

Epidemiology of Figure Skating Injuries: A Review of the Literature

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Context: As the popularity and technical demands of figure skating increase, so will the number of athletes presenting with sport-related problems.

Evidence Acquisition: Searches were performed across PubMed from 1980 to 2017. The keywords searched were *skating*, *skaters*, *incidence*, and *injuries*. The search was limited to English-language articles and human participants. Relevant articles were cross-referenced.

Study Design: Clinical review.

Level of Evidence: Level 5.

Results: Previous studies suggest an increase in incidence of figure skating injuries from 1982 to 2003. When combining all disciplines of figure skating, there is a similar proportion of acute and overuse injuries. Within disciplines, overuse injuries appear to be more common in singles skating, while acute injuries are more common in pairs skating, ice dancing, and synchronized skating. Lower extremity injuries are more common than upper extremity injuries in all disciplines, and pairs skating accounts for the majority of upper extremity injuries. Ankle sprains are the most common skating injury, and patellar tendinitis is the most common overuse injury across all disciplines. Stress fractures are the most common overuse injury in female singles skaters.

Conclusion: The predominance of overuse injuries in singles disciplines reflects their increasing technical difficulty, with more difficult jumps and longer training hours. Partner disciplines are more likely to involve acute injuries and upper extremity injuries due to high-risk throws and lifts. Emphasis should be placed on properly fitting skating boots, intrinsic foot and ankle strengthening, and lower extremity flexibility, which may prevent many of the common lower extremity and back injuries in figure skating.

Keywords: figure skating; epidemiology; sports injury

The popularity of figure skating has been growing in recent decades as both a recreational and a competitive sport.^{18,19} United States Figure Skating (USFS) is the national governing body for the sport of figure skating in the United States and notes nearly a doubling in membership, from 102,647 members in 1991-1992 to now 184,200 members in more than 750 member clubs, collegiate clubs, and school-affiliated clubs in 2016-2017.¹ Figure skating is a unique sport that combines tremendous strength and athleticism with grace and artistry.¹⁵ Also noteworthy is adult figure skating, which has been growing tremendously over the past several years and includes skaters over the age of 21 years and of any level in any discipline of the sport.

Figure skating is an evolving sport in which the technical and artistic demands continue to rise. The sport comprised intricate tracing of figures on the ice in the early 1800s and has now evolved to include technically demanding jumps and spins that were previously thought to be impossible. Men are routinely performing 5 different quadruple jumps (4 revolutions in the air), and more women are performing triple axels (3-and-a-half revolutions in the air) and attempting quadruple jumps.¹⁹

Currently, there is a paucity of well-designed research to determine the exact incidence of injuries in figure skating. Of the few epidemiologic studies that do exist, most are retrospective and lacking a standard definition of injury, and

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Table 1. Prevalence and incidence of skating injuries

Study	Prevalence of Skaters With Injury	Incidence of Injuries
Smith and Micheli ²⁴	8/19 skaters (42%)	0.09 injuries per year (0.12 injuries per competitive year) 0.18 acute injuries per year (0.22 acute injuries per competitive year) 0.61 overuse injuries per year (0.78 overuse injuries per competitive year)
Brock and Striowski ⁷	—	3/1000 hours of training
Kjaer and Larsson ¹⁴	—	1.37/1000 hours of training
Dubravic-Simunjak et al ¹¹	373/469 skaters (79.5%)	—

Table 2. Injuries by discipline

Study	Pairs ^a	Singles ^a	Dance ^a	Adult, n (%)
Fortin and Roberts ¹³	1.83	1.32	0.97	—
Ferrara and Hollingsworth ¹²	—	—	—	1 injury: 58 (45) 2 injuries: 9 (7) 3 injuries: 5 (4)

^aData presented as injuries per participant unless otherwise indicated.

thus, more research is needed in this area. As the popularity and technical demands of figure skating increase, so will the number of athletes who present with sport-related problems, and sports medicine physicians should be knowledgeable about common figure skating injuries. The purpose of this article is to discuss common musculoskeletal injuries seen in figure skating, supplemented by a review of the epidemiologic studies to date on figure skating injuries.

INCIDENCE

In one of the earliest epidemiologic studies on skating injuries by Smith and Micheli²⁴ in 1982, the incidence of skating injuries appeared to be less than that of other sports. More recent studies report a slightly higher injury incidence (Table 1).

Injuries by Discipline

When comparing the disciplines of skating, injuries are most common in pairs skating followed by singles skating and then ice dancing.¹³ Table 2 shows injuries by discipline of figure skating.

