Pay Attention to the Imaging Study of Sport Injury and Illness in Winter Olympics Sports

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After successfully holding the 2008 Beijing Olympic Games, the series of National Games, and a successful bid of Beijing and Zhangjiakou for the 2022 Winter Olympic Games, Chinese sports face the greater opportunities of development. The imaging study of sport injury and illness in winter sports is to be developed for effective diagnosis and evaluation, which aims to stay in step with the progress in winter sports field.[1-4] This will boost the development of sports promoting health strategy and advance the 2022 Winter Olympic Games.

Ice and Snow Sports, and Analysis of Their Injury Mechanism

"Ice and snow sports" refer to cold-weather sporting events that depend on ice and snow. They are usually performed when the temperature is below 0°C. The overall category is subdivided into ice sports and snow sports. Western ice sports originated in Northern Europe, snow sports originated in Norway, and ice hockey originated in Canada. Chinese ice and snow movement was introduced by Russia and Japan in the mid-20th century. In 1924, Chamonix, France, held the first International Olympic Winter games, elevating ice and snow sports to the peak of world sporting events.

Ice and snow sports involve high speed, high resistance, and high metabolism. Thus, injuries resulting from ice and snow sports are often serious and can directly impact the competitive state and the quality of life of sports fans and athletes alike. Flørenes *et al*.[5] surveyed the 2006–2008 skiing World Cup and showed that alpine and free skiing sports injuries occurred as frequently as 72%, with severe injury sustained among 28%. These rates of injury are significantly higher than the rates seen among other sports. Nearly 93% of the athletes suffered from an athletic injury during training in the 2014 England Winter Olympic Games, among which freestyle skiing, ice hockey, and alpine skiing had the highest incidence of injury.[6] Sport injuries and illnesses during the first Winter Youth Olympic Games in 2012 were reported at an incidence of 108.7 injuries per 1000,[7] reaching nearly 11%. More than 70% of these injuries occurred in skiing and skating. A statistical analysis indicates that ice and snow sports injury are most likely to result in ice hockey and freestyle skiing followed by speed skating, figure skating, snowboarding, and alpine skiing. The injury rate is the lowest among curling sports.

Sprains and strains are the most common injuries sustained during ice and snow sports followed by falls, ligamentous injuries, fractures, and fatigue injuries. The incidence of frostbite is the lowest. The sites of injuries sustained during ice and snow sports injury vary from other types of athletic injuries due to the unique movements, sports environments, and technical and tactical characteristics. The most common site of ice and snow sports injuries is the lower extremity. Acute sports injury is a common phenomenon in ice hockey sports, mainly in the athletes and athletes and guardrail between the high-speed collision and high antagonism. Tuominen *et al*.[8] reported that the occurrence of ice hockey injuries to the head and face, upper limb, lower limb, and spine or trunk was 39.8%, 21.8%, 30.7%, and 7.8%, respectively, from the 2006 to 2013 Winter Olympics and

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World Hockey Championships. Wilcox *et al*.[9] reported that a collision between ice hockey players was the most common impact mechanism, and that a collision between ice hockey players and the ice produces the greatest traumatic force to the head, with more common occurrences of head impact with greater force, and the incidence of concussion in male athletes is high with a 50.4% incidence, greater than the occurrence among female athletes (50%).[10] Conversely, too much attention is paid to agility in ice hockey training with less attention to avoiding the main causes of chronic injuries. Alpine skiing requires high speed and strong endurance. In addition, it necessitates excellent balance given that the squatting position is its basic posture. In these athletes, the long-term semi-flexion of the knees leads to laxity of the medial and posterior ligaments and decreases the stability of the knee joint. Therefore, the incidence of anterior cruciate ligament (ACL) injury is the highest of all injuries. The majority of alpine skiing injuries occurred in giant slalom (56%), while 31% of injuries occurred in slalom and 13% occurred in super giant slalom.[11] Anterior torsion of the knee is the most common mechanism of injury to the ACL.[12] Bere *et al*.[13] identified three main mechanisms of alpine skiing injury mechanisms: slip-catch, landing with posterior loading, and snowplow in movement. Slip-catch is the most common mechanism of injury. Thus, training should be emphasized for the prevention and control of ACL injuries.

