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83.1 Characteristics of the Sport

The earliest evidence of ice skating appeared more than 4000 year ago in Finland, since this time people used to perform this practice to spare energy during winter journeys.

The practice of “modern” ice skating was born in fourteenth century, when Dutch invented skates made of steel, with sharpened edges on their bottom. The first skating club was founded in 1742 in Edinburgh. The National Skating Association, the first national ice skating body in the world, was born on 1 February 1879 in Cambridge. An European figure skating championship was organized for the first time in Hamburg in 1891 and the first world championship took place in London in 1898. Figure skating became an Olympic discipline in 1908. Races on

ice skates first developed in the nineteenth century but long track speed skating was introduced as a winter Olympic discipline only in 1916.

The first world championships of short track speed skating took place only in 1981, making this discipline a relatively young one. First Olympic medals have been attributed in 1992 at the winter Olympic Games in Albertville. For this reason, the literature is poor concerning speed skating injuries.

Since this discipline was born, professional and nonprofessional ice skaters had to deal with physical issues. Improvement in materials, as well as prevention, had significantly reduced the incidence of injuries. Ice hockey is by nature a very different sport and will be not discussed in this chapter. Furthermore, ice hockey is specifically discussed in another chapter of this book (Fig. 83.1).

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83.2 Physiological and Biomechanical Demands on Athletes

A professional skater trains her/himself about 7/7 days, 4–6 h per day on ice and 1–3 h per day at the gym. Off-ice training includes strength and endurance work. Figure skaters performs a great number of jumps per day. This leads to repetitive landings, and consequently to high stress on the joints of lower limbs, mostly on the ankle, tibia, fibula, and foot. It has been shown that each

Fig. 83.1 Two speed skaters in a competition



Fig. 83.2 Two figure skaters at the winter Olympic Games in PyeongChang 2018



reception after a jump generates a mechanical load of about eight times the body weight of the performer on the landing limb (Fig. 83.2).

83.3 Epidemiology of Injuries

All injuries could be classified in three great groups of lesions:

1. Traumatic:
 - such as ankle sprains and fractures, patellar dislocations, skin lacerations (due to the blades of skates), wrist and forearm injuries, knee ligaments tears, hip injuries, head injuries.
2. Overuse:
 - stress fractures, patellofemoral syndromes, Osgood–Schlatter disease, knee bursitis, low back pain.

3. Equipment related:

in this particular group are included all injuries caused by a non-proper fitting equipment, leading to repetitive friction and pain. Tendonitis (Achilles, ankle), retrocalcaneal bursitis, and “Lace bite” injuries are some examples.

Traumatic injuries are often the results of falls or gliding. These are common in pair figure skaters and speed skaters, due to the complex timing and synchronization, and for speed skating the high speed. Falls, collisions, misses, and catches are the most common causes.

Overuse diseases, on the contrary, occur because of repetitive movements that the discipline requires, leading to inflammation and chronic pain. In addition, professional skaters have often the tendency to continue their training even if they are injured, which prevents any prompt healing.

Equipment is nowadays a great issue and an important matter of research. Improving mate-

rials, especially boots fitting, is fundamental to prevent such injuries.

In 2018, a study conducted by The Micheli Center for Sports Injury Prevention at Waltham Massachusetts has classified the figure skating injuries by body location.

Ankles sprains and fractures were the most common injuries among ice skaters (27%), followed by knee injuries (18%), low back injuries (15%), leg injuries (11%), and head injuries (10%). Hip, shoulder, and neck were less frequently concerned. Among overuse injuries, stress fractures were the most common (between 7 and 20%) according to different studies. In 2017, in a study conducted at the Department of Exercise and Sport Sciences of the Ithaca College in New York, 204 skaters were asked to report about their injuries. The ankle was the most frequently affected joint (20%), followed by the knee (18%), the foot (11%), and low back (11%). All other localizations were reported in less than 10% of cases (Table 83.1).

Table 83.1 Most common injuries by region and their cause

Injury	Cause
<i>1. Foot</i>	
Retrocalcaneal bursitis and Achilles tendonitis	Most common foot injury up to 30%. Calcaneal rubbing and hyper-compression of the tendon into the boots
Hammer toes	Up to 25%. Dorsal pressure in the toe box leading to a grip of the toe inside the boot while skating
Lace bite	Irritation of toes extensors tendons, related to their friction against the tongue of the boot during ankle dorsiflexion
Stress fractures	Occurring mostly in first and second metatarsal
<i>2. Ankle</i>	
Ankle sprains	Up to 20–30% according to different studies. Mostly related to unfitted boots or falls
Ankle fractures	Type of fracture depends of mechanism of injury (external, rotation, abduction, or adduction)
Malleolar bursitis	Friction of ankle in the boot
<i>3. Knee and lower leg injuries</i>	
Patellar and quadriceps tendonitis	Up to 25% in young elite skaters. Related to stress on knee extensor mechanism
Patellofemoral syndrome	Up to 21% in junior elite skaters. Due to great stress on the trochlear groove caused by the constant activation of the knee extensor mechanism that can lead to a chronic condition
Patellar dislocation	Direct blow or twisting injury with the knee extended and foot externally rotated
Patellar fractures	Rare. Results from a fall on the knee

