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Osteoarthritis and/or Sports

Arthrose und/oder Sport

REVIEW

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Summary

› **Osteoarthritis** – degeneration of joints – is a common process and increases in the older generation. 70-80% of people older than 70 are confronted with this condition, but fortunately only about 10-30% have symptoms and pain. The triangle of age – degeneration – and inflammation is substantial to its etiology.
› **Sports** are popular amongst all generations and are accompanied by varying joint loads. Moreover, the number of people involved in recreational sport is increasing in western countries, some of which are high-impact sports such as tennis or soccer. Therefore osteoarthritis and sports is a challenging problem for sports physicians.
› **The question** of the interaction of the degenerative process and the loading condition of various sports activities deals with the progression and /or onset of osteoarthritis through sports and recommendation of adequate sports modalities for osteoarthritic patients. Elite sports often lead to joint overload, but moderate training can induce adaption of the musculoskeletal system including improved cartilage conditions.
› **Lately, sports programs** are introduced to treat osteoarthritis by training of muscle-strength and coordination; this put sports and osteoarthritis in a new perspective of sports-medical care. Nevertheless, consulting sports physicians before the onset of complaints remains important in order to asses risk factors such as axis deformities, but also to adjust risk factors accordingly after the onset of symptoms. Therefore, prevention remains a central issue for sports physicians.

KEY WORDS:
Sports, Osteoarthritis, Cartilage, Training, Sports Overuse, Sports Injury

Zusammenfassung

› **Arthrose** – die Degeneration von Gelenken – ist ein weit verbreitetes Problem durch alle Bevölkerungsschichten, das im zunehmenden Alter vermehrt auftritt. 70-80% der über 70-Jährigen zeigen Zeichen einer Gelenksdegeneration, davon sind ungefähr 10-30% symptomatisch. Die Ätiologie dieser Erkrankung ist von unterschiedlichen Faktoren bestimmt. Zentral dabei ist die Trias aus Degeneration – Alter – Inflammation.
› **Sport** zieht sich als Phänomen durch alle Altersgruppen, ist mit hohen Gelenkbelastungen verbunden und stellt damit eine hohe Herausforderung an degenerativ veränderte Gelenksstrukturen dar. Zudem steigt in westlichen Industrienationen die Zahl an Hobby- und Breitensportlern, insbesondere auch bei jenen Sportarten, die als „high-impact" und „stop-and-go"-Sportarten bezeichnet werden können, wie Tennis oder Fußball.
› **Diese Entwicklungen** rücken die Fragestellung der Arthroseentstehung generell und gekoppelt mit dem Problem der Sportausübung, immer mehr in den Fokus von Sportmedizinern. Dieser beschäftigt sich mit Themen, ob Arthrose durch Sport induziert wird und inwieweit Sport und Arthrose noch kompatibel sind. Belastungen im Spitzensport bei gelenkbelastenden Sportarten gehen häufiger mit Arthroseenstehung einher, moderate Trainingsformen mit mittlerer Intensität können jedoch günstige Auswirkungen auf die Knorpeladaptation haben.
› **Sporttherapeutische** Ansätze zeigen, dass Sport und Bewegung auch ein wichtiges Mittel gegen Arthrose bzw. in der Arthroseprävention sein können. Zentral bleibt die Untersuchung durch den Sportarzt auch bevor Beschwerden auftreten, um etwaige Risikofaktoren wie Beinachsendefomitäten und Traininsplandesigns zu optimieren, aber auch eine adäquate Anpassung bei bereits bestehenden Beschwerden vornehmen zu können. Somit ist die Prävention zentrales Anliegen des Sportmediziners.

SCHLÜSSELWÖRTER:
Sport, Osteoarthrose, Training, Sportschaden,Sportverletzung

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Introduction

Osteoarthritis – joint degeneration – is a commonly spread phenomenon in the overall-population. Its incidence increases with age. 70-80% of the population beyond 70 shows signs of joint degeneration, of which 10-30% are symptomatic.

Sports in general is as well a widely spread phenomenon amongst all age groups. Due to its association with increased joint loads it poses a challenge to degenerated joint structures. Sports medicine deals with questions such as investigating a possible causal relationship of sports and osteoarthritis or how sports and osteoarthritis are compatible.

