Review Article

Osteoarthritis: Impact of Mechanical Loading and Exercise

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Abstract

Osteoarthritis, degenerative joint disease: is the commonest cause of pain, disability and impairment in general population. Many risk factors are involved in the development of osteoarthritis but its etiology is still poorly understood. It can affect any joint but mostly it is common in weight bearing joints like hip, knee and spine. The forces acting on joint and variations of the structures of the joint are important. There may be mechanical source is one of the reason in which there is abnormal load distribution on weight bearing joints that accelerate wear and tear process. Excessive stress or lack of normal stress may cause major part in the development of osteoarthritis. Excessive stress may be in the form of strenuous physical activates or in case of obesity. Lack of stress may be due to sedentary life style or immobilization of joints after injury. Normal weight bearing is very important for the preservation of normal articular cartilage because it's essential for the supply and distribution of nutrition in the form of synovial fluids throughout the articular cartilage. Normal weight bearing can be maintained by regular exercise in the form of high repetition and low intensity exercises and by managing weight to prevent over stress on joints.

Key words: Degenerative joint disease, Exercise, Joint loading, Weight bearing.

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Introduction

Osteoarthritis is the chronic progressive musculoskeletal disorder in which there is gradual degeneration of articular cartilage.[1] In osteoarthritis, cartilage breakdown results into matrix fibrillation, thickness of subchondral bone, marginal osteophytes, loss of joint space and loss of joint function.[2] Osteoarthritis can affect any joint but mostly it affects the weight- bearing joints like hip, knee and spine.[1,3,4] The osteoarthritis is generally considered as the consequences of only wear and tear process in the joint of elderly peoples. Recently work showed that it is not only due to wear a tear process but pathological changes in osteoarthritis are more dynamic in nature[3]. Osteoarthritis is complex, metabolically active process that involves the balance between anabolic and catabolic processes which affect the joint tissues. The balance of these processes dictates the rate of progression of joint damage.[5] Osteoarthritis is multi-factorial disease, mechanical overload in the form of strenuous physical activities or sports, instability of joints, trauma and repeated injuries play a

part in the development and progression of osteoarthritis. Prevention of sports or work related injuries, weight control and proper exercise planning are the one of the best ways for the prevention and slowing down the progression of osteoarthritis.[1]

Epidemiology

Osteoarthritis is the common degenerative disease that affects greater extent of population all over the world. According to a rough Worldwide estimation indicates 9.6% of men and 18% of women more than 60 years of age have symptomatic osteoarthritis. Osteoarthritis is the main factor of impaired mobility in individuals. In 1990, Osteoarthritis was included in top ten non-fatal burden of disease accounting for 2.8% of total years of living with disability. It is the highest-ranking disease among the musculoskeletal diseases and causes approximately 50% of the disease burden in musculoskeletal disease group.[1,6]

Classification

Often the cause of osteoarthritis is unclear called primary or idiopathic osteoarthritis but in some cases there is some obvious cause called secondary osteoarthritis.[9] The primary osteoarthritis may be localized to one joint like hand, knee or hip etc or generalized in which three or more than three joints are involved in osteoarthritis. Secondary osteoarthritis may be linked with trauma, congenital anomalies, perthes disease, Pre-existing bone and joint disorders, metabolic disease, Endocrine disorder, work related, immobilization, mechanical and local factors in the form of obesity and deformity.[5]

Risk Factors

There are number of risk factors which contribute the development of osteoarthritis. Some risk factors are modifiable and others are not. Systemic and local biomechanical factors may determine the severity of the condition. Non-modifiable risk factors may include gender, age, sex, genetic factors, racial predisposition and bone density. The modifiable risk factors which can be change like injury, deformity, obesity, muscle weakness, mal-alignment and joint loading. Sometimes, osteoarthritis is linked with heavy mechanical load.[1,5] Mechanical loading and injuries play an important part in the development of osteoarthritis. Recreational activities and active range of motion do not seem to provoke early changes of osteoarthritis.[8] All the joint tissue relies on each other for their function and constancy. Injury of any tissue has impact on other tissue which affects the whole joint.[5]

Joint Changes in Osteoarthritis

In old age, the enzymatic modeling, metabolism, collagen synthesis and nature of tissues in the joint remain normal. The tissues around the joint become thicker, hyper plastic and hypertrophic as a result of arthritis which can increase deformity. Osteoarthritis is the imbalance between the cartilage synthesis and its break down. The primary cause of cartilage losses is the active protease. The most significant resource of this protease is Chondrocytes themselves.[5]

The physiological changes occur in osteoarthritic joints in several steps. Tearing of articular cartilage occurs due to friction which is absorbed by synovium and initiate inflammatory reaction.[9] Due to inflammatory response, patient feels aching and stiffness in the joint after exercise rather than during exercise. Remodeling of cartilage during repair is inadequate so that the weight bearing capability of the joint is affected. The lesions on the surface of the articular cartilage are unable to repair themselves. Sub-chondral bone density increases below the damaged cartilage.[10] As a result, there is formation of less resilient bone which results in increase chances of micro-fracture. Marginal osteophytes are covered by fibro cartilage. These osteophytes resist joint movement. The bone associated with damaged cartilage is exposed and become hard and eburnated. Eburnation of bone and cyst formation results into disorganization. As a result osteophytes enlargement the bone surfaces are more worn out causing joint pain, stiffness and deformity. So, the normal joint function is altered in the form of restricted movement and structural changes.[11]

Osteoarthritis and Impact of Joint Loading

Exact source of osteoarthritis is still unclear. There may be many reasons for the development of osteoarthritis. Mechanical source is one of the reasons that accelerate wear and tear process due to abnormal load distribution on weight bearing joints. There are two possibilities regarding abnormal load bearing in joints.

