

The Short- and Long-Term Complications Associated with Obese Patients who Undergo Tibiofemoral Joint Replacement Surgery, and the Role of Physical Therapy in Meeting These Challenges

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## Abstract:

### **Objective:**

The objective of this research is to examine the complications associated with obese patients who undergo tibiofemoral joint replacement surgery compared to non-obese patients.

### **Methods:**

In this research, the pathophysiology of osteoarthritis of the tibiofemoral joint was reviewed, in obese patients compared to patients of normal weight. The incidence of short- and long-term complications following arthroplasty was determined in obese patients compared to patients of normal weight. The success rates of obese patients were compared with patients of normal weight in terms of functionality of the joint and the ability to return to routine physical activity. Lastly, ways in which the recovery after arthroplasty can be improved were examined, and the role of physical therapy in meeting these challenges of obese patients undergoing tibiofemoral joint replacement surgery was discussed.

### **Results:**

The degradation of articular cartilage that leads to osteoarthritis progresses at a faster rate in obese patients than in non-obese patients due to increased mechanical load, decreased muscle strength, altered joint mechanics, decreased structural integrity, and mechanoreceptor activation. Following arthroplasty, obese patients are at a greater risk for short-term complications, including mortality, longer operative times, infection, and continued drainage. These patients are also at an increased risk of long-term complications, including increased pain and stiffness, unmet physical therapy range of motion goals, and the need for a revision. Obese patients are less likely to return to functionality following arthroplasty than non-obese patients. The physical therapist plays several roles in this process, including pre-arthroplasty muscle strengthening, post-arthroplasty rehabilitation, and post-revision rehabilitation. The therapist may face several challenges when treating obese patients due to the patient's inability to walk long distances, increased weight of their limbs, excess amounts of subcutaneous fat around their joints, and increased risk for co-morbidities.

### **Conclusions:**

Obese patients face a greater incidence of short- and long-term complications after undergoing total knee arthroplasty. These patients present unique challenges to physical therapists during rehabilitation of the joint. While obese patients are at a disadvantage both pre- and post-operatively, the physical therapist is uniquely positioned to help combat these challenges and restore function to the joint.

## Introduction:

Despite efforts to reduce obesity, it continues to be a major public health concern (Mitchell 2011). Based on the 2011-2014 National Health and Nutrition Examination Survey (NHANES) data, 36.5% of American adults are classified as obese (Ogden 2015). These

estimates are based on body mass index (BMI), which defines obesity as a ratio of a person's weight to their height squared. In general, a BMI of 30 or greater meets the criteria for obesity. A BMI of 30.0 to 34.9 is classified as obesity class I, 35.0 to 39.9 as obesity class II, and 40.0 or greater as obesity class III. While there can be genetic factors and other health conditions (e.g., thyroid disorders, growth hormone deficiency, adrenal gland disorders), the major factor that leads to weight gain is a caloric intake which is greater than the caloric expenditure. There are a number of comorbidities associated with obesity, including type II diabetes, hypertension, cardiovascular diseases, certain cancers, and musculoskeletal conditions. In particular musculoskeletal conditions such as osteoarthritis often present earlier in obese individuals and have been associated with a loss of productivity and a lower quality of life (Anandacoomarasamy 2008). Osteoarthritis can make mobilization of the joint painful, further decreasing physical activity for obese individuals and further weight gain.

Osteoarthritis is the most common musculoskeletal disease (Lementowski 2008). Degradation of articular cartilage located at the end of the epiphyseal region of bone results in inflammation of the bone and cartilage tissue within the joint. It is estimated that 37.4% of adults in the United States have been diagnosed with osteoarthritis of the knee, making it the most common site affected (Dillon 2006). The Framingham Study showed a large proportion of the patients with a new diagnosis of knee osteoarthritis were obese, thus demonstrating that obesity is a risk factor for osteoarthritis. Felson and colleagues (Felson 1988) reported that 33% of the subjects who were obese had knee osteoarthritis. Weight-bearing joints are more likely to experience degradation because of the mechanical forces. As a patient's weight increases, the load in which the weight-bearing joints must carry increases. Because the joints were not designed to carry such a load, the articulating cartilage begins to degenerate and becomes

inflamed, leading to osteoarthritis (Lementowski 2008). Muscle weakness and joint laxity are two other risk factors for osteoarthritis. Because muscles, ligaments, and tendons, support the joint's movements, weak muscles and loose ligaments lead to a decrease in range of motion and stiffness within the joint (Felson 2000).

