

## Metabolic impact of obesity on osteoarthritis

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### **Abstract**

*Obesity is defined by calculating the Body Mass Index (BMI) of an individual. A BMI of  $>30$  kg/m<sup>2</sup> is considered clinically obese. Physical inactivity and high caloric intake have been directly correlated with an increasing BMI. An increasing number of patients with obesity are presenting to orthopedic departments. Specifically, an elevated BMI can impact orthopedic issues through two broad mechanisms: biomechanically and metabolically. These two concepts cause issues to both the bone itself and/or the surrounding soft tissue and its structures. Obesity increases the risk of multiple co-morbidities, including but not limited to: hypertension, type 2 diabetes, coronary artery disease, stroke, sleep apnea, and osteoarthritis (Molina et al. 2023). Additionally, moderate dynamic mechanical loading is one of the most important mechanical factors for maintaining joint homeostasis. The integrity of articular cartilage is maintained under moderate loading conditions during routine daily activities. However, when receiving abnormal excessive mechanical loading, disruption of cartilage homeostasis and deformation of normal joint morphology occurs, further inducing and accelerating the progression of osteoarthritis (Chen et al., 2020). Recent studies highlighted the role of obesity and metabolic syndrome in the pathogenesis of knee osteoarthritis not simply through increased mechanical loading but the systemic effects of obesity-induced inflammation. The current concept of knee osteoarthritis is that of a 'whole joint disease', which highlights the involvement not only of articular cartilage but also the synovium, subchondral bone, ligaments and muscles (Shumnalieva et al., 2023). These findings highlights that the adequate management of knee osteoarthritis needs to include an optimization of body weight, a beneficial mobility regimen and obesity-related inflammation treatment as a possible pharmacological therapy targeting specific molecules and a personalized approaches of physical therapy. Keywords: body mass index, total knee arthroplasty, orthopedics, exceeds body weight.*

## Presnovni vpliv debelosti na osteoarthritis

### **Povzetek**

*Debelost definiramo z izračunom indeksa telesne mase (ITM) posameznika. ITM  $>30$  kg/m<sup>2</sup> velja za klinično debelost. Telesna nedejavnost in visok vnos kalorij sta neposredno povezana z naraščajočim ITM. Vse več bolnikov z debelostjo prihaja na ortopedске oddelke. Natančneje, povišan BMI lahko vpliva na ortopedске težave prek dveh širokih mehanizmov: biomehanskega in presnovnega. Ta dva koncepta povzročata težave tako sami kosti kot tudi okoliškemu mehkeemu tkivu in njegovim strukturam. Debelost poveča tveganje za številne sočasne bolezni, vključno, vendar ne omejeno na: hipertenzijo, sladkorno bolezen tipa 2, koronarno arterijsko bolezen, možgansko kap, apnejo v spanju in osteoarthritis (Molina et al. 2023). Poleg tega je zmerna dinamična mehanska obremenitev eden najpomembnejših mehanskih dejavnikov za vzdrževanje sklepne homeostaze.*

*Celovitost sklepnega hrustanca se ohranja v pogojih zmerne obremenitve med rutinskimi dnevnimi aktivnostmi. Vendar pa ob prejemu nenormalne prekomerne mehanske obremenitve pride do motenj homeostaze hrustanca in deformacije normalne morfologije sklepov, kar dodatno povzroči in pospeši napredovanje osteoartritisa (Chen et al., 2020). Nedavne študije so poudarile vlogo debelosti in*

*presnovnega sindroma v patogenezi osteoartritis kolena, ne le zaradi povečane mehanske obremenitve, temveč sistemskih učinkov vnetja, ki ga povzroča debelost. Trenutni koncept osteoartritis kolena je "bolezen celotnega sklepa", ki poudarja vpletenost ne le sklepnega hrustanca, ampak tudi sinovije, subhondralne kosti, vezi in mišic (Shumnalieva et al., 2023). Te ugotovitve poudarjajo, da mora ustrezno obvladovanje osteoartritis kolena vključevati optimizacijo telesne teže, ugoden režim mobilnosti in zdravljenje vnetja, povezanega z debelostjo, kot možno farmakološko terapijo, usmerjeno na specifične molekule in prilagojene fizioterapevtske pristope. Ključne besede: indeks telesne mase, totalna artroplastika kolena, ortopedija, prekomerna telesna masa.*

