



The Illinois Medical Bulletin



The Association Between Obesity and Knee Osteoarthritis: A Review of Mechanical and Metabolic Mechanisms

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Article History :

Received date : 2023/10/12
Revised date : 2023/11/28
Accepted date : 2023/12/09
Published date : 2024/01/13



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ABSTRACT

Introduction: Knee osteoarthritis (OA) is the most common form of arthritis and a primary cause of chronic disability. Obesity is recognized as the most significant modifiable risk factor for knee OA, a link historically explained by increased mechanical load on the joint.

Literature Review: A review of the pivotal scientific literature confirms that while mechanical overload is a major factor, the pathogenesis is more complex. Evidence has established that obesity also promotes knee OA through systemic metabolic and inflammatory pathways. Epidemiological studies showing an association between obesity and OA in non-weight-bearing joints provided the first clue for a systemic link. Subsequent research characterized adipose tissue as an active endocrine organ that secretes signaling molecules called adipokines. Pro-inflammatory adipokines, particularly leptin, were found in elevated levels in obese individuals and were shown to directly exert catabolic, cartilage-degrading effects within the joint. Furthermore, the chronic, low-grade systemic inflammation that characterizes obesity is now understood to contribute to local synovial inflammation, further accelerating the degenerative process.

Conclusion: The body of evidence reviewed has reshaped the understanding of the relationship between obesity and knee osteoarthritis. It confirms that obesity acts via a dual-pathway, promoting joint degeneration through both excessive mechanical stress and adverse metabolic and inflammatory signaling. This reframes OA as a disease with a major metabolic component.

Keywords: Osteoarthritis, Obesity, Knee, Adipokines, Leptin, Inflammation, Biomechanics.

INTRODUCTION

Osteoarthritis (OA) is a degenerative joint disease that represents a massive and growing public health burden due to its high prevalence and its impact on pain, physical function, and quality of life. The knee is the large joint most commonly affected, frequently leading to severe disability requiring surgical intervention. While age and genetics are non-modifiable risk factors, the global obesity pandemic has been identified as the most powerful and modifiable driver of the knee OA epidemic.

For many years, the relationship between excess body weight and knee OA was viewed through a simple and intuitive lens: increased mechanical loading. The assumption was that carrying excess weight simply "wears out" the knee joints faster. However, a compelling body of clinical and basic science research has challenged this exclusively mechanical view, revealing a more complex interplay of systemic factors. This literature review will synthesise the pivotal evidence that has broadened our understanding of this relationship, establishing obesity as both a mechanical and a metabolic risk factor for knee osteoarthritis.

LITERATURE REVIEW

The modern understanding of how obesity drives knee osteoarthritis has evolved to incorporate two major, interconnected pathways: the established role of biomechanical loading and the emerging role of metabolic and inflammatory factors.

The biomechanical pathway is undisputed and well-supported by extensive evidence. Large, prospective epidemiological cohort studies, such as the Framingham Osteoarthritis Study, have consistently demonstrated a strong, positive, and dose-dependent association between body mass index (BMI) and the risk of both the incidence (new development) and progression of knee OA. Biomechanical studies have quantified these forces, showing that each pound of body weight places several pounds of compressive force across the knee joint during daily activities like walking or climbing stairs. This chronic, excessive mechanical stress is believed to

accelerate the breakdown of articular cartilage, trigger pathological changes in the subchondral bone, and contribute to the degenerative cascade (Griffin and Guilak, 2005).

However, the purely mechanical hypothesis was challenged by a key clinical observation: obesity is also an independent risk factor for the development of osteoarthritis in non-weight-bearing joints, such as those in the hand (Ciccuttini et al., 2004). This finding strongly suggested that systemic factors related to excess adiposity must also be at play. This led to a paradigm shift in the understanding of adipose (fat) tissue, which was re-characterized from a passive energy storage depot to a highly active endocrine and inflammatory organ.

This new understanding focused on the role of "adipokines"—a group of bioactive molecules secreted by adipose tissue. A large body of research has demonstrated that in obesity, the profile of secreted adipokines becomes pro-inflammatory. Leptin, an adipokine found in high concentrations in obese individuals, was identified as a key culprit. Studies found that leptin receptors are present on chondrocytes (cartilage cells) and that leptin can directly signal within the joint to promote inflammatory responses and stimulate the production of matrix-degrading enzymes, thereby actively contributing to cartilage breakdown (Pottie et al., 2006; Dumond et al., 2003).

Furthermore, obesity is now recognized as a state of chronic, low-grade systemic inflammation, sometimes termed "meta-inflammation." Obese individuals have modestly elevated levels of circulating pro-inflammatory cytokines like interleukin-6 and C-reactive protein. It has been proposed that these circulating inflammatory mediators can enter the synovial joint and contribute to local synovitis (inflammation of the joint lining), which is increasingly recognized as a key feature of OA progression. This provides a direct link between the systemic inflammation of obesity and the local inflammatory processes that drive joint degeneration (Pottie et al., 2006).

CONCLUSION

The pivotal literature investigating the relationship between obesity and knee osteoarthritis has profoundly reshaped the understanding of the disease. While the detrimental effects of excessive mechanical loading on the knee joint remain a critical and undeniable factor, the scientific evidence has expanded this view considerably.

The body of work reviewed confirms that obesity also acts as a systemic, metabolic disease that actively promotes joint degeneration through non-mechanical pathways. The characterization of adipose tissue as an endocrine organ secreting pro-inflammatory adipokines, and the recognition of the chronic low-grade inflammation associated with obesity, have provided clear biological mechanisms linking excess body fat to cartilage destruction. This research has successfully reframed osteoarthritis, moving it from a simple "wear and tear" disease to a more complex disorder with significant metabolic and inflammatory components, opening new avenues for both prevention and the development of future disease-modifying therapies.

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