Once a patient has osteoarthritis, there are a number of different treatment approaches that are used to manage the pain. One approach is to give injections directly into the joint, which have anti-inflammatory effects as well as other benefits that provide pain relief. For example, corticosteroid injections contain cortisone, which is a potent anti-inflammatory agent (Raynauld 2003). Corticosteroid injections are typically given once every three months and are often the first line of injection treatment (Lo 2003). In cases where corticosteroid injections do not relieve pain and joint stiffness, hyaluronic acid injections may be used to give the patient a higher dose at a higher frequency. These injections contain hyaluronan, a structural component of skin which is found in connective tissue (Paliwal 2014). Hyaluronic acid injections are given three to five times, each one week apart and have been shown to have chondro-protective and analgesic effects in addition to their anti-inflammatory properties (Lo 2003). There are also nonsteroidal pharmacological options for treatment of pain. Nonsteroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen or naproxen, provide short-term alleviation of pain and inflammation by blocking the production of prostaglandins through both the cyclooxygenase (COX)-1 and COX-2 enzymes (Juni 2002). COX-2 is specifically located at sites of inflammation. NSAIDs are useful in reducing inflammation, but because they inhibit both COX-1 and COX-2, they can also cause stomach pain, as well as ulcers and intestinal bleeding (Juni 2002). COX-2 inhibitors are also classified as NSAIDs, but differ in that they selectively block the COX-2 enzyme (Juni 2002). COX-2 inhibitors allow for a reduction in inflammation without damaging the gastric and

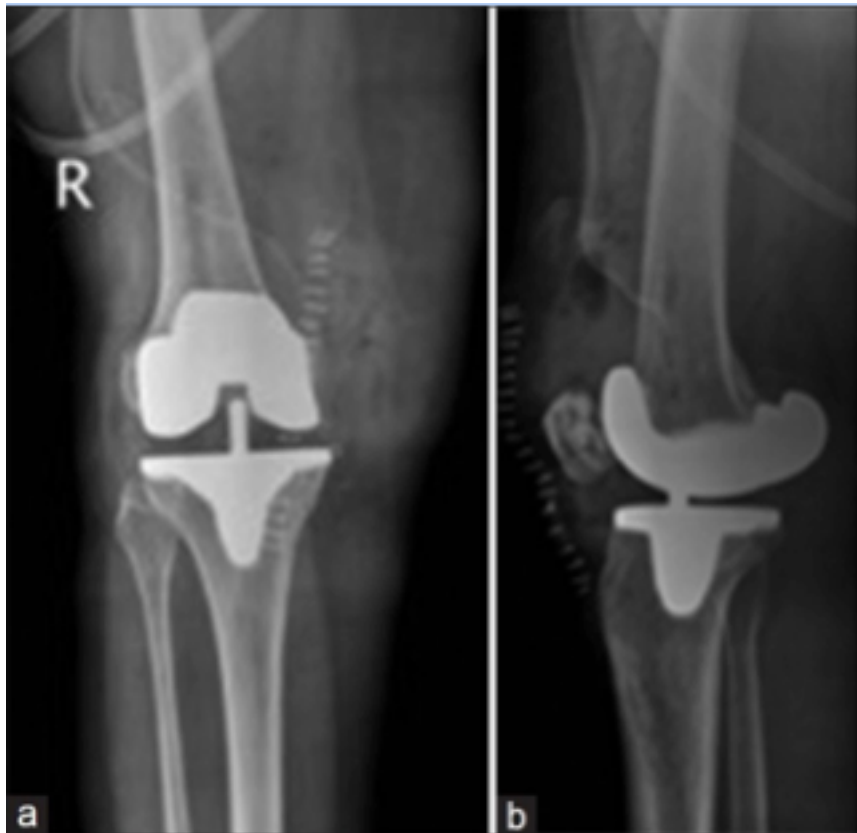
intestinal lining. Another important treatment approach that is used to reduce the pain associated with osteoarthritis is physical activity. Cardiovascular endurance and weight training can improve muscle strength and endurance, therefore providing more effective joint support and protection.