Acute Versus Overuse Injuries

Findings are somewhat inconsistent and equivocal regarding the predominance of acute versus overuse injuries in figure skating (Table 3).^{7,14,24}

Table 3. Acute versus overuse injuries in figure skating

Study	Acute Injuries, n (%)	Overuse Injuries, n (%)
Smith and Micheli ²⁴	16 (30.7)	36 (69.2)
Brock and Striowski ⁷	14 (50) ^a	12 (42.9) ^a
Kjaer and Larsson ¹⁴	10 (56)	8 (44)

^aStudy also recorded non-skating injuries: 2 (7.1%).

The specific skating discipline might affect whether a skater is at greater risk for acute or overuse injuries (Table 4). Overuse injuries may be more common in singles skaters, whereas acute injuries may be more common in pairs skaters and ice dancers because of lift-related injuries.^{11,23}

Similar to pairs skaters and ice dancers, acute injuries are more common than overuse injuries in synchronized skaters (Table 4), and the majority of overuse injuries for these skaters occurred prior to joining the synchronized skating team.¹⁰ The relative lack of repetition and emphasis on jumps as well as the elements of lifts and skating in close proximity to teammates are common to synchronized skating, pairs skating, and ice

Table 4. Acute versus overuse injuries by discipline

Study	Discipline	Acute Injuries, n (%)	Overuse Injuries, n (%)
Dubravcic-Simunjak et al ¹¹	Singles ^a	39 (16.7)	165 (70.5)
	Pairs ^a	68 (60.2)	33 (29.2)
	Ice dancing	17 (65.4)	9 (34.6)
Dubravcic-Simunjak et al ¹⁰	Synchronized skating	412 acute injuries reported in synchronized skating career	54 overuse injuries reported in synchronized skating career
Ferrara and Hollingsworth ¹²	Adult skating	51 (66.2)	26 (33.8)

^aStudy separately recorded low back pain: Singles low back pain 30 (12.8%), pairs low back pain 12 (10.6%).

dancing, which may explain the similarity of the predominance of acute injuries in these skating disciplines.¹⁰

A majority of acute compared with overuse injuries was seen in adult figure skaters across all skating disciplines combined (Table 4).¹² Training differences and less hours skating per week in adult skaters compared with young, elite skaters may account for the relative lack of chronic overuse injuries in adults.¹²

Lower Extremity Versus Upper Extremity Injuries

The distribution of lower and upper extremity injuries by injury location is shown in Table 5. Lower extremity injuries are more common than upper extremity injuries across all disciplines.^{10,12,23} Lower extremity injuries are often related to the skating boot and falling.^{12,23} In adult skaters, falling accounted for 41% of injuries.³

FOOT INJURIES

Retrocalcaneal Bursitis

A study by Campanelli et al⁸ on lower extremity injuries found that retrocalcaneal bursitis was the most common lower extremity condition, affecting 26 of 76 (34%) skaters studied. All cases were bilateral but more symptomatic in the landing leg. There was a significant association between greater body weight and retrocalcaneal bursitis, noting a 30% increased risk of retrocalcaneal bursitis per additional kilogram of body weight. Additionally, greater ankle dorsiflexion in the skating boot was another significant risk factor for retrocalcaneal bursitis in nonelite skaters. Increased ankle dorsiflexion and compression of the retrocalcaneal bursa of the landing leg may contribute to the development of retrocalcaneal bursitis.⁸

Superficial Calcaneal Bursitis

Superficial calcaneal bursitis was the second most common lower extremity overuse condition in that same study.⁸ Greater boot-foot length difference, less ankle dorsiflexion, and lower jump height were significant risk factors for superficial calcaneal bursitis in the landing foot of elite skaters. For every millimeter of boot-foot length difference, there was a 37% increased risk of

superficial calcaneal bursitis, which suggests that more heel slippage in skating boots contributes to the development of superficial calcaneal bursitis.⁸

Lace Bite

“Lace bite” is a tenosynovitis of the toe extensors and tibialis anterior due to friction of these tendons against the tongue of the boot during ankle dorsiflexion and knee flexion, typically due to improper and uneven lace tying.^{2,6,19} This problem can be alleviated by changing the tongue padding to denser closed-cell foam or silicone and centralizing the tongue with a central hook placed on the tongue, around which the lace can be tied to prevent tongue movement during skating.^{22,26}

