INJURIES AND SPECIAL CONCERNS OF FEMALE FIGURE SKATERS

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The popularity of figure skating in the United States has increased significantly over the past decade, primarily because of the success of American athletes at the Winter Olympic Games and the resulting number of televised figure skating events. The United States Figure Skating Association (USFSA) was established in 1921 and currently has approximately 340,000 members at 450 clubs around the country. At the lower levels, there are 15 female figure skaters to each male figure skater, and there are 4 female skaters to each male skater at the more elite levels. Figure skating is a sport that combines athleticism and grace. The athlete must bring tremendous strength and endurance to her sport to create the effortless artistry that we have come to appreciate in this dynamic and growing sport.

Competitive figure skating for women and girls includes four major disciplines: singles, pairs, dance, and synchronized skating. A singles skater performs alone on the ice and combines the highest level of athleticism with composition. A female pairs skater performs with a male partner in highly athletic and daring programs. A female ice dancer also performs with a male partner in intricately choreographed programs that focus on precision and artistry. Synchronized skating teams are typically composed of 20 skaters on the ice together (usually all female in the United States) who perform in unison. In each discipline, there are as many as six levels of competition, each subsequent level requiring increasingly difficult technique. These levels include juvenile, intermediate, novice, junior, senior, and master.
DEMANDS OF THE SPORT

Competitive figure skaters are judged on technique, athleticism, originality, and aesthetic artistry. The athlete receives a separate score from each of the judges for technical merit and presentation. Throughout history, judges have rewarded skaters for increasingly difficult elements in their programs and choreography, including recently, an increasing number of triple jumps—jumps in which the athlete rotates 3 to 3.5 times in the air. Because of the complexity of the programs, significantly higher neuromuscular and aerobic demands are placed on these athletes. Although the athletes, coaches, and choreographers have continued to push the standard of performance envelope, the science of strength and conditioning in figure skating has been slow to meet this demand.

Figure skating has an inherent risk of injury because of the technical and physiologic demands on the young athletes involved. It is important to have an understanding of the sport from a biomechanical and physiologic perspective. An appreciation of these demands of the sport assists the clinician in appropriately diagnosing and treating these athletes. Female figure skaters often begin rigorous training as early as 5 years of age, and some are performing jumps requiring two revolutions by the age of 8 years. The more elite athletes can spend more than 30 hours a week dedicated to their sport: roughly 15 to 30 hours per week on the ice and 5 to 15 hours performing off-ice conditioning, that is, strength training, plyometrics, ballet, and aerobic conditioning. Additionally, time is spent with choreographers, on music selection, and on costume design and fitting. As the physical demands of figure skating continue to increase, more emphasis is being placed on using off-ice time optimally to enhance athletic ability. Figure skaters train year-round in preparation for the fall and winter seasons.

Strength Training

Muscular strength, flexibility, and explosive power are important requirements for successful figure skaters. Most figure skaters are right-leg dominant, rotate counterclockwise, and land on their right legs. It has been shown that the jump height of single and double axels is correlated with the strength of the athlete's knee extension and flexion, hip extension and flexion, and shoulder abduction and adduction. Further, it has been shown that to perform the increasingly difficult triple and quadruple jumps, the athletes are not actually jumping higher but are exploding into and out of the jump and rotating faster. An athlete's upper body strength and consequent ability to pull her arms in against the centrifugal forces when initiating a rotating jump is correlated positively with the athlete's ability to perform the more difficult jumps. Spinning on the ice is also an integral part of figure skating. When athletes were polled informally, it was found that spinning actually requires more energy than jumping. During a spin, the skater may rotate three to six revolutions per second and create 200 to 300 lb of centrifugal force. Upper and lower body strength and core strength are required to keep the arms and legs close to the axis of rotation to counteract this centrifugal force.