In addition to the approaches described above, there are several modalities used in physical therapy that can help manage the symptoms of osteoarthritis. Thermal modalities, ultrasound, electrotherapy, and manual therapy have all been shown to be effective (Kladny 2005). Thermal modalities include heat and ice, which offer the patient temporary pain relief. Moreover, the heat can improve muscle mobility and ice can decrease swelling and inflammation (Feine 1997). Ultrasound works as a pain management tool by warming muscles, tendons, and ligaments around and within the joint that cannot be reached with thermal modalities by transmitting sound waves (Wong 2007). Electrotherapy works with electrical stimulation to relax the muscles around the effected joint (Medlicott 2006). As the articular cartilage degenerates and the musculature around the joint loses strength, the muscles can be overworked and begin to spasm. Electrotherapy is an effective treatment for these scenarios (Medlicott 2006). Manual therapy involves the therapist manipulating the joint to enhance range of motion and to stretch the muscles surrounding the joint (Deyle 2005). However, in every case each of the approaches described above primarily treats the symptoms of osteoarthritis and not the fundamental pathology. Currently there is only one avenue of treatment to rid the joint of osteoarthritis, and that is through arthroplasty, or joint replacement surgery (Bhatia 2013).

Joint replacement surgery is the process of removing a joint that has been damaged or degenerated and inserting a new, artificial joint in its place. Over seven million joint replacements are completed each year in the United States (Kremers 2015). Out of these seven

million patients, >34% require a replacement of the tibiofemoral joint, or the knee.

Approximately 2.5 million total knee replacement procedures are done each year in the United States, with the rates projected to increase in the coming years (Kremers 2015). The current standard of care following surgery is the patient will undergo physical therapy to regain the motion and strength within the joint. If successful, the patient may expect to restore their range



**Figure 1. Artificial joint in patient after total knee arthroplasty (Agarwala 2013)**

of motion to the joint within four to six months (Rodgers 1998). Artificial or prosthetic joints are made from a mixture of metal and ceramic material, as seen in **Figure 1** (Agarwala 2013). However, these artificial joints have a much shorter life expectancy than the original joint (Clarke 2016). Recent studies have shown that >85% of artificial joints have a longevity of approximately 20 years (Su 2002). Originally the limited functional lifespan of these prosthetic joints resulted in them being used only in patients who were expected to live 20 years or less. However, revision surgery is now available to replace the prosthetic joint after degradation (Slover 2012).

of motion to the joint within four to six months (Rodgers 1998). Artificial or prosthetic joints are made from a mixture of metal and ceramic material, as seen in **Figure 1** (Agarwala 2013). However, these artificial joints have a much shorter life expectancy than the original joint (Clarke 2016). Recent studies have shown that >85% of artificial joints

As the population has become more obese and at an earlier age, osteoarthritis is being diagnosed earlier in life (Mitchell 2011). Obesity not only means that the onset of osteoarthritis occurs earlier, but also these patients are at greater risk of co-morbidities and are more likely to have poor overall physical conditioning that may prohibit them from maximizing the benefits of rehabilitation following joint replacement surgery. The purpose of this research is to examine the short- and long-term complications associated with obese patients who undergo tibiofemoral joint replacement surgery compared to non-obese patients. Short-term complications are likely to include increased infection rates, delayed incision healing, loss of balance, and a lack of cardiovascular endurance. Long-term complications are likely to include increased joint pain and stiffness in other joints, as well as the need for a revision in the surgical joint. The hypothesis to be tested is that obese patients will face greater short- and long-term complications after undergoing total knee arthroplasty due to osteoarthritis than non-obese patients, and will present unique challenges to physical therapists during rehabilitation of the joint. Obese patients experience bone loss and joint degradation specifically in the tibiofemoral joint at an earlier age than a patient of normal weight, leading to the need for pre-mature joint replacement surgery. Excess body fat also presents greater risk of post-surgical complications and artificial joint success that can increase the chance of needing to have revision surgery. The hypothesis will be tested by accomplishing the following specific aims:

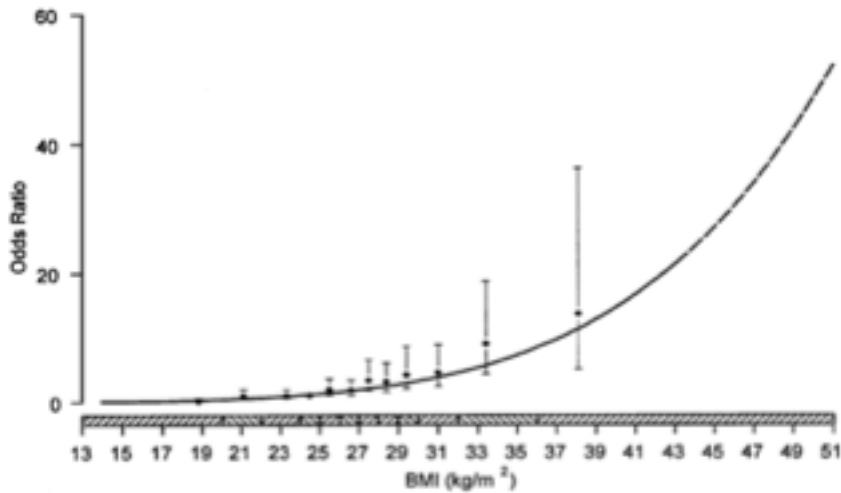
- 1) To review the pathophysiology of osteoarthritis in the knee joint in obese patients compared to patients of normal weight.
- 2) To determine the incidence of short-term complications following arthroplasty of the tibiofemoral joint in obese patients compared to patients of normal weight.