(continued)

Table 83.1 (continued)

Injury	Cause
Osgood–Schlatter disease	Affects skaters at puberty age in a percentage between 6 and 9%. Repeated stress leading to traction apophysitis of tibial tubercle
Overuse tibia fractures	Repetition of jumps and landings. Rare condition
Knee sprains	Resulting from a knee torsion that occurs mostly after a jump, when the body continues to turn while the landing foot remain fixed on ice
<i>4. Hip</i>	
Groin, hip flexor, adductor complex, external oblique, and internal oblique strains	Commonly seen in skaters performing jumps. These strains result from hard training performances. They could be prevented by a correct warming-up
Avascular necrosis of the femora head	Very rare condition due to loss of blood supply of the femoral head caused by repetitive axial traumas
Hip impingement and labral hip tears	The increased range of motion of the hip in figure skaters and the repetitive falls in speed skaters can reveal this pre-existing condition, which is rarely post-traumatic but often congenital
<i>5. Upper limb</i>	
Wrist sprains and fractures	Most common in nonprofessional skaters. Occur when falling on the outstretched arm
Rotators cuff injuries such as tears or tendonitis	Common in pair skaters after repetitive lifts in which the rotator cuff is stressed
Shoulder dislocations	Commonly they occur in speed skaters after a fall
<i>6. Low back</i>	
Spondylolisthesis, lumbar strains, facet pain, lumbar fractures, sacroiliac joint dysfunction	Reported to be as high as 13% in singles and pairs skaters. Back injuries are the results of an excessive load on the low back vertebrae mostly at the reception of a jump Hyperextension of the lumbar spine increases the risk of spondylolysis Sacroiliac joint dysfunctions may occur as an overuse condition, due to the disbalance subsequent to the repetitive jump reception on a single leg in figure skaters. Rarely it is seen as a consequence of falls in speed skaters
<i>7. Head Injuries</i>	
They include contusions, concussions, and lacerations. Less common in professional skaters but still a matter of care	A fall involving a head trauma that could lead to simple scalp and cranial contusion or in worst cases to cerebral concussions

83.4 Recovery, Rehabilitation, and Return to Play

The treatment of these injuries is really complex, not only because of their variety, but also due to the repetitive movements required by the discipline. To achieve a good healing, the skater will have to respect long off-ice period which is always a source of great distress, since the athlete is so used to the great amount of training hours required by the discipline.

Sprains of the ankle, not involving fractures, are usually treated by classic “PRICE” otherwise said “Protection, Rest, Ice, Compression and Elevation” and functional treatment. Usually, the recovery after an ankle sprain takes at least

4–6 weeks and the skater will remain off-ice for this period time. Ankle fractures (if surgery is needed) need in general about 3 months to recover, which corresponds to the off-ice period. Knee injuries such as collateral ligaments lesions may take several months to heal.

ACL tears usually require surgery in professional skaters because the nature of the sport may induce recurrent instability of the knee. If an ACL reconstruction is needed, a professional skater will need at least 5–6 months to resume training and normally 8–9 months to come back to competition. Knee contusions may occur by direct hit on the ice. Those contusions are usually minor injuries, but attention should be paid to persistent pain after a knee contusion. In this situation,

the pain might be due to a hidden post-traumatic cartilage lesion. Foot injuries are often an issue for skaters, because of the micro-movements of the foot in a leather or synthetic composite boot. These movements can easily lead to an inflammation of the Achilles tendon, a toe extensors tendonitis, a calcaneal bursitis, and a plantar fasciitis, which needs rest and anti-inflammatory treatment for at least 4–6 weeks before complete healing. The so-called “Lace Bite” is a common and typical ice sport-related inflammation, caused by the tongue of the boot on the tibialis anterior and toes extensor tendons. Completion of the healing properly requires about 4 weeks of rest and is possible at the end of the season.

Improper fitting boot could lead to toes callosity and bunion or hammer deformity of the foot. The explosive power required to propel a skater upward into a jump puts tremendous pressure on leg and **groin muscles**. This may result in muscle strains and tears. Traditional treatment of muscle injury can there be applied. However, care must be taken to an intense reconditioning of the muscle leading to a complete recovery of the power before going back to full practice. Wrist injuries occur typically when a skater falls on his outstretched arm. This may go from minor sprain to a complex fracture of the wrist or of the distal radius.