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Basics: Cartilage and Osteoarthritis

Only 5% of articular cartilage consists of cells, the chondrocytes. 20-40% are collagen and glycosaminoglycans that make up cartilage matrix. The remaining 60% of cartilage volume is water. Cartilage does not have any vessels of nerve endings. Diffusion is its main source of nutrients. The biphasic structure of water and matrix is the basis for the biomechanical and viscoelastic properties of cartilage. Mechanical loading presses fluid out of the cartilage which in turn serves as a puffer and increases the sliding capacity. The ultrastructure of the collagen skeleton and its bound glycosaminoglycans, responsible for water trapping, co-create the concept of what cartilage is. In case the integrity of this ultrastructure gets injured – due to critical traumatic impacts for instance – ruptures of the collagen skeleton may follow. As a consequence, glycosaminoglycans get washed out. Chondral or osteochondral fragments may also break out as a whole. The isolated, traumatic cartilage defect is a common cause of joint degeneration. However, causes for osteoarthritis vary. The physician should not only take local conditions into considerations but also systemic influences that might contribute to a decreased load bearing capacity of the functional unit subchondral bone and cartilage. A complex interplay of intrinsic and extrinsic factors contributing to induction and progression of osteoarthritis are known. The „triangle" of age – degeneration – inflammation builds the center in this process (30). Age for this matter is associated with decreased cartilage thickness, less proteoglycans, less collagen density and cell dedifferentiation (24). As a consequence a proteolytic matrix-breakdown at the cartilage surface occurs leading to macroscopically visible fibrillation, swelling of the cartilage, washing out of glycosaminoglycan and rupture of collagen matrix. Finally, the cartilage surface is completely lost. Aging on a cellular level is a rather new therapeutic target. The selective elimination of senescent cells with „senolytics" is in the context of any degenerative disease a rapidly evolving and promising branch of research that might bear therapeutical fruits in the near future (18). This very mechanical view of joint degeneration must be seen in parallel to a biological process that contributes to cartilage degradation. Soul et al. have pointed out fundamental biological aspects of osteoarthritis and distinguished between two major subgroups (35). The main difference between them were the pathways that were involved in disease-induction and -progression, namely differences in the Wnt and TGFβ pathways as well as an altered response of the inborn immune system and the complement activation.

Basically, cartilage degenerations is associated with an inflammatory irritation of the synovial membrane that is prominently mediated by interleukin-1 and TNF-Alpha. These factors trigger a cascade were metalloproteases (collagenases) come into play that further destruct the collagen skeleton. This inflammatory process is the primary reason for pain in osteoarthritic joints and leads to effusion, limited range of motion and a decreased joint function (20). Osteoarthritis might affect any joint. For sports medicine, primarily the knee and ankle joint are of relevance followed by the hip and the shoulder joint. Die induction of joint defects is accelerated by injuries that appear more commonly during sports (6). Considering the knee, meniscal, anterior-cruciate ligament – and cartilage injuries are most common. In the upper ankle joint, ligament instability, cartilage contusion and injuries of the capsule contribute to trigger osteoarthritis. In the hip joint labrum lesions and impingement syndromes contribute to osteoarthritic processes (25, 26). Chronic overload in joints, especially in the knee, might be additionally worsened in patients with varus- or valgus deformities. Moreover, dysplastic changes in hip joint have comparable effects.

In conclusion, the osteoarthritic joint can be considered like a complex organ, in which the interplay of pathologic factors of biological responses, mechanical stress and genetic predisposition cause disease induction and progression. The degenerative altered organ in turn has systemic effects on the whole organism. Circulating inflammatory mediators play a central role hereby for example in myocardial and neurodegenerative disease progression (5).

The major radiological sign on x-rays is joint space narrowing. Additionally, subchondral sclerosis, subchondral cyst formation, calcification, osteophyte formation and an increasing axis deformity, associated with ligament instability, occurs. Novel developments in musculoskeletal imaging aim to analyze radiological data fully automated with the help of advanced algorithms and to better detect „early onset" signs of osteoarthritis (figure 1). The microarchitecture of the subchondral bone is here the region of interest to detect early disease related changes in order to be able to intervene in a preventive or therapeutic setting as soon as possible (27). The MRI provides additional information on the extend of cartilage alteration and associated pathologies. Thus, MRI examination is obligatory for proper diagnosis and treatment.

