes at significant risk for hypothermia. Water-sports legs or multiple water crossings do not give athletes time to dry off and change into dry clothing. In what current competitors would probably consider a quaint waste of time, early Ironman competition athletes actually would go into a changing area to take a warm shower and then move on to a tent to change into dry clothes. In the mid-1980s, one of the competitors actually changed out of her swimsuit and into her bicycling gear in full view of the television camera to cut down her transition time. After this famous incident, most competitors just completed the race in wet clothing. Eventually, specialized triathlon suits were designed and are now worn by most competitors throughout the race. These suits dry out while the athlete completes the bicycle leg. However, exposure to wet clothing may be prolonged and increase the risk of hypothermia.

In the inaugural ultra-endurance Discovery Channel World Championship Adventure Race, an athlete suffered severe hypothermia during a canyoneering leg, and ended up in a near-drowning incident requiring almost 1 hour of cardiopulmonary resuscitation. Miraculously, the athlete survived, although she was in a coma for more than a month and still has significant neurologic dysfunction.

Other problems to consider are location-dependent and include altitude illness, heat injury, sunburn, dehydration, animal bites, plant dermatitis, and exposure to unusual microbes. In a recent international multiday, multisport ultra-endurance race in Borneo, 40% of the participants developed an infection with leptospirosis from exposure to contaminated animal urine [30]. Such infections can also be found close to home. In 1998, after participating in a triathlon in Illinois, 120 athletes (13.6% of the total competitors) became ill and were eventually treated for leptospirosis infection [31].

Handling injuries during the race may require complex logistics. It may be difficult to evacuate injured athletes from remote sites. In order to reach an injured athlete at a remote site, medical personnel may need skills such as rappelling, belaying, or spelunking. If specialized skills or equipment such as climbing gear or flotation devices are needed to extricate injured competitors, arrangements for equipment and individuals with these skills should be made before the event. Specialized transportation such as helicopters, boats, or all-terrain vehicles may be needed to extricate injured athletes from remote sites, and the nearest hospital may be hours away. Arrangements for vehicles and transportation also must be made well before the competition starts. While mapping the route and considering inherent dangers, access points for medical teams should be planned with event organizers as early as possible.

The coordination of a team of specialized rescuers requires good communication. This can be difficult in remote sites because these areas may not have telephone land lines, and cell phone communication may not be available in hilly areas and deep canyons.

Consideration should be given to planning mandatory medical examinations and sleep/rest breaks in ultra-endurance events. Contingency plans should be made for extreme temperature, humidity, and other weather conditions to increase the number of food and re-supply stations. Thus, the physician needs to discuss with the event organizers the placement of medical checkpoints and access.

Finally, the medical personnel need to familiarize themselves with the sports they are covering. Learning the rules will help to identify areas and activities that may place athletes at higher-than-average risk. This information can be useful in planning placement of medical personnel and supplies. In addition, learning the terminology of the sport can be useful in communicating with the athletes when taking a medical history.

Conclusions

Extreme sports will continue to gain in popularity and number of participants. These sports will probably continue to evolve into newer activities that further push the limits of human endurance, agility, and imagination. There is a tremendous need for medical coverage of these athletes and their sporting events. In addition, in order to help provide better and more efficient medical coverage of these sports, design protective equipment, and assist in event planning, research into the epidemiology of extreme sports injury needs to be undertaken and published. Limitations (such as the possible misclassification of injuries by untrained observers) must be taken into account when utilizing nonscientific sources to assist in planning for medical coverage. When covering extreme sports, the medical team needs to build on experiences from the medical coverage of traditional sports and events. At the same time, they must consider the unique aspects of these sports, including unusual overuse and traumatic injuries, environmental injuries, and the potential difficulty of treating and extricating injured athletes in remote locations. Despite these challenges, providing medical coverage to these unique athletes is as rewarding as providing medical coverage to the those in more traditional sports.

Acknowledgments

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References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance


An analysis of 331 in-line skating injuries seen in a 9-year period.
27. Speedy DB, Rogers IR, Noakes TD, et al.: Diagnosis and prevention of hyponatremia at an ultradistance triathlon. *Clin J Sport Med* 2000, 10:52–58. This study describes the diagnosis and treatment of hyponatremia. The authors also describe an intervention program that successfully decreased the number of athletes who presented with hyponatremia when compared with the previous year’s event.