In a training program, the athlete must functionally and progressively stress the neuromuscular and skeletal systems without causing tissue breakdown and resultant injury. As in all sports, there is a thin line between overtraining and maximum performance. An important principle of conditioning is periodization, although currently it is not well used in figure skating. Periodization is the division of training into different phases to achieve a desired outcome. For example, one 3-month cycle may emphasize endurance, another strength and speed, and another, shorter phase may be for rest, technique refinement, and peaking for a championship event. Periodization may reduce an athlete's fatigue, boredom, and injury. It also may allow selective conditioning of different physiologic variables.
Progressive overload means that once the body has become accustomed to a specific level of training, the load must be increased to stimulate new neuromuscular adaptation. With respect to figure skating, one must recognize the importance of flexibility, core strength, explosive power, and aerobic conditioning. When constructing an appropriate conditioning program, emphasis must be placed on sport-specific skill development, which depends on the skater's discipline, level of ability, and goals. Symmetry of the athlete's flexibility and musculature is the ultimate goal to prevent injury and depends on the development of a balanced program as described previously.

Nutrition

Nutrition is an integral part of optimal training and performance. The most common problems encountered are inadequate caloric intake, inappropriate food choices, and underhydration. Because of the aesthetic demands of the sport, female figure skaters may feel pressure to undereat. In one study, 55% of female skaters reported dieting although over one half of the dieting girls and women were already below the 25th percentile in the weight for height category. One study demonstrated that female figure skaters consumed only 59% of estimated caloric needs. Intakes of certain micronutrients, including vitamin D, vitamin E, iron, calcium, magnesium, and zinc, were considerably lower than those observed in the general teenage population. Long-term implications of these nutritional practices are unknown.

Recommendations for a successful nutritional strategy include eating frequent, small meals; consuming adequate amounts of complex carbohydrates; keeping fat intake low (about 20% of calories); consuming six to eight glasses of water daily and supplementing this fluid intake with a sports beverage during practice and competition; and eating simple sugars and starches within 30 minutes after practice and competitions to replenish glycogen stores. For the athlete who is traveling, the following recommendations can be added: pack snacks, plan ahead, avoid prepackaged fast foods, and strive to balance caloric intake throughout the day.

Figure skating, a sport that requires strength and explosiveness, has not been influenced notably by the use of ergogenic aids. Information about performance enhancing drugs is limited in figure skating and suggests primarily nutritional approaches without the use of illicit performance-enhancing substances. The most common dietary supplements used are multivitamins, vitamin C, beta carotene, iron, calcium, and vitamin D.

INJURIES

Musculoskeletal injuries frequently occur in figure skaters. Prospective and retrospective analyses indicate that approximately 50% of competitive skating injuries are traumatic and 50% are the result of an overuse mechanism. Female figure skaters generally develop a larger percentage of overuse injuries, particularly those involving the lower extremity, whereas male skaters develop a greater percentage of acute injuries. Currently, there are no published longitudinal prospective studies of figure skating injuries among only female skaters. It is difficult to determine injury rates from the current literature because authors have used different injury severity criteria. Anecdotally, the type and frequency of injuries seen in the lower extremities are changing. Some clinicians have reported an increased fracture rate, including growth plate injuries, in the lower extremities of young skaters, which may be secondary to the increased difficulty of the choreography, more technically demanding jumps, and the increased time spent on training. Clinicians also have concerns about boot design and skate technology as a significant source of injury (Angela Smith, MD, personal communication, April 1999).
Skaters involved in pairs, ice dancing, and synchronized skating suffer a higher risk of trunk, shoulder, and upper extremity injuries as compared with single skaters. These skaters also suffer from a greater risk of concussion and lacerations. Overall, female pairs skaters are likely to have the most significant risk of injury as compared with female skaters in other skating disciplines because jumps and throws are elements of their programs (Table 1) (Table Not Available).

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<th>TABLE 1 -- TYPES OF FIGURE SKATING INJURIES</th>
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Common causes of musculoskeletal injuries include inflexibility, asymmetric or inadequate strength, inappropriate warm-up or cool-down, poor diet, fatigue, and overuse. Factors related to injuries may be broken down into intrinsic and extrinsic issues. Intrinsic factors include anatomic and functional leg-length discrepancy; asymmetric or insufficient lower extremity alignment, strength, and flexibility; and lower extremity biomechanical abnormalities, specifically structural irregularity of the leg and foot. Extrinsic factors include boots, ice surface, and other influences such as coaching.