## **INTRODUCTION**

Obesity has been linked to exacerbate many orthopedic problems. The evidence is overwhelming on the association of obesity to a number of medical conditions. These include: insulin resistance, glucose intolerance, diabetes mellitus, hypertension, dyslipidemia, sleep apnea, arthritis, hyperuricemia, gall bladder disease, and certain types of cancer. The independent association of obesity seems also clearly established for coronary artery disease, heart failure, cardiac arrhythmia, stroke, and menstrual irregularities (Pi-Sunyer, 1999).

Metabolically, obesity is thought to cause a chronic, low-grade, proinflammatory state (Ouchi et al., 2011). Overweight and obese adults have elevated serum markers of inflammation; these include C-reactive protein, interleukin-6, and leptin. These cytokines are derived from adipose tissue, hence 'adipokines.' Clinical studies have shown a correlation between adipokine levels and cartilage volume loss. Additionally, leptin – one of the adipokines – is responsible for triggering an intra-articular pro-inflammatory cycle which contributes to the breakdown of collagen, thus leading to worsening osteoarthritis (Das, 2001).

## **OBESITY AND SOFT TISSUES INJURIES**

This may explain why osteoarthritis is also more prominent in non-weight bearing joints of the obese population, such as the shoulder and hand. Within the upper limb, rotator cuff tendonitis and shoulder impingement are more common in the obese population (Wendelboe et al., 2004). Further to this, surgical management of these conditions in the obese population has shown inferior surgical outcomes compared with non-obese individuals undergoing identical surgical procedures (Warrender et al., 2011). The incidence of carpal tunnel syndrome correlates with obesity, yet weight loss does not improve symptoms (Kurt et al., 2008). This alludes to the potential impact of the metabolic effects previously mentioned and their role in carpal tunnel syndrome in the obese.

Plantar fasciitis, Achilles tendonitis, and posterior tibial tendon dysfunction are more common in the obese population within the lower limb (Khaodhiar et al., 1999; Frey and Zamora, 2007). Studies have also demonstrated the significance between meniscal tears within the knee and an increased BMI. A larger proportion of the obese population requires surgical intervention for these conditions when compared to those with a normal BMI (Ford et al., 2005).

## **OBESITY AND FRACTURES**

The association between fracture risk and obesity is less well documented. It was previously thought that obesity was a protective measure against fractures. However, reports over the last decade have suggested a higher incidence of fractures in those with obesity, especially in the elderly population. It must be noted that to date, obesity is a proven risk factor for ankle, leg, and humeral fracture but a protective factor for wrist, hip, and pelvic fractures (Premaor et al., 2014, Court-Brown et al., 2019). The science behind this correlation is not fully understood but thought to be due to falls risk, co-morbidities in obesity, distribution of body fat, and fracture patterns observed.

## **OBESITY, INFECTIONS, PAIN AND COMPLICATIONS WITH IMPLANTS**

Studies have indicated that obesity leads to worsening outcome measures in the peri-operative period. Lack of anatomical landmarks may make the surgical intervention more difficult and prone to unfavorable outcomes. Obesity also increases the risk of post-operative infection, non-union, chronic

pain, and failure of implants. The reduced vascularization to adipose tissue and the higher incidence of protein malnutrition can adversely affect wound healing. Further to this, comorbidities associated with obesity, such as type II diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, stroke, sleep apnea, hyperuricemia, gout, and others, can adversely affect the perioperative period, anesthetic risk, and surgical outcome (Khaodhiar et al., 1999).

## **METHODS**

A short literature review was made to overview the harmful metabolic effects of obesity in orthopaedics.