Pump Bumps

“Pump bumps” refer to the Haglund deformity, which occurs at the posterior calcaneus when the heel slips up and down inside a rigid boot or wide heel of the boot.^{2,19,26,27} Pain is caused by the resulting callus or blister and sometimes a bony overgrowth.²² The best remedy is ensuring properly fitting skating boots with an adequately narrow heel to prevent heel slippage inside the boot. Additional measures to solve this problem include heel padding with moleskin, foam, or silicone material to pad the heel and prevent slippage.²²

Hammer Toes/Toe Corns

Up to 25% of skaters may have hammer toes or toe corns due to dorsal pressure in the toe box with gripping of the toe inside the boot while skating.²¹ They are oftentimes bilateral and typically found on the dorsolateral aspect of the fifth toe and dorsum of the proximal interphalangeal joints of the toes.⁸ These deformities rarely cause symptoms requiring treatment and typically resolve after retirement from skating.²¹

ANKLE INJURIES

Malleolar Bursitis

A prospective 1989 study of elite pair skaters and ice dancers reported 2 of 48 skaters with malleolar bursitis.²³ Adventitious bursitis can also occur on the fibula at the boot top.⁴ Malleolar

Table 5. Lower and upper extremity injuries reported by injury location^a

Injury Location	n (%)
Injuries reported on medical history forms	
Ankle	79 (27.7)
Knee	53 (18.6)
Leg	33 (11.6)
Back	44 (15.4)
Head	28 (9.8)
Hip	19 (6.7)
Shoulder	19 (6.7)
Neck	6 (2.1)
Foot	4 (1.4)
On-site injuries at competition	
Knee	10 (18.2)
Leg	9 (16.3)
Back	8 (14.6)
Hip	8 (14.6)
Shoulder	7 (12.7)
Wrist	3 (5.5)
Foot	3 (5.5)
Hand	2 (3.6)
Elbow	2 (3.6)
Neck	2 (3.6)
Ankle	1 (1.8)

^aAdapted from Fortin and Roberts.¹³ The authors compiled data from medical history forms of 208 figure skaters (singles, pairs, and dance), some reported more than 1 injury per skater, and on-site evaluation forms of 55 skaters who presented for treatment at the time of a national figure skating competition.

bursitis and adventitial bursitis resolve with protective padding or changing of the skating boot.²⁴

Achilles Tendinopathy

A recent study of 33 elite skaters found a prevalence of 12% with Achilles tendinopathy (4 of 33 skaters).⁸ Given the relative lack of dorsiflexion in the skating boot, it is important to address lower leg and ankle flexibility and intrinsic foot and

Table 6. Prevalence of anterior knee pain in figure skating

Condition	Prevalence
Patellofemoral syndrome	12%-21% ^{8,14,24}
Osgood-Schlatter disease	6%-9% ^{8,11}
Patellar tendinitis	8%-25% ^{8,11,14}

ankle strength in addition to the usual physical therapy prescription for rehabilitating figure skaters with this injury.¹⁵

Ankle Sprain

Ankle sprains are among the most common injuries in figure skaters, with a prevalence of greater than 50%.⁴ Per discipline, ankle sprains occurred equally in both male and female singles skaters.¹¹ However, the rate of ankle sprains is much lower in synchronized skating than in singles figure skating.¹⁰ Singles skaters practice multirotation jumps that place them at risk of ankle sprains if landing occurs prior to completing rotations in the air, causing continued rotation of the upper body while the landing leg remains fixed on the ice, which can result in ankle sprain. Synchronized skaters are limited to single rotation jumps, which have less risk for injury and likely explains the lower rate of ankle sprains in this discipline.¹⁰

KNEE INJURIES

Knee injuries were the most common acute lower extremity injury in synchronized skaters (41.5% in female synchronized skaters and 37.5% in males), followed by ankle injuries.¹⁰ Adult skaters also reported the greatest number of injuries to the knee.³

Anterior Knee Pain

The constant activation of the knee extensor mechanism when gliding and accelerating on the ice as well as the high force absorbed by the knee extensor mechanism during jump landings likely contribute to anterior knee pain, which can encompass patellofemoral syndrome, Osgood-Schlatter disease, and patellar tendinopathy.¹¹ Thirty percent of elite junior singles and pairs skaters have either patellofemoral pain, Osgood-Schlatter disease, patellar tendinitis, or a combination of these conditions.²⁵ The prevalence of each condition is summarized in Table 6. Skaters with anterior knee pain have tighter quadriceps muscles than those without knee pain, and poor hamstring flexibility is present in those specifically with isolated patellofemoral pain.²⁵ Quadriceps, hamstrings, and iliotibial band stretching may minimize development of extensor mechanism knee pain.²⁵

