The Adolescent Knee and Risk for Osteoarthritis — An Opportunity or Responsibility for Sport Medicine Physicians?

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INTRODUCTION

Knee osteoarthritis (OA) is a degenerative joint disease that affects articular cartilage, bone, and synovium. It most commonly occurs in adults over the age of 50 yr, affecting women more than men. Knee OA, unfortunately, can occur in younger adults who are in their 30s, often through sport-related joint injury (19,32). Exceptionally, degenerative joint disease can occur in children or adolescents with a syndromic disease such as Stickler syndrome, Kniest syndrome, or spondyloepiphyseal dysplasia (6). Knee OA risk factors and disease mechanisms include mechanical, systemic, and genetic causes. A recent meta-analysis including 49 prospective studies showed that body mass index (BMI), previous knee injury, female gender, intensive physical activity, certain occupational activities, and increased bone mineral density are risk factors for onset of knee OA (4). Obesity and joint injury from sports participation in young adults are known risk factors that lead to osteoarthritis onset in adults, and both risk factors are on the rise among adolescents today (11,29,31). Thus, knee OA is a chronic disease that may evolve over years and involve multiple risk factors that may be present in young adults and possibly even in adolescence. Accordingly, sports medicine practitioners need to counsel young patients and their families about the risks for knee OA.

Osteoarthritis is the fifth leading cause of disability in older Americans today (2). With the increasing prevalence of musculoskeletal complaints and sports injuries in children at younger ages, are we to expect an increase in the prevalence of knee OA, and will it occur at an earlier age? Not surprisingly, there is an impetus to understand the natural history and significance of adolescent risk factors on incidental knee OA in adulthood. Understanding this relationship may lead to identifying at-risk adolescents and lead to evidence-based interventions targeted at preventive and disease modifying treatments to decrease the burden of knee OA. Here we present the evidence on adolescent sports-related trauma and incident knee OA, the association of sports on joint injury in adolescence, biomechanical risk factors for incidental knee OA, and promising treatment approaches.

SPORTS INJURIES AND KNEE OA

The evidence to date is limited to young adults and clearly links knee OA to anterior cruciate ligament (ACL), meniscal, and articular cartilage injuries. Among young adults, knee injury was shown to lead to knee OA with a cumulative incidence of 13.9% at age 65 compared to 6.0% in those without knee injury (11). Subsequent prospective studies found radiographic osteoarthritis developing within 12 to 15 yr in female and male soccer players with ACL and meniscal damage (20,32). In long-term follow up of young athletes who had meniscus surgery, more than 50% developed knee OA, pain, and functional impairment (22).

The data on children and adolescents and whether they develop osteoarthritis in childhood due to sports injuries is sparse. One study in children, aged 4 to 17 yr, who had internal derangements of the knee found chondral lesions to be prevalent, and more so in skeletally immature children than in older mature children. However, there was no follow up on the long-term resolution of these early lesions and whether they progress to osteoarthritis (27).

SPORTS-RELATED INJURIES IN THE ADOLESCENT

Epidemiologic data demonstrate that sport injuries cause acute morbidity among adolescent athletes and at alarmingly

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1537-890X/0906/329–331
Current Sports Medicine Reports

increasing rates in the ankle and the knee (7). Most commonly, football, wrestling, basketball, and soccer are the cause of injuries that occur at the knee, ankle, and ligaments (9). Compounding the already-high adolescent injury rate is the added burden of obesity in children, which leads to a threefold risk of musculoskeletal injuries (23,35). In an environment where sports participation is greater, at a higher intensity level, and occurring at a younger age, the risk of mechanical knee injuries in adolescence is great and sets the stage for knee OA.