Muscular Atrophy and Osteoarthritis

Osteoarthritis is associated with muscular pathologies, primarily structural atrophy and functional muscle weakness (14, 23, 31). A decreased range of motion counterintuitively is only one of many causes (31). The arthrogenic muscle inhibition is another major factor in a cascade of gradual loss of strength and muscle mass in osteoarthritis. Literature uses the term „reflex – arthropathy" synonymously. It describes a specific reaction of the nervous system, the so called „arthrogenic muscle inhibition" (15). Due to signals from abnormal nociceptive afferences from joints, a neurotransmitter release occurs which in turn inhibits the activity of alpha-neurons leading to a secondary muscular atrophy in conjunction with a lowered muscular activity (15). Muscular imbalances are consequences of this muscular weakness and further destabilize the already damaged joint. Hereby, the joint instability mainly results from a poorly controlled movement. This circumstance leads to irregular loads on the cartilage and thus further accelerates cartilage degeneration. Often, associated pain occurs in osteoarthritis patients which hinders them to conduct strength exercise. This immobilization leads to changes in the muscle with functional loss, independent of the duration of the immobilization. A reduction of muscular fibers, loss of muscle mass and biomechanical changes have been shown (1, 3, 37).

Recently published papers show, that muscular atrophy already starts before the first symptoms of osteoarthritis (2, 12, 16, 28, 33, 34). Sarcopenia as a multifactorial disease leads to generalized muscle loss (8). Primarily, older people are affected although it could have been shown that also younger adults show signs of sarcopenia (11, 17, 19). The only effective therapy for this condition is, similar to muscular atrophy, regular strength exercise. Isokinetic training should be applied, in which agonists and antagonists are trained simultaneously to avoid joint overload. Moreover, training should be adapted according to the change in muscle mass (13).

Osteoarthritis is a consequence of joint overload affecting the healthy cartilage. People with muscular weakness and a thus insufficient joint stability have a seriously increased risk to develop progressive degenerative joint destruction.

Cartilage and Sports

The definition of "physiological" exercise for cartilage is based on the understanding of its structure and biomechanics. Cyclic loading and unloading is necessary for cartilage stimulation and nutrient supply. Chondrocytes depend on diffusion, which is facilitated by the pump mechanism occurring during loading and unloading. Unloading is necessary because with continuous loading cartilage loses its interstitial fluid support and viscoelastic properties, thus lacking proper lubrication. Therefore, static load, like standing still or being in a sitting position for a long time, can be problematic for the nutrient supply of cartilage. Furthermore, trauma with high impacts exceeding the ultimate load of articular cartilage can cause immediate damage.