83.5 Specific Aspects in Different Populations

Acute traumatic injuries are more common (ratio of 2:1) in nonprofessional skaters, whereas professional skaters seem to have more overuse injuries. Due to the nature of the sport, the most important injuries in professional skaters concern the ankle and the knee (in rare cases the hip). Upper limb injuries occur, on the contrary, in nonprofessionals skaters, in which the predominant mechanism is a fall on the extended forearm. Blade cuts are also mostly encountered in this skater’s population. A good number of studies have been performed in figure skating, but the literature is sparse concerning inline speed, long and short track skating. A retrospective study

conducted by Quinn et al. in 2003 reviewed the incidence and characteristics of speed skating injuries during the 1999–2000 competitive season on 95 professional short track skaters. The two most common lesions occurring in ice-speed skaters were lacerations from the knee down to the leg (11.1%) and ankle fractures (10.2%).

83.6 Prevention Strategies

Good and methodical “off-ice-training” seems to be useful to prevent injuries resulting from physical dysbalance. Warm-up and muscle conditioning, stretching after every training or competition session, have been demonstrated to reduce the incidence of joint sprains and muscle injury. Quadriceps, hamstrings, and iliotibial band stretching and proper conditioning may reduce the frequency of tears and overuse that may result from an imbalance between the different muscular groups. Wearing proper fitting boots and protections at the lower and upper limb joints may avoid some traumatic conditions like bruises, fractures, and lacerations.

Concerning overuse injuries, four stages of symptoms could help the skater to recognize incoming injuries:

- First stage is characterized by a discomfort before warming-up that disappears during training.
- Second stage, the discomfort appears at the end of each warm-up. At this time, the activity may continue at a modified pain-free level but needs specific adjustments.
- Third stage, the discomfort worsens during the activity. At this point, the activity must be stopped and an investigations including X-rays and MRI should be undertaken to assess if a stress fracture is present.
- Fourth stage is characterized by the presence of a constant pain. In this case, a thorough examination plus in-depth investigations including X-rays, MRI, and eventually scintigraphy should be performed. This may lead to a period of non-weight bearing and/or immobilization in a cast that may result in a long time-off.

83.7 Equipment and Protection Consideration

The reasons of this kind of injuries are not only related to the repetitive movements during training and competitions and/or to falls, but also to the equipment that ice skaters need to wear to perform their discipline.

Boots need to be stiff to assure stability and rigidity of the ankle, this means that the stiffer is the boot the less mobility is allowed to the ankle, inducing specific mechanical load to the knee and hip. This limited motion can lead to weakness of the lower leg, thus facilitating sprains and fractures.

The placement of the blade below the shoe plays also an important role in the dynamics of skating. If they are not correctly middle-placed or centered, the skater could shift more to an outside or inside edge leading to repetitive stress on the lateral or medial side of the ankle and knee.

The blade sharpness plays an important role too. The sharper the blade, the higher the mechanical stress applied on the limb. Furthermore, blades that are too sharp can lead inexperienced skaters to be pulled by the blade. In addition, sharp blades can also cut the skin and cause lacerated wounds that occur mostly on the lower limb in nonprofessional skaters.

83.8 Other Health Aspects and Diseases

In addition to purely mechanical injuries, mostly professional, than occasional, skaters suffer from other conditions related to the sport and its characteristics.

They experience dermatological injuries due to mechanical factors such as exposure to cold temperatures, infectious agents, and inflammation.

Cold skin injuries are classified into non-freezing and freezing injuries. In the first category, there are frostnip, trench foot, chilblains, and Raynaud phenomenon, whereas frostbite, or a freezing of the superficial tissues, represents freezing injury of the skin.

Due to the sweating inside the boots they can also develop skin infection, mostly in the inter-

digital spaces of the toes and mostly caused by *Trichophyton rubrum* or *Trichophyton mentagrophytes*, common genus of fungi, which include the parasitic varieties. They can lead to a dermatological condition so-called *Tinea Pedis* (Athlete's Foot) characterized by an infection of the interdigital webspace.

Onychomycosis, Warts (*Verrucae Vulgaris* and *Plantaris*), and Pitted keratosis are also described as possible dermatological conditions.

Another non-negligible aspect of this sport is also the so-called "eating disorders."

Particularly in aesthetic sports such as figure skating, athletes seek a perfect and thin body type, not only for the resulting ease of the performance but also for appearance reasons. Anorexia nervosa, and nutritional deficiencies such as lack of crucial vitamins and minerals are a great part of this problem.

83.9 Fact Box

- Injuries related to ice skating represent an issue for team physicians, physical therapist, and all care providers involved in this sport.
- Prevention and load management are keys to avoid most injuries, especially in professional skaters that sustain repetitive and intense trainings.
- Speed and figure skating injuries are similar, but traumatic upper limb injuries are predominant in speed skating, whereas overuse and traumatic injuries of the lower limb are mostly encountered in figure skaters.
- Applying protective padding and choosing proper fitting skating boots can really improve the quality of skating and prevent overuse as well as traumatic injuries.
- Changes in boot design should be prospectively studied in an attempt to reduce the high injury rate among elite speed skaters, and in pair and ice dancers.
- A comprehensive educational program for adult skaters may really be important in preventing injuries by explaining basic training principles and off-ice preparation.

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