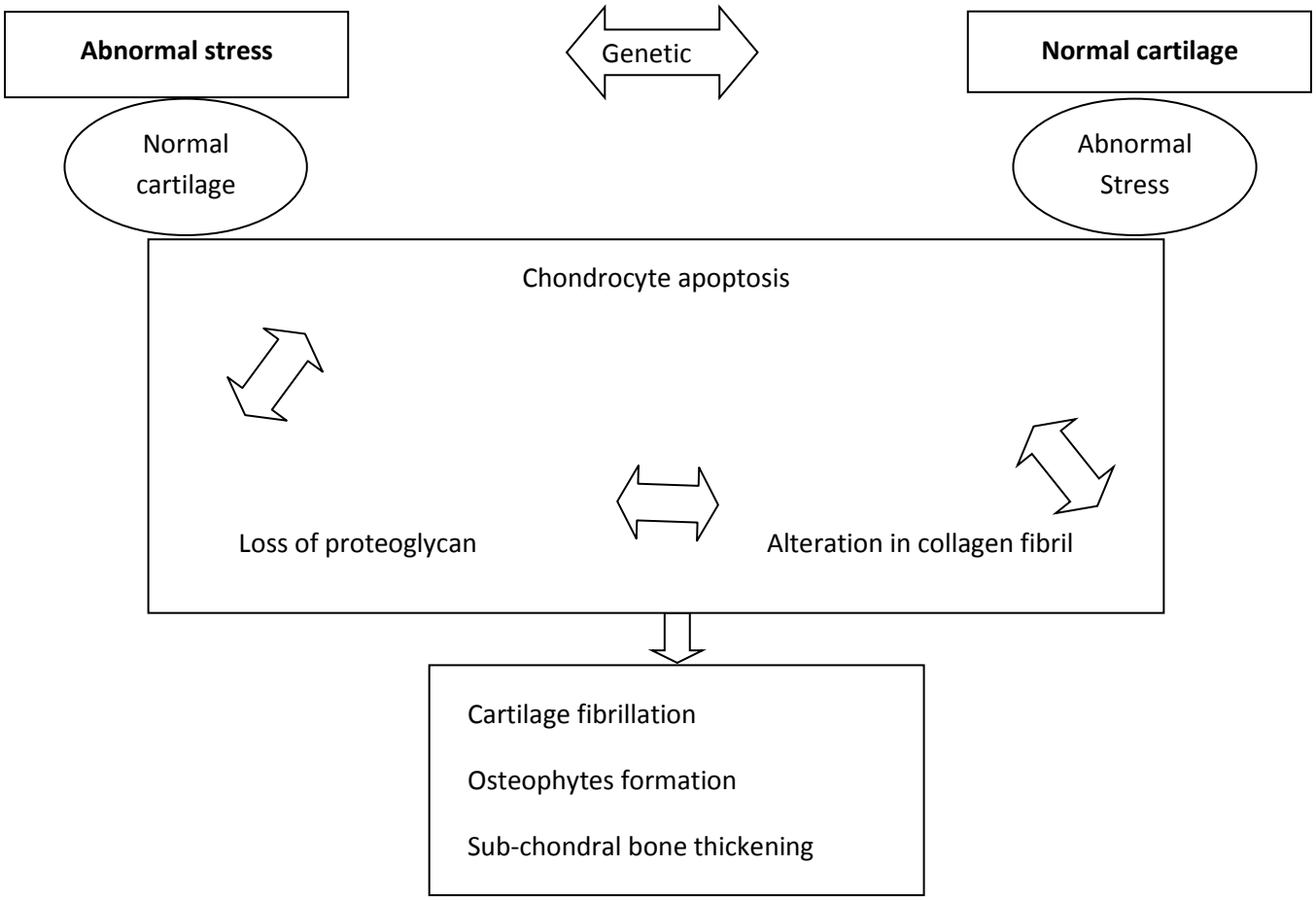

Fig. 1: Mechanical stress and osteoarthritis.