- 3) To determine the incidence of long-term complications following arthroplasty of the tibiofemoral joint in obese patients compared to normal-weight patients and the need for a revision.
- 4) To compare success rates of obese patients with patients of normal weight in terms of functionality of the joint and the ability to return to routine physical activity.
- 5) To determine the ways in which the recovery after tibiofemoral joint replacement surgery can be improved in the future for obese patients and to identify the role physical therapy can play in meeting the challenges of obese patients undergoing tibiofemoral joint replacement surgery.

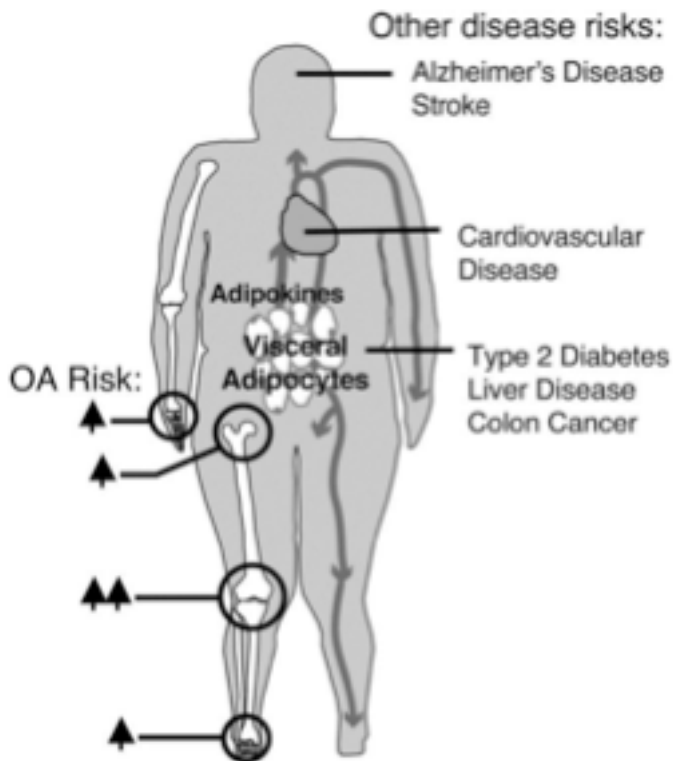
### Pathophysiology of Osteoarthritis in Obese Patients:

Articular cartilage is found at the end of bones within the joint and, along with the synovial fluid, allows for the joint to move with little friction while cushioning the mechanical load placed on the joint during weight-bearing activities. However, over the course of time excessive loading can cause the articular cartilage to degrade, beginning the development of osteoarthritis. The earliest sign of degeneration is fibrillation of the articular cartilage, followed by remodeling of subchondral bone, which sits just below the cartilage (Felson 2000). As the cartilage begins to degrade, the synovial fluid within the joint effuses. This effusion leads to inflammation of the joint, which causes joint stiffness, pain, and lack of functionality (Sellam 2010). Meanwhile, the subchondral bone underneath the cartilage begins to thicken. This change to the bone initiates the formation of osteophytes, commonly known as bone spurs, which further inhibit joint motion (Sellam 2010). Together, the degeneration of the articular cartilage and the





**Figure 2. Odds ratio of osteoarthritis associated with BMI (Coggon 2001)**



**Figure 3. Most common sites for osteoarthritis (OA) in obese individuals (McMillan 2010)**

formation of osteophytes leads to narrowing of the joint space, which is one of the classic radiographic findings in osteoarthritis (Sellam 2010).