Meniscal and Ligamentous Knee Injuries

Meniscal and ligamentous knee injuries rarely occur in figure skating, likely due to the relative lack of fixation of the blade on

the ice. Anecdotally, anterior and posterior cruciate ligament injuries have been reported when a skater lands a jump with a fixed edge while the body continues to rotate.²²

HIP INJURIES

Groin, hip flexor, adductor complex, external oblique, and internal oblique strains are commonly seen in skaters performing triple jumps.¹⁵ Iliac crest apophyseal avulsion injuries and anterior superior iliac spine avulsion fractures have been reported.¹⁵ Many of these injuries are mechanical in cause, but they also have a biomechanical etiology due to muscle imbalances in strength and flexibility as well as inadequate core strength.¹⁵ Hamstring injuries may be seen in skating because of repetitive hip extension during skating. Hamstring strength and flexibility are necessary to perform spiral elements in which the free leg is extended maximally from the hip into an arabesque position.² Hip impingement and labral tears are likely due to the increased range of motion necessary with advanced techniques, similar to those seen in dancers and gymnasts.⁵

BACK INJURIES

Generalized low back pain has been reported to be as high as 13% in singles and pairs skaters.¹¹ The etiology of back injuries in figure skating may be due in part to the rigid skating boot, which limits knee and ankle motion and thereby prevents adequate absorption of force during jump landing. This in turn causes extreme flexion at the hip during jump landing with compensatory lumbar extension to land a jump successfully, subsequently loading the posterior elements of the spine and increasing risk of back injury.¹⁵ Certain elements of figure skating increase risk of spondylolysis due to hyperextension of the lumbar spine, such as the layback spin and Biellmann position, which require extreme hyperextension of both the lumbar spine and hip.^{9,16,20} Additionally, skaters with tight hip flexors and weak core abdominal muscles may have excessive lordosis, thereby increasing stress on the posterior elements of the spine. Sacroiliac joint dysfunction is seen in figure skaters and results from repetitive falls onto one side of the hip and repetitive unilateral absorption of force from jump landings onto a single leg.¹³

UPPER EXTREMITY INJURIES

Upper extremity injuries are less common than lower extremity injuries, and pairs skaters account for most of the upper extremity injuries.¹⁵ Repetitive lifting by male pair skaters can predispose to rotator cuff injuries, biceps tendinosis, and trapezius strain.^{13,19}

HEAD INJURIES

Head injury in figure skating is a growing area of research interest. The number of head injuries in figure skating reported in the literature is shown in Table 7. Head injuries occur in all disciplines of figure skating and include contusions,

Table 7. Head injuries in figure skating

Study	n (%)
Dubravcic-Simunjak et al ¹¹	14 skaters (2.9)
Fortin and Roberts ¹³	28 injuries (9.8)
Dubravcic-Simunjak et al ¹⁰	81 skaters (15.3)

concussions, and lacerations.^{10,11,13} Head injuries occur most frequently in pairs skaters followed by ice dancers and singles skaters.¹³ In synchronized skating, head injuries mainly occur during on-ice team elements of lifts, blocks, and intersections.¹⁰

STRESS FRACTURES

Stress fractures in figure skating tend to occur in the lower extremity and have been reported in various locations, including the tibia, fibula, tarsal navicular bone, metatarsals, and base of the fifth metatarsal.^{11,17} In a study investigating stress injuries in skating, 9 of 42 skaters reported stress fractures in their skating careers, about half occurring with increased mileage during off-ice training and the other half occurring during the skating season.¹⁷ Stress fractures were reported in 20 of 107 (19.8%) female junior skaters and 14 of 104 male junior skaters (13.2%), making it the most frequent overuse injury in female junior skaters.¹¹

CONCLUSION

There is a paucity of epidemiologic studies on figure skating injuries, and it is difficult to compare results among the existing studies as they lack a standard definition of injury and vary in methods of data collection. Most studies were retrospective in design, which has its inherent recall bias. Regardless, the incidence of figure skating injuries has increased, and this likely parallels the increase in popularity of the sport and ever-increasing demand in technical difficulty, with more quadruple jumps in singles skating, quadruple throws in pairs skating, repetitive triple jumps, and longer hours spent training.

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