**Prevention of Injuries**

Currently, the USFSA is focusing significant attention on injury prevention. A 4-year longitudinal study begun in 1991 found that approximately 50% of all injuries in ice dancers and pairs skaters could be prevented by early diagnosis of the injury and appropriate rehabilitation focusing on strength, flexibility, boot fitting, and decreased emotional stress. Additionally, there are data to support that up to 78% of injuries may be prevented by comprehensive off-ice conditioning programs. Data obtained from figure skating sports science camps have demonstrated that off-ice-training programs can decrease stress fractures, overuse injuries, and ankle injuries and increase ankle proprioception. It is important to adjust time spent on the ice, however, as the athlete spends more time taking part in off-ice conditioning programs.

The necessary components of an appropriate off-ice conditioning program include core strength; symmetry of limb flexibility and strength, especially hip, ankle, and foot; and cardiovascular fitness. Athletes should be encouraged to practice new elements early in practice sessions and to focus on technique instead of repetition of the more complex elements, attempting to eliminate fatigue as a factor in injury. The use of physioballs and exercises emphasizing body weight, ground-reaction forces, and balance are also key elements in a comprehensive conditioning program.

**Equipment**

The boot and blade are the most important pieces of equipment of the figure skater and are considered by some sport medicine specialists to be the culprits in most injuries. Clinicians believe that the boot, blade, and ice interface plays a key role in injury production. When new boots are stiff and must be carefully and slowly broken in to prevent undue pressure points on the foot and lower leg, which cause stress injury. The intrinsic stiffness of the boot transmits tremendous ground-reaction forces when the skater lands a jump. The shape of the skate (more or less rocker-bottom) and the sharpness of the edge affect the ability of the athlete to feel the ice. The inherent rigidity of the boot and blade results in the force of jump takeoff and landing...
being transmitted up the kinetic chain, potentially causing lower back, hip, pelvis, groin, and knee injuries. Some clinicians believe that figure skaters have weak ankles because of the intrinsic stiffness of the boot absorbing the ground-reaction forces. Other clinicians believe that, as in skiing, the rigidity of the boots actually allows the athlete to perform more complex maneuvers and does not result in ankle weakness.

To prevent injuries, correct boot fit is of the utmost importance. The skater's boot should fit snugly around the heel and have a wide toe box. Orthotics, if they are required, can be built into a boot or created separately for insertion. When breaking in the boots, the skater should be sure that the tongue remains in a neutral position, as it has a tendency to migrate laterally and cause increased pressure over the foot extensors. It is also useful to include a comprehensive ankle and foot program in the athlete's overall training, focusing on strength and proprioception. Some clinicians have suggested that young skaters wear less stiff boots to improve intrinsic ankle and foot strength and proprioception. In addition, because the boots would be less able to absorb ground-reaction forces, the skater is compelled to develop precise technique. Most elite skaters wear stiff, custom-made boots. Skaters typically replace boots when the ankle support breaks down. Stock boots, which are less rigid, are available for half the price of custom-made boots but must be replaced more often.

**Types of Injuries**

The most common location of injuries for a figure skater is the foot. These injuries often are attributed to the boot. The second most commonly injured area is the knee, although it is probably the most commonly injured region brought to the physician's attention. The hip and pelvis are perhaps the third most commonly injured area but can be the most challenging to rehabilitate. In figure skating, as in all sports, it is important to determine the cause of the injury and the associated biomechanical factors to create appropriate and comprehensive rehabilitation programs. Moreover, it is advantageous to maintain open communication with the athlete, coaches, parents, and the sports-medicine physical therapist to ensure that the athlete receives optimal care.

**Foot Injuries**

Frequently occurring injuries of the foot include tibialis anterior tendinitis and toe extensor tendinitis, also called *lace bite*, which are often caused by compression by the tongue and lace crease of the boot. In addition to typical treatment modalities, alternative lacing techniques should be employed or a hard substance such as orthoplast molded over the affected area of the foot to decrease direct pressure and distribute the forces. Malleolar bursitis also is related to boot pressure. It is important to modify the boot as part of the treatment plan by punching out the leather on the boot or forming a foam donut or by inserting a silicone pad around the bony prominence to provide additional relief from the pressure. *Pump bumps*, or *Haglund's deformities*, are caused by a boot heel that is too wide and generates friction on the athlete's heel as it slips up and down in the boot.