Obese

patients are at an

increased risk for developing osteoarthritis. **Figure 2** shows that as BMI increases, the odds ratio for a patient to develop osteoarthritis also increases (Coggon 2001). Coggon et al. (Coggon 2001) found that more than one-third of osteoarthritis cases are in patients classified as obese. The development of osteoarthritis in a joint is accelerated in obese patients due to the altered bone structure and joint integrity. Specifically, obesity contributes to development of

osteoarthritis in the tibiofemoral joint, which is two times more likely to be the site affected than that of the hip or the feet (Griffin 2005). **Figure 3** shows many of the disease risks associated with obesity, along with the osteoarthritis risks in the four most common joints, three of which are load-bearing (Griffin 2005). The acceleration of osteoarthritis development in obese patients is due to their altered bone structure and increased mechanical joint load (Sowers 2010).

As a person gains weight, the load carried by the joints increases, averaging approximately three to six times that of the body weight (Bhatia 2013). As this load increases, the cartilage within the joint begins to thin and degrade beginning the development of osteoarthritis at a faster rate than that of a normal-weighted patient (Anandacoomarasamy 2012). Because obese individuals are less likely to exercise, they also have decreased muscle strength,



**Figure 4. Limited gait in obese patient due to joint deformity (Lozano 2011)**

reducing joint support (Wluka 2013). Furthermore, there is a difference between joint mechanics in obese patients compared with patients of normal weight. People who are obese tend to have a limited gait due to their increased weight and leg circumference, which minimizes movement in their joints (McMillan 2010).

**Figure 4** shows the increased thigh circumference, leading to the tibiofemoral joint deformity (Lozano 2011). Because of the increased load on the joint along with the minimal activity and use of the joint, there is a decrease in structural integrity and function over time (McMillan 2010).

The increased mechanical load due to obesity largely increases the progression of osteoarthritis. While mechanical loading is necessary for maintaining articular cartilage, increased weight-bearing increases the

risk of cartilage degradation (Griffin 2005). Chondrocytes, within the cartilage, have mechanoreceptors on their surface, which are activated upon an increase of pressure (Pottie 2006). Mechanoreceptor activation leads to cytokine and growth factor expression, as well as production of prostaglandin mediators. Through these mediators, matrix synthesis is inhibited, and cartilage degradation is accelerated (Pottie 2006). As a result of the activated immune cells and increased cytokine production, inflammation is increased, resulting in pain and loss of joint function (Pottie 2006). An increased mechanical load also decreases the strength of surrounding muscles (Sowers 2010). Muscle forces determine how the load is distributed across the joint. Consequently, when muscle forces are hindered, the majority of the mechanical load is placed on the articular cartilage, resulting in an accelerated progression of the degenerative process (Sowers 2010).

It is not uncommon for obese patients to be less physically active, which also contributes to an increased risk of osteoarthritis. Physical activity helps maintain muscle strength, joint structure, and joint function (Macera 2003). A loss of muscle strength reduces the joint's ability to absorb the weight load, leading to cartilage fibrillation, the first sign of osteoarthritis (Pottie 2006, Sowers 2010). Furthermore, lack of physical activity results in the deterioration of the quadriceps muscles (Thorstensson 2004). Reduced quadriceps strength leads to decreased functional performance and endurance of the joint, which is predicted to cause tibiofemoral osteoarthritis in over 50% of the cases (Thorstensson 2004).

Lastly, obesity is associated with an increased level of pro-inflammatory cytokines that results in a low level chronic inflammation. Cytokines upregulated by adipose tissue are known as adipokines and can contribute to synovial tissue inflammation and cartilage matrix degradation (Rital 2012). One mediator secreted by adipocytes thought to increase the risk for

osteoarthritis is leptin. Elevated body fat with increased leptin signaling is shown to induce systemic inflammation and eventually osteoarthritis (Rital 2012). Furthermore, impaired leptin signaling in mice showed protection from osteoarthritis due to obesity (Rital 2012). As adipose tissue develops, pro-inflammatory cytokines are secreted and synovial tissue inflammation is induced. This inflammation leads to degradation of the joint and, in turn, osteoarthritis (Rital 2012).

### Short-Term Complications of Arthroplasty in Obese Patients:

Obese patients are at an increased risk of short-term complications following arthroplastic surgery, such as intra-operative complications and post-operative complications. In general, obese patients are at a higher risk for surgical complications than their non-obese counterparts. This is due to the fact that obesity is associated with comorbidities, such as coronary artery disease, hypertension, and type II diabetes mellitus. All of these complications increase the patient's risk for mortality during surgery, as well as experiencing a major cardiac event such as a stroke (Mun 2001). Obesity is also associated with longer operative times, as seen in **Table 1** (Liabaud 2013). Furthermore, prolonged operative times shown in obese patients are associated with an increase in post-operative infection rates (Peersman 2006).