The first possibility is that some congenital abnormalities of the joints that left undiagnosed or not properly treated lead to structural changes in joints and start bases of osteoarthritis process. According to second theory, normal joints become osteoarthritic due to abnormal weight bearing through joints.[11] The abnormal load[12] may be in the form of obesity or in the form of strenuous sports or activities.[8] Joint alignment effects the sharing of load on articular cartilage. Intrinsic and extrinsic changes are vital in the development of osteoarthritis.[5]

Abnormal mechanical forces, increased bone stiffness and Chondrocytes dysfunction are the important factor that can affect cartilage. The normal joint function depends on ability of cartilage to resist and repair any injury in response to forces acting on joint and chemical processes in cartilage. Fig. 1 shows that, abnormal loading on normal cartilage or normal mechanical loading on abnormal cartilage results into joint failure. Abnormal stress may be due to traumatic injury, dysplasia, obesity, mal-alignment, muscle weakness and loss of proprioception. Inflammation, aging, metabolic changes and endocrine factors have vital role in abnormal changes in cartilage.[5] Forces acting on the joint and the variations of the structures of the joint are important. Joint loading induces changes in the cartilage of the joint. Compression of the joint surfaces and sudden shocks can cause degenerative changes in the cartilage.[13] The normal forces acting on the joint are more than the normal body weight during vigorous activities. More than normal stress[9] may be acting on the joint during vigorous physical training or in sports like in tennis, soccer or in hockey [8]. Frequent use of joints without higher mechanical loading is not harmful for the articular cartilage.[14] The effect of loading on joints has been shown to depend on the amount of loading.[21] So, normal physiological loading is safer for cartilage.[8]

Joints are specializes structure that transmit mechanical load of the body. The mechanical loading have

affect on properties as well as quality of cartilage. Articular cartilage is an avascular structure[8]. Free flow of synovial fluids is very necessary for the nutrition of the cartilage. The static loading reduces absorption of synovial fluid, because in static loading fluid movement occurs only by diffusion. Whereas, in dynamic loading increase the rates of transportation of synovial fluid by means of cyclic convection.[15] Expanded pressure on the cartilage affects the normal nutrition of the cartilage by limiting the free flow of fluids. Similarly, lack of normal stress also affects the nutrition because there is lack of compressive forces that play important part in synovial fluid flow. Joint movement and normal weight bearing plays an important role in the preservation of the articular cartilage. The movement of joint without normal stress on joint leads to atrophic changes in joints. Same changes were experienced during immobilization[16-18] due to casting, extended bed rest or structural alteration.[8] When structural alteration is found in a joint, its function may be altered due to unbalance distribution of stress and nutrition in articulating cartilage.[19,20] The changes observed following immobilization were similar to the changes like in osteoarthritis. The cartilage of immobilized joint resumes partially its structure on normal weight-bearing to the joint in case of joint is under the abnormal load in this phase, the cartilage does not resumes its normal state and osteoarthritis changes can be accelerated.[8]

Obesity and Osteoarthritis

Obesity is the form of mechanical loading that exerts continues stress on joints particularly on weight bearing joints. That's why; osteoarthritis is more common in weight bearing joints like knee and hip. The obesity includes one of the major risk factors for the development of osteoarthritis due to mechanical loading on joint.[8] So, weight loss and weight management is very important in osteoarthritis and person should be encouraged to reduce their extra weight.[19,20] Observation showed that obesity is modifiable risk factor. Currently one clinical study shows that weight reduction alone can be associated with reduced pain and improvement in function in patients affected with osteoarthritis.[1]

Exercise and Osteoarthritis

Exercises play an important part in reducing impairment, improvement in physical function and prevent disability in patient with osteoarthritis. Osteoarthritis is more common in persons engaged with strenuous sports or physical work and persons engaged with heavy load working occupation. The developments of osteoarthritis are common in sports like soccer, wrestling, cycling and boxing without prominent injury to joint surfaces and in persons engaged with heavy load working. Similarly, normal joints are at higher risk for the development of osteoarthritis in the absence of exercise or physical activity.[8] But the abnormal joints show degenerative changes on exposure to repetitive, high or low impact recreational exercises. The normal mechanical loading on regular use is not harmful for the articular cartilage.[14] Strong muscles can't prevent the progression of osteoarthritis. Both therapeutic and recreational physical activity with moderate intensity and duration is an effective therapy in osteoarthritis but the moderate intensity exercises have no effect on progression of osteoarthritis related with immobilization.[8] So, low impact; repetitive, recreational activities like aerobics in the form of jogging, walking, cycling, muscle strengthening and range of motion exercise should be done on regular basis.[19,20]

Conclusion

Weight management is one of the best ways to decrease the pain and disability associated with osteoarthritis. Weight can be managed by doing proper exercise and by controlling diet. Over weight places extra stress on the weight – bearing joints. By controlling weight, the stress and pain in the joints will be greatly reduced. So, weight management greatly reduces the risk for the development of osteoarthritis.

Regular exercises are very important, not only for prevention purposes but also for the treatment of the osteoarthritis. Exercise helps to support and stabilize joints. It can greatly reduce pain and disability related with osteoarthritis. Planning of exercise is very important. So, care must be taking to avoid overuse and prevents injuries. Each exercise programme should include both warm up and cool down period. Low impact recreational exercises like aerobics in the form of walking, jogging, swimming are very helpful in osteoarthritis. Strong muscles are very important because they promote stable joints. So, exercises particularly, strengthening exercises targeting the muscles surrounding the joint are very important in osteoarthritis.

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