## **RESULTS**

Obesity is heritable and predisposes to many diseases. To understand the genetic basis of obesity better, researchers conducted a genome-wide associations. Pathway analyses provide strong support for a role of the central nervous system in obesity susceptibility and implicate new genes and pathways, including those related to synaptic function, glutamate signalling, insulin secretion/action, energy metabolism, lipid biology and adipogenesis (Locke et al., 2015). The body mass index (BMI) is widely recognized as a prognostic factor in multiple operations; however, the relationship between the BMI and outcomes following total knee arthroplasty (TKA) is extensively debated. Researchers aimed to evaluate the effect of the BMI at different cutoff values on the outcomes following primary TKA. Patients with a BMI  $\geq 30$  kg/m<sup>2</sup> were at a higher risk of lower functional scores and developing complications following primary TKA. It appears reasonable to encourage obese patients to lose weight before selective TKA (Si et al., 2015).

Researchers reviewed the evidence about the effectiveness of exercise in patients with overweight or obesity suffering from knee osteoarthritis. Exercise interventions seem effective in improving quality of life in people with overweight or obesity suffering from knee osteoarthritis, reducing pain and improving physical function (Jurado-Castro et al., 2022). Chu et al. (2021) suggested that diet and exercise intervention is beneficial overall for muscle mass in overweight or obese adults with lower-limb osteoarthritis, especially those who are undergoing weight management. Fransen et al. (2015) emphasized that individually delivered programmes tended to result in greater reductions in pain and improvements in physical function, compared to class-based exercise programmes or home-based programmes; however, between-study heterogeneity was marked within the individually provided treatment delivery subgroup.

## **DISCUSSION**

The increase in the number of individuals with an unhealthy high body weight is particularly relevant worldwide. Obesity (body mass index  $\geq 30$  kg/m<sup>2</sup>) is a well-documented risk factor for the development of osteoarthritis. Furthermore, an increased prevalence of total knee arthroplasty in obese individuals has been observed in the last decades. The primary aim of recent literature was to determine whether obesity has a negative influence on outcome after primary total knee arthroplasty. Obesity had a negative influence on outcome after total knee arthroplasty (Kerkhoffs et al., 2012). Moreover, obesity and severe obesity were associated with significantly higher revision and lower implant survival rates. Obesity did not influence clinical and most functional outcomes after unicompartmental knee arthroplasty, whereas Knee Society Score (KSS) function score was significantly lower only for the severely obese patient group (Vasso et al., 2022).

Obesity in orthopedics requires a multidisciplinary approach. There are several team members that can positively improve a patient's outcome and help manage obesity. This team includes a nutritionist, an endocrinologist or internal medicine doctor to manage related disorders such as thyroid disease or diabetes, a physical therapist, and in severe cases, a nurse who specializes in weight loss, a psychologist or therapist, a general surgeon who specializes in bariatric surgery. Presurgical obesity is associated with worse clinical outcomes of hip or knee arthroplasty in terms of pain, disability, and complications in patients with osteoarthritis (Pozzobon et al., 2018). Therefore, through interprofessional communication, these team members can maximize improved outcomes and enhance team performance. For example, a physical therapist may communicate that a patient is working out hours

per day and the dietician also notes that the patient is eating a healthier diet. This communication to the endocrinologist may encourage them to do a further metabolic workup on the patient. Physical therapy may help the patient learn proper exercises to help recover from injuries that result from excessive weight-bearing. A systematic review has shown that the consultation of a dietician has been shown to improve dietary change, cholesterol, blood pressure, and triglycerides (Mitchell et al., 2017). Therefore, we suggest the involvement of different medical professionals in orthopedic rehabilitation of individuals with excess body weight.

## CONCLUSION

To conclude, the evidence for the relationship of obesity to several comorbidities is strong, though the strength of the relationship varies with the condition. Much more research is necessary on causation and on what other factors such as the environmental factors may play an interactive role.

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