After the patient undergoes a successful joint replacement surgery, they are more likely to face post-operative complications, including continued drainage, metabolic alkalosis, severe hypobolemia, and pulmonary embolism (Schwarzkopf 2012). Obese patients are at an increased risk for these complications due to their increased operating space and operation length, reduced blood flow in fat tissue for healing, and their comorbidities (Schwarzkopf 2012).

**Table 1. Operative times for patients based on BMI categories along with associated surgical complication rates (Liabaud 2013)**

BMI (kg/m <sup>2</sup> )	Number of Patients	Operative Time (min)	Number with Complications
Normal: >25	47	97.26	6.4%
Overweight: 25-29.9	59	97.24	13.6%
Obesity: >30	167	107.84	12.0%
Class I: 30-34.9	80	103.28	8.8%
Class II: 35-39.9	57	105.74	8.8%
Class III: >40	30	114.5	26.7%

Additionally, obese patients are more than twice as likely to develop an infection at the site of surgical entry (Yuan 2013). **Table 2** shows infection rates in obese patients compared to their non-obese counterparts found in several different studies including Amin et al. (Amin 2006) and Krushell et al. (Krushell 2007). In a systematic review, Kerkhoffs et al. (Kerkhoffs 2012) found that out of twenty studies, 15,276 total patients presented with an infection. Deep infection requiring a debridement was found in nine studies for a total of 5,061 patients. Obese patients had higher rates of both general infection and deep infection, with average odds ratios of 1.90 and 2.38, respectively (Kerkhoffs 2012). Obese patients are also at a higher risk for failure of healing in the wound and incision. Generally, around 20% of obese patients undergoing total knee replacement surgery will have wound healing complications, such as fat necrosis or transient drainage (Krushell 2007). Winiarsky et al. (Winiarsky 1998) found that 22% of obese patients have a wound complication, including failure to heal or increased drainage, where as 2%

**Table 2. Infection rates in obese patients compared to patients of normal weight**

Study	BMI >30 kg/m <sup>2</sup>			BMI <30 kg/m <sup>2</sup>		
	Infection Present	Total Subjects	Infection Rates (%)	Infection Present	Total Subjects	Infection Rates (%)
(Amin 2006)	9	41	21.95%	0	41	0%
(Chesney 2008)	36	568	6.34%	28	710	3.94%
(Dowsey 2010)	34	318	9.77%	7	211	3.32%
(Ersozlu 2008)	8	96	8.33%	1	40	2.50%
(Jarvenpaa 2010)	2	52	3.85%	0	48	0%
(Krushell 2007)	8	39	20.51%	0	39	0%
(Namba 2001)	5	422	1.18%	4	1391	0.29%

of non-obese patients have wound complications post-arthroplasty. The decreased ability for obese patients to heal leads to increased complications not typically seen in non-obese patients.

Obese patients are also likely to spend more days in the hospital prior to discharge than their non-obese counterparts, and they are more likely to discharge to a skilled nursing facility or rehabilitation facility than to their home. The mean hospital stay for patients of normal weight is 14.5 days, whereas the mean hospital stay for obese patients is 19.3 days (Ersozlu 2008). Furthermore, less than half of obese patients are discharged from the hospital to go home instead of a skilled nursing or rehabilitation facility, whereas ~42% of non-obese patients go home immediately following discharge (Krushell 2007). **Table 3** shows the discharge disposition of obese patients in comparison to non-obese patients (Abdel 2014). In non-obese patients, it is most common to be discharged to a rehabilitation facility or back to their home. However, in obese patients, it is most common to be discharged to a rehabilitation facility.

Due to the potential for a much more complicated post-operative course for obese patients, obesity also affects inpatient rehabilitation outcomes in physical therapy prior to discharge. Functional independence measures (FIMs) are recorded at admission and discharge. There are 18 FIM categories, which include motor score, cognition score, stairs, ability to transfer, and walking without assistance. Each category is worth 7 points for a total of 126

**Table 3. Discharge disposition of obese patients compared to that of non-obese patients following arthroplasty (Abdel 2014)**

Discharge Disposition	BMI >30 kg/m <sup>2</sup>	Percent of Patients	BMI <30 kg/m <sup>2</sup>	Percent of Patients
Home	800	37.5%	1045	42.4%
Rehabilitation Facility	1321	61.9%	1388	56.3%
Hospice	14	0.7%	33	1.3%

points, and 78 points are needed for discharge. Non-obese patients typically score over 105 on the discharge FIM, whereas obese patients score an average of 103 (Vincent 2008). While obese patients are able to perform specific skills, their functionality is lower than that of non-obese patients. Their functional independence is compromised due to their obesity and the associated complications. This compromise leads to an increase in long-term complications in this patient population, including slower recovery rates and higher rates of revisions.