Achilles tendinitis in a skater can be a sign of overtraining. The Achilles' tendon plays a crucial role in creating the explosive power necessary for jumping. Weakness or pain in the Achilles' tendon or the gastrocnemius-soleus complex can cause uneven gait or skating stroke and inability to perform certain elements. Tendinitis, tendinosis, partial tears, and nodules of the Achilles' tendon can all be caused by compression by the top of the boot with planterflexion of the foot or by the boot adding pressure to the posterior-medial and posterior-lateral portions of the foot, causing compression of the middle third of the Achilles' tendon. Skaters actually dorsiflex little in the boot and their heels are high in the boot. Ice dancers often have boots with low cutout areas for the Achilles' tendon to improve their *line* and ability to bend their knees. Boot modifications that may be helpful are padding the posterior portion of the boot to protect the
injured area and distribute forces and considering a posterior cutout area to relieve pressure mechanically. In rehabilitating figure skaters with these injuries, in addition to the usual modalities, it is important to address intrinsic ankle and foot strength, lower leg and foot flexibility, and biomechanical alignment of the foot in the boot.

Other common foot injuries include stress fractures, particularly of the first and second metatarsals caused by repetitive forces while perfecting pick-assisted jumps (i.e., toe loops, flip, lutz) and stress fractures of the tibia, fibula, and tarsal navicular. Skaters are more likely to get a stress fracture in their take-off leg. Accessory tarsal navicular, prominence at the base of the fifth metatarsal, corns, and hammer toes are all common foot abnormalities that ordinarily do not cause problems for the skater.

Knee and Leg Injuries

Patellofemoral syndrome is common and is associated with relative vastus medialis obliquus weakness and adductor complex insufficiency. Figure skaters typically have well-developed quadriceps, particularly the vastus lateralis. Other causes of patellofemoral syndrome include abnormal patellar shape, abnormal patellar tracking, and inadequate flexibility of the quadriceps and hamstrings. In the literature, anterior knee pain in junior elite figure skaters has been attributed to flexibility deficits in the thigh musculature. Skaters also commonly experience knee pain from patellar compression injuries from falling but rarely experience patellar fracture. The frequency of reports of these injuries is related to increased jump repetitions and the performance of increasingly difficult jumps. Infrapatellar tendinitis and patellar tendinitis, by many clinicians' reports, are less common in skating than in other jumping sports. They are seen most often in elite skaters and are difficult to treat because jumping is a necessary component of figure skating at the higher levels. Osgood-Schlatter syndrome is seen often in early adolescent skaters. Ligamentous injuries are not prevalent particularly in figure skating. In fact, an informal poll of multiple clinicians and a review of the literature revealed only three reports of anterior cruciate ligament injuries, which may be because skaters land jumps skating backward where cocontraction of the quadriceps and hamstring muscles is essential for control of the landing. Meniscal injuries also are uncommon. Rehabilitation of knee injuries in figure skaters is similar to that of most athletes.

Other Injuries

Clinicians are observing an increasing frequency of hip, lower back, and core musculature injuries among skaters. The female figure skaters who are developing these injuries are typically those performing triple salchows, double and triple axels, and triple loops. Athletes are presenting with groin, hip flexor, adductor complex, external, and internal oblique strains. Many of these injuries have been attributed to the increasing number of rotations in an athlete's jumping repertoire. Anterior iliac crest injuries have been reported, particularly iliac crest apophyseal avulsion injuries. Skaters describe pain in the abdominal transversalis, lumbar, and gluteal musculature with tenderness in the iliac crest region. The athlete also may have pain and stiffness in the iliopsoas and quadriceps. These injuries can take 2 to 3 months or more to heal. Like most injuries, although there is frequently a mechanical component to the cause, there is also a biomechanical component. Many of these injuries are caused by muscle imbalances in strength and flexibility and by inadequately strong core musculature. The authors believe that the dominance of the Russian figure skaters can be attributed to their focus on obtaining superior core strength.

The current belief about the mechanism of lower back injuries is related to the figure skating boot. The rigidity of the boot limits ankle and knee motion significantly. As a result, neither the ankle nor the knee can go through the full range of motion to flex enough to absorb the force of a jump landing adequately. The skater then must excessively flex at her hips, which causes her trunk to pitch forward. Thus, to land the jump, the skater must extend her lumbar spine. Consequently, the
A skater loads the posterior elements of the spine, causing potential for lumbar strain, facet pain, posterior iliac crest injury, spondylolysis, and spondylolisthesis. Sports medicine physicians have been reporting an increased frequency of these injuries, particularly in young women. Appropriate therapy involves strengthening the core musculature to provide stability of the trunk and to assist in maintaining alignment of the body in the air during jumps and lifts. Rehabilitation programs also should include strengthening ankle-supporting musculature to permit the use of a more flexible boot, which accommodates greater dorsiflexion during landing. For young athletes with spondylolysis, clinicians may want to consider using a neutral lumbar orthosis as part of their initial management strategy.