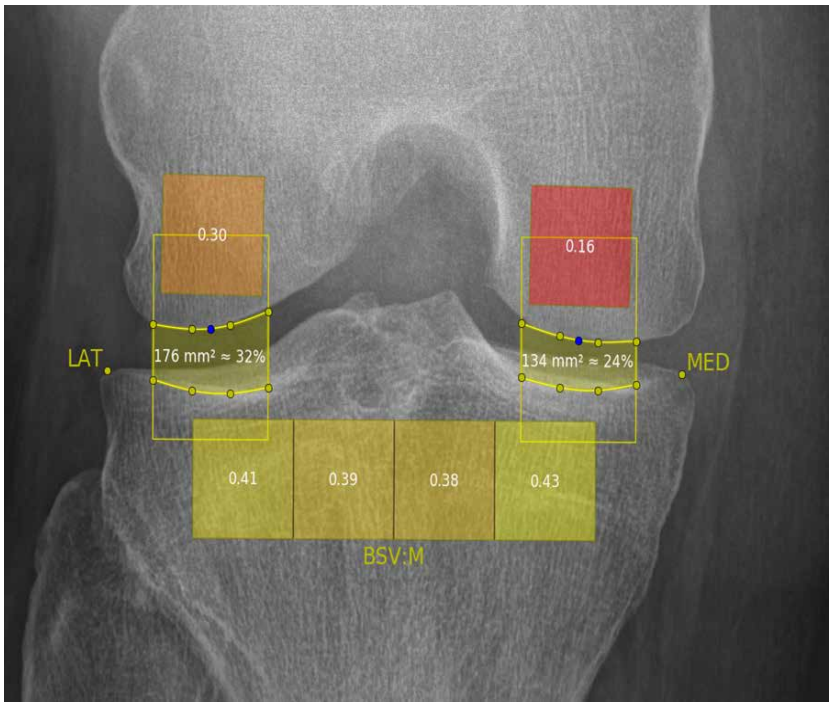

Figure 1

Digital Radiographic Image Analyses: The i3A Software (ImageBiopsy Lab) utilizes Artificial Intelligence and Deep Learning to analyze Osteoarthritis.

Animal studies investigating the impact of exercise on cartilage could demonstrate, that moderate running exercise led to an increase in cartilage thickness and glycosaminoglycan content in canine. When exposed to higher intensity and longer duration, both, cartilage thickness and glycosaminoglycan content decreased. Low intensity running caused a slight decrease in cartilage thickness and glycosaminoglycan content, but also led to thinning of subchondral bone without signs of osteoarthritis. Those results suggest, that cyclic exercise leads to an improvement of cartilage structures and composition and therefore allowing a higher load capacity. Another interesting finding was that cartilage regeneration after immobilization was negatively affected by excessive running, illustrating the importance of a proper rehabilitation regime. Studies investigating the impact of running on synovial joints, show similar results in humans.

Top athletes show an increased risk for osteoarthritis, especially with long distance high intensity running. Nevertheless, athletes show better clinical outcome scores compared to patients with similar radiological signs of osteoarthritis who are not physically active (32).

For moderate exercise, various authors reported no increased risk for osteoarthritis, but an even improved joint function (9). In those studies training volumes of 5 hours or 40km running per week for up to 9 years were not associated with an increased incidence of osteoarthritis. A consensus paper by Bosomworth in 2009 also stated that moderate exercise, especially running, was not a risk factor for developing osteoarthritis (7). Elite athletes with high training volumes do have an increased risk for osteoarthritis, but seem to develop fewer symptoms and limitations in activities. All competitive sports with direct contact with the opponent and high impact have a higher risk for osteoarthritis, due to injuries and subsequent posttraumatic changes. Beside the influence of exercise, it has to be emphasized, that overweight and axis deviations play a major role in the development of osteoarthritis, with one increasing each other (38).

Recent studies demonstrated that moderate exercise, especially isometric and isokinetic training, improved clinical performance of patients suffering from knee osteoarthritis. Importantly, also patients who did not exercise before benefitted from a structured work out. The challenge is to implement prevention programs that have to be continued for several years and to find a dose-response relationship for exercise as a therapy or tool for prevention (29, 36).

The most frequent comorbidity with osteoarthritis is overweight, with the percentage of body fat having the strongest correlation with the incidence of osteoarthritis. Evident factors influencing the development of osteoarthritis are age and gender. Women are affected twice as often as men and with increasing age the incident of osteoarthritis increases in both men and women.

The possible influence of genetic factors in the development of osteoarthritis are more and more recognized. In this context abnormal joint axes and dysplasia as well as specific genetic defects, like defects in the collagen synthesis or other metabolic disorders, are correlated with higher incidence of osteoarthritis. Furthermore, rheumatic disorders have to be taken into consideration. In contrast to the factors mentioned above, who are hardly influenceable, there are various factors that can be modified. Overweight is probably the most important factor that can be controlled. An increased body mass index is correlated with a higher incidence of osteoarthritis, with a notable increase with a BMI of 27 or higher. Physical activity can influence development and progression of skeletomuscular disorders. It is important to notice that the degree of osteoarthritis, measured by radiological grading, does not always correlate with the patient's symptoms. It is rather a deficit of coordination or muscular strength and balance that leads to painful conditions associated with osteoarthritis.

Beside the impact during exercise, recreational activities and labor also have to be taken into account as it is the total amount of joint load that influences the risk for osteoarthritis. ›

Rody and Zhang (2004) (29) published evidence-based recommendations for physical activity in the management of hip and knee osteoarthritis in the "move consensus". They noted, that there is evidence for a positive effect of exercise on the development of osteoarthritis and that the recommendations are effective, without an evident dose-response relationship. With the purpose of treating degenerative changes, they recommended isometric training with the main goal of the restoration of muscular strength and coordination. They could show that there is evidence that exercise therapy can lead to improvement of joint function and pain and can prevent further thinning of articular cartilage.