### Long-Term Complications of Arthroplasty in Obese Patients:

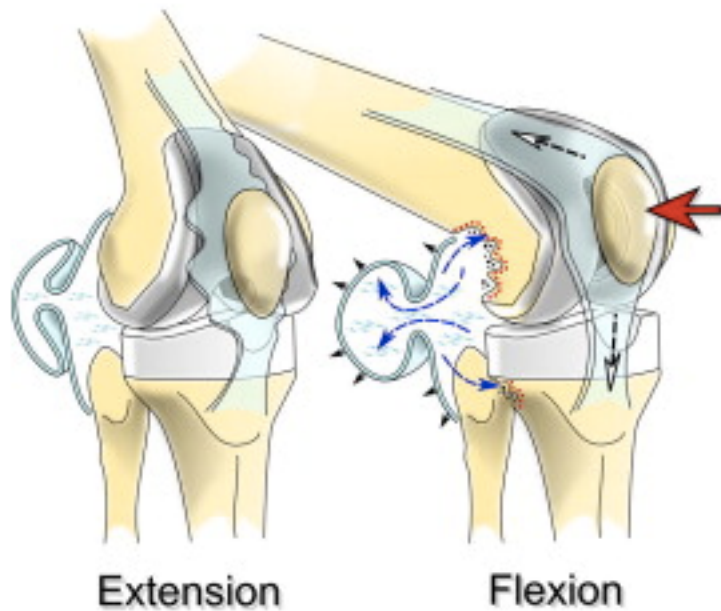
Assuming the complications in the obese patients are minimized or never occur, obese patients will continue on to physical therapy for rehabilitation, just as a non-obese patient would. However, obese patients tend to have worse outcomes than their non-obese counterparts. Amin et al. (Amin 2006) tested knee function in non-obese and obese patients following total knee replacement surgery beginning before surgery, as well as 6, 18, 36, and 60 months after surgery. In every time interval, obese patients had less functionality of their knee than non-obese patients did (Amin 2006). Jones et al. (Jones 2012) found the same results in a study that used the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) to test post-surgical outcomes. The WOMAC questionnaire asks patients 24 questions comprised of 5 questions over pain, 2 questions over stiffness, and 17 questions over physical function. The questions are answered on a scale of 0 to 4, with 0 indicating no difficulty and 4 indicating extreme difficulty. The points are added to get a sum WOMAC score. Jones et al. (Jones 2012) found that at 6 months for pain, obese patients scored a 22.6 on the WOMAC scale, whereas non-obese patients scored a 19.2. At 3 years for pain, obese patients scored a 19.5 on the WOMAC scale, where as non-obese patients scored a 17.1. At 6 months for function, obese patients scored a 27.8 on the



WOMAC scale, where as non-obese patients scored a 23.3. At 3 years for pain, obese patients scored a 27.8 on the WOMAC scale, whereas non-obese patients scored a 24.4 (Jones 2012). Collectively, obese patients experience higher pain and less function following joint replacement surgery than non-obese patients.

Before outpatient physical therapy is completed and the patient is discharged from the therapist, the goal for the patient is to be able to flex the knee to 120° and extend to 0°. Typically only 7% of obese patients obtain this goal, and it is the range of motion for the flexion portion of the exam that is not achieved. Only 22% of obese patients are able to flex their knee past 100° at the time of discharge, making the majority of patients unable to function with their knee and experience high pain levels (Chiu 2002). Because of this, obese patients are usually in physical therapy for longer than non-obese patients. The average stay of non-obese patients is 4-6 weeks; however, for obese patients who are not able to flex their knee to 120°, they could be in physical therapy for 8-12 weeks until their can bend their knee to the desired measurement (Chiu 2002).