KNEE BIOMECHANICS AND OA

The biomechanical causes of osteoarthritis arise from traumatic ligament and cartilage injuries, leading to abnormal loading of the joint that causes alteration of shear and compression forces. Thus the disease process ensues with disruption and fibrillation of cartilage, change in the cartilage matrix, and involvement of underlying bone (33). Articular cartilage damage also can occur as a result of repetitive joint loading (8) that causes blunt impact on the tissue and subsequent matrix degradation and chondrocyte death (5,16) Animal models demonstrate that, even at impact energies not great enough to sustain articular fracture, progressive chondrocyte death occurs specifically in areas of thinner cartilage (30). Thus increased loading forces across the joint and articular cartilage lead to remodeling by way of an accelerated healing that occurs in response to tissue injury known as the "regional acceleratory phenomenon." The chrondral response curve further explains how cartilage responds to increasing load 1) initially accelerated longitudinal growth of the limb which reaches a peak and then 2) at larger loads decreased or cessation of growth (10). Thus for child and adolescent athletes whose bones and cartilage are developing, added stress and loading forces may alter the normal joint development and serve as an additional risk factor for knee OA.

TREATMENT

As known risk factors for knee OA (such as sports-related injury and obesity) are becoming more prevalent in children and adolescents, sports medicine personnel have an opportunity to modify their approach to injury management and counseling on health lifestyles. Treatment of these injuries can be addressed through both primary and secondary interventions. To date, primary prevention strategies have focused on altering lower extremity biomechanics. A meta-analysis revealed that multiintervention training programs were effective in reducing the risk of lower limb injuries by 39%, acute knee injuries by 54%, and ankle sprains by 50% (13). Another systematic review concluded that using insoles, external joint supports, and training programs were effective (1).

Secondary treatment of the adolescent athlete traditionally has been limited to surgical intervention. Treatment of ACL and meniscal injuries has focused on tissue repair and reconstruction, with much attention paid to the impact of these procedures on epiphyseal damage in skeletally mature versus immature children but little attention paid to long-term outcomes (22). The protective role of ACL reconstruction for osteoarthritis onset was accepted by many; however, systematic review of randomized control trials (RCT) showed a lack of evidence to support that surgical management is better (18,24). Adjunctive surgical intervention such as functional tissue engineering for ACL injuries with growth factors, gene therapy, cell therapy, and extracellular matrix scaffolds have been used in human subjects and lab models (12). For cartilage injuries, marrow stimulating therapies, microfracture of subchondral bone to release pleuripotent cells, growth factors to regenerate tissue, osteochondral autograft, autologous chondrocyte implantation, and osteochondral allografts all have been suggested for prevention of osteoarthritis (21,25).

Chondroprotective pharmacological therapies, commonly used in adults with knee OA, may offer promise in adolescents sustaining significant joint injuries. The early use of cyclooxygenase inhibitors, nonionic surfactant, or derivatives of glucosamine following joint injury has shown to reduce chondrocyte death (14,15,26). Recent Osteoarthritis Research Society International (OARSI) recommendations for osteoarthritis demonstrated that intraarticular hyaluron had the highest effect sizes for improvement in pain, function, and stiffness (34). Chrondroitin sulfate had no significant effect sizes for pain, but one RCT demonstrated a statistically significant decline in the rate of reduction of joint space narrowing over 2 yr in the treatment arm (17) The effect of intraarticular corticosteroid injection showed some effect over the first year with regard to pain but did not have any effect on function and stiffness. Glucosamine sulfate had a small effect size for pain but was even smaller when only higher-quality trials were included, while its effect on structural modification remains controversial (34).

The evidence for chondroprotective therapies in sports injuries is less robust, with fewer studies, small numbers, and short follow up. In one randomized study (treatment or no treatment) with 58 d of follow up, there was improvement with pain and mobility in the intraarticular sodium hyaluronate treatment arm for acute knee injuries with mild to moderate ligament tears and instability (3). More recently, a 2-yr follow-up study of athletes with acute ankle sprain showed that hyaluronic injections compared with placebo were more effective in reducing pain and reinjury (28). Long-term follow up to assess the impact of chondroprotection for sports injuries on the risk of incidental knee OA has not been studied.

In conclusion, we know that athletic knee injuries can predispose to knee OA. Further, more children are playing sports at a higher intensity level and are incurring more injuries. Whether these injuries put the child at higher risk for developing knee OA at an earlier age remains an important and unresolved issue. However, the treating physician should be cognizant of the potential for later onset degenerative disease in the younger athlete and particularly should be concerned with children who have multiple risk factors for adult onset osteoarthritis, such as female gender and obesity. Finally, while primary prevention is important, newer chrondroprotective approaches may be of clinical use and require more research in the younger athlete.

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