Furthermore they demonstrated that exercise therapy is best conducted primarily under the guidance of a physiotherapist (36) and has to be continued for a longer period of time at home. Before entering an exercise training patients are recommended to do a medical check-up. It is recommended to establish a baseline value to adapt the exercise program accordingly. In adjusting range of motion and intensity overload during exercise can be avoided. It has been shown, that scheduled follow-up appointments and periodic trainings under guidance are important for the success of such exercise programs (21, 22).

Sports Consulting and Sports Physical

For consultation regarding exercise and osteoarthritis a proper past medical history is important. Questions have to address past injuries and immobilization, but also systemic diseases, like metabolic diseases. During the clinical examination the long-leg axes, joint axes and muscle functions have to be examined to investigate the whole musculoskeletal system. By the use of simple clinical tests, like the one leg stand, muscular balance and coordination can be tested and give important information on the functional capacity. Regarding the specific sport history it is important to know if sport technique and skills have been known before the development of osteoarthritis. Suffering from osteoarthritis acquisition of a new sport can be challenging because of an impaired coordination and painful limited range of motion. In this case alternative sports like swimming and cycling may be more suitable. Particularly suitable for osteoarthritis patients are sports such as cycling, hiking with sticks or nordic walking, cross-country skiing and water aerobics (4, 7). Especially during cycling, the cyclic motion in a sitting position with unloading for the lower extremity appears particularly favorable. Adaption of the bicycle, like a lowered top tube can facilitate getting on and off easier. With already limited mobility the bicycle ergometer is recommended, because getting on and off is a lot easier and safer. Proper gear shifting, but also planning of trips and equipment, can help keeping the joint load to a minimum. During nordic walking joint load might not be as low as expected, because by using poles, steps becomes a little bit bigger, and therefore also the impact increases, so that this sport can only be recommended if it is well mastered.

As already mentioned, sports with a higher technical requirement must be mastered before the development of osteoarthritis, since learning with osteoarthritis is difficult or impossible. These sports include tennis, golf, skiing, table tennis, sailing and horseback riding. With appropriate experience and acceptance for the somewhat limited level of performance, these sports can certainly be carried on. When doing so, it is important to use well-cushioned shoes, walking aids or golf carts when golfing. Furthermore, modifications of the technique are necessary, as in tennis and golfing without pronounced trunk rotation and knee balance movement. With proper adjustments these sports can still be performed. Unsuitable sports in osteoarthritis are team sports or sports that are associated with high speed and unpredictable change of direction or direct contact with opponents, like squash, trampoline jumping, basketball, handball, football or disciplines such as lifting weight and athletics.

Prevention

A basic principle of preventive strategies in osteoarthritis are cyclic movements and joint loading. Cyclic joints loadings maintain the functionality of cartilage and joints especially trough the improved nutrition of chondrocytes via diffusion. To optimally exploit this effect, movements need to be performed with minimally possible weight. This is why biking is an ideal preventive intervention. Exercises like these help to also minimize associated inflammatory processes that would also contribute to progressive cartilage destruction. If an inflammatory irritation still occurs, any sports activity needs to be stopped along with a proper anti-inflammatory treatment regime (10). It is important to mention, that such inflammatory irritation are the only reason to stop sports for osteoarthritis patients. The prophylaxis of injuries is besides a number of other measurements for sure a major column in the prevention of osteoarthritis. The support with chondroprotective substances might be helpful, but should only be considered as an additive measure and not the main strategy. Finally, acceptance of the athlete remains an important point in the treatment process of osteoarthritis patients. Osteoarthritis requires a choice of certain sports and the avoidance of others, that guarantee the lowered possible joint loading capacity. This psychological component has to be implemented as an equally important part of the treatment regime. Under consideration of these rules, sports can and should still be conducted in patient suffering from osteoarthritis. Therefore, proper sports is a major factor in maintaining and increasing the quality of life in osteoarthritis patients.

Conflict of Interest
The authors have no conflict of interest.

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