Diagnostic Value of Medical Imaging in Ice and Snow Sports

In the recent years, the rapid development of medical imaging technology has become more and more important in the diagnosis and treatment of sports injury. Magnetic resonance imaging (MRI) has become one of the most important means of injury diagnosis for sports medicine with its advantages of noninvasive, many dimensions, and high resolution. Considering the example of ligamentous injury from alpine skiing, a meta-analysis of MRI studies revealed that the sensitivity and specificity of diagnosing ACL injuries using this imaging modality were 87% and 90%, respectively, with an area under the curve of 0.93.[14] Palmer-Green and Elliott[6] reported three grades of degree of sports injury in the 2014 Sochi Winter Olympic Games: (1) Time-loss, defined as an injury/illness that prevented an athlete's participation in any training or competition; (2) performance restriction, defined as an injury/illness where training and/or competition participation continued but the volume and/or intensity was restricted as a result of the injury or illness; and (3) medical attention (only), defined as an injury/illness that required medical attention but did not cause time loss or performance restriction. Taking the medical security during the Winter Olympic Games as an example, lower limb muscle strain sustained by speed skating and ice hockey athletes due to high speed is divided into three grades:[15] (1) Grade I: No obvious strength or mobility limitations, MRI signal is normal or consists of only mildly abnormal muscle signal (edema, hemorrhage, and feathery changes); muscle pain and imaging abnormalities can be restored to normal after proper rest and avoidance of strenuous exercise, (2) Grade II: Muscle tendon hematoma, which often requires conservative treatment (ice compress, physical therapy, and ultrasonic therapy). This injury grade returns to normal in about 2 weeks, but often results in chronic pain and recurrence, (3) Grade III: Complete tearing of muscle fibers and retraction with or without broken ends. MRI shows complete tearing of the tendon with irregular edges and separation. The end of the gap is filled with blood and edematous fluid. Surgical closure and long-term rehabilitation are required to restore exercise capacity. MRI examination can be used for early warning and early diagnosis of injuries in athletes. By identifying early warning signs and by diagnosing sports injuries in a timely fashion among competitive athletes, we can prevent irreparable serious consequences such as ligament tears.

Focus on Basic Research of Ice and Snow Sports Medicine with Modern Imaging Technology

At present, international research in ice and snow sports medicine focuses on the etiology of injuries and injury prevention. Emerging research foci include qualitative diagnosis and rehabilitation evaluation. The combination of modern medical imaging technology and molecular biology is an important part of molecular imaging. Modern imaging technology is of great clinical significance to the basic research of ice and snow sports. Quantitative analysis of MRI functional imaging of cartilage (T2 mapping, T2* mapping, T1ρ, and three-dimensional-delayed gadolinium-enhanced MRI of cartilage [dGEMRIC]) could comprehensively, earlily, accurately, and effectively evaluate the changes of cartilage in pathology, molecular imaging, and function. Measurement of T2 relaxation time in T2 mapping acts as a noninvasive biomarker for cartilage injury and repair procedures,[16] T2 value stays in step with the damage level in the area of cartilage damage. T2* value in normal cartilage of the hip joint is 32.4 ms, while the T2* value with the loss of cartilage thickness is 29.4 ms.[17] T2* value and dGEMRIC can analyze various grades of cartilage degeneration[18] quantitatively. Joint cartilage injury is frequent in winter sports, especially in the knee cartilage. Quantitative analysis of MRI functional imaging of cartilage can be used in the diagnosis and long-term longitudinal comparison of early articular cartilage lesions. It is of great clinical significance to selecting early interventional targets, treatment opportunity, and accurately evaluating various conservative and surgical treatment effects. Moreover, the ultrastructure of cartilage repair tissue can be examined in the physical examination, and multiple articular cartilage repair and biological engineering cartilage repair of articular cartilage defects can be evaluated qualitatively and quantitatively. Diffusion tensor imaging (DTI) can quantitatively analyze the water molecular diffusion in skeletal muscle fibers, which is combined with high-resolution anatomical images to show the arrangement and connection of muscle fibers. Scheel *et al*.[19] used 1.5T MRI to analyze DTI images of 12 healthy volunteers and showed that fractional anisotropy (FA) value was significantly correlated with the type of muscle fiber and increased FA value indicates a high proportion of Type I muscle fiber. Magnetic resonance microscopy (MRM) is a small MRI system combining molecular biology with a clinical medical diagnosis that is predominantly used in physiology, pathology, and other subjects to study the imaging of the living body. Lee *et al*.[20] reported that MRM can be used to image single myofibers with 6-µm resolution. The intuitive display of muscle fibers is the basis for future molecular imaging studies of healthy and myogenic cells. The molecular imaging study of muscle fiber transformation based on DTI and MRM has a great potential value in guiding the selection of ice snow athletes, in the formulation of training models and in fatigue recovery.

Expectations

After the success of Beijing and Zhangjiakou bidding for 2022 Winter Olympic Games and the launch of national health plan that 300 million people participate in winter sports, sports medicine in China faces new challenges. A new journey is needed to be started, which means that the imaging diagnosis transfers from the general morphological level to physiological, metabolic, and genetic level, the awareness of mechanism of sports injury transfers from organ, cells level to molecular, genetic level, the concerns transfer from individual sports injury treatment to the people's health care, sports injury prevention and treatment. The discipline development of medical imaging in China is needed to advance the imaging diagnosis of sports injuries and illness in winter sports. Based on the international standard and combined medical integration, further progress in clinical and basic research of sports injuries and illness in winter sports through medical imaging can be achieved systematically and deeply, and more people will benefit from healthy China planning.

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