UNDERLYING MEDICAL CONDITIONS

There are several medical conditions that are encountered frequently in figure skaters, including asthma, exercise-induced bronchospasm, hypothermia, and disordered eating, among others. Head injuries and lacerations are also prevalent in figure skaters, particularly in pairs and synchronized skaters.

Asthma and Exercise-Induced Bronchospasm

Asthma or exercise-induced bronchospasm have been reported in as many as 50% of figure skaters. Cold, dry air is often cause of bronchospasm in the general athletic population. In addition, there have been several reports of athletes in ice rinks who demonstrate sensitivity to the chemicals used to maintain the ice surface. Athletes may have exercise-induced asthma without having chronic asthma; however, it is rare for an athlete to be diagnosed with chronic asthma that is not exacerbated by the cold, dry air of the ice rink. These athletes most often present with a cough. Because of the significant aerobic demands and environment of figure skating, a clinician should have a high index of suspicion for exercise-induced asthma. Prompt diagnosis and adequate treatment of this condition is imperative.

Eating Disorders

Disordered eating is prevalent in figure skating because appearance plays a major role in performance evaluation. To perform the highly complex elements necessary to be successful in elite figure skating, athletes are typically thin and small in stature. It has been reported that 69% of female figure skaters diet to lose weight, although it is unclear whether the risk of eating disorders increases as skaters climb in the ranks of skating through the national and international levels.

A prominent sports dietitian describes weight cycling as a significant concern in these athletes. Weight cycling is similar to wrestlers making weight for a competition. Weight cycling often occurs after participation in a major competition and after the onset of puberty (Paula J. Zeigler, PhD, RD, personal communication, April 1999). It is commonly the outcome of poor eating habits and can result in altered aerobic capacity and poor performance. Disordered eating has short-term physiologic effects, such as menstrual abnormalities, poor performance, and increased risk of injury, and long-term effects, such as osteoporosis and poor self-esteem. Female figure skaters have been described as having delayed onset of menses by approximately 1 year, attributed to a high level of training and low percentage of body fat. Bone mineral density of the trunk and lower extremities was reported to be significantly higher in skaters compared with nonskaters, suggesting that intense weightbearing exercise may diminish the negative effects of hormonal irregularities on bone mass. In general, eating disorders are extremely difficult to treat. Education of athletes, coaches, and parents regarding early recognition of irregular menses,
eating disorders, and realistic expectations of body and appearance is essential. As in the predominance of sports in which appearance is judged, clinicians must be aware of the potential for the female athlete triad (i.e., disordered eating, amenorrhea, and osteoporosis) in these young female athletes.

**SUMMARY**

Figure skaters are often young athletes involved in an extremely stressful, structured environment that is focused solely on skating. These athletes are at risk for a multitude of psychologic concerns, including poor communication skills, performance anxiety, stress, and family issues. Helping athletes develop self-awareness, techniques to control stress and anxiety, motivational strategies, ability to maintain concentration, and emotional balance is best done with the guidance of a sports-trained counseling professional.

Communication among the athlete, parents, and coaches is extremely important. Often, coaches tell the athlete how and what to feel, and the athlete falls into a routine of trying to please coaches and parents instead of developing her own persona. The communication between pairs skaters and ice dancers is integral to their success. Excellent interpersonal skills among members of pair teams are advantageous in creating a lasting relationship. Honesty, respect, clarity, consistency, and sincerity are essential components of outstanding teammates and should be cultivated. On the other hand, sarcasm, disrespect, castigation, and ridicule should be addressed immediately and should be discouraged strongly.

**References**

2. Benardot D: Achieving energy balance for optimal performance and composition. The Fourth Congress on The Sports Medicine and Sports Science of Figure Skating; February 12-13, 1999; Salt Lake City, UT


   Abstract


36. Yu L, Smith AD: Figure Skating. In Ireland M (ed): The Female Athlete. Philadelphia, WB Saunders, in press

   Abstract

   Citation