This higher level of pain and lower level of functionality during recovery of arthroplasty is often an indication that a revision of the prosthetic joint is needed. There are several causes of this increased pain, including infection, tibial loosening, and osteolysis (Krushell 2007). Deep infection that spreads past the osseous tissue and into the bone is the most frequent reason for revision in the United States (Kurtz 2009). In this case, the patient's prosthetic joint is removed, the joint is debrided, and an antibiotic spacer is placed in the new prosthetic joint before it is placed in the patient's knee (Kurtz 2009). Another source of pain in the joint that leads to revision is aseptic loosening. This occurs most commonly in the tibia. In the case of joint loosening, the prosthetic joint comes unbound from the tibia and the only way to repair this defect is by replacing the joint. The most common cause of revision in obese patients is



**Figure 5. Osteolysis in the tibiofemoral joint caused by increased mechanical load and hydrostatic pressure (Gallo 2013)**

osteolysis, or the degradation of surrounding bone tissue at the joint. Due to the increased mechanical load on the tibiofemoral joint, osteolysis occurs at greater rates than in patients who are non-obese (Gallo 2013). **Figure 5** shows the effects of an increased mechanical load and hydrostatic pressure on the tibiofemoral joint following arthroplasty (Gallo 2013). As the

load and pressure increase, bone resorption also increases, causing osteolysis. This will require that the degraded bone tissue be removed and replaced with a bone graft, followed by replacement of the prosthetic joint.

**Table 4** shows revision rates according to BMI in patients who underwent arthroplasty (Kerkhoffs 2012). Out of 970 obese patients, 50 required a revision, compared to revisions in 35 out of 1314 non-obese patients. This translates to a 5.15% and 2.66% rate of revision in obese patients compared to non-obese patients and indicates obese patients are twice as likely to need a revision than their non-obese counterparts (Kerkhoffs 2012). Following revision, however, both non-obese and obese patients have successful outcomes (Kerkhoffs 2012). Roughly 20.1% of non-obese patients had moderate to severe knee pain two-years after revision of arthroplasty, whereas 23.6% of obese patients experienced the same moderate to severe knee pain two-years post-arthroplasty (Singh 2011). These findings indicate that while obese patients are at a higher risk of revision than non-obese patients, they experience similar outcomes following a revision.

**Table 4. Revision rates based on BMI in patients following total knee replacement surgery (Kerkhoffs 2012)**

Study	BMI >30 kg/m <sup>2</sup>			BMI <30 kg/m <sup>2</sup>		
	Revision Completed	Total Subjects	Revision Rates (%)	Revision Completed	Total Subjects	Revision Rates (%)
(Amin 2006)	4	147	2.72%	3	181	1.66%
(Dewan 2009)	9	135	6.67%	4	85	4.71%
(Foran 2004)	9	30	30%	3	30	10%
(Griffin 2005)	0	32	0%	3	41	7.32%
(Hamoui 2006)	0	30	0%	2	53	3.77%
(Jackson 2009)	6	153	3.92%	7	382	1.83%
(Krushell 2007)	2	39	5.13%	0	39	0%
(Spicer 2001)	16	326	4.91%	13	425	3.06%

Return to Functionality in Obese versus Non-Obese Patients:

<b>Pain</b> <input type="radio"/> None <input type="radio"/> Mild / Occasional <input type="radio"/> Mild (Stairs only) <input type="radio"/> Mild (Walking and Stairs) <input type="radio"/> Moderate - Occasional <input type="radio"/> Moderate - Continual <input type="radio"/> Severe	<b>Flexion Contracture (if present)</b> <input type="radio"/> 0°-10° <input type="radio"/> 10°-15° <input type="radio"/> 16°-20° <input type="radio"/> >20° <b>Extension lag</b> <input type="radio"/> <10° <input type="radio"/> 10-20° <input type="radio"/> >20°
<b>Total Range of Flexion</b> <input type="radio"/> 0-5 <input type="radio"/> 6-10 <input type="radio"/> 11-15 <input type="radio"/> 16-20 <input type="radio"/> 21-25 <input type="radio"/> 26-30 <input type="radio"/> 31-35 <input type="radio"/> 36-40 <input type="radio"/> 41-45 <input type="radio"/> 46-50 <input type="radio"/> 51-55 <input type="radio"/> 56-60 <input type="radio"/> 61-65 <input type="radio"/> 66-70 <input type="radio"/> 71-75 <input type="radio"/> 76-80 <input type="radio"/> 81-85 <input type="radio"/> 86-90 <input type="radio"/> 91-95 <input type="radio"/> 96-100 <input type="radio"/> 101-105 <input type="radio"/> 106-110 <input type="radio"/> 111-115 <input type="radio"/> 116-120 <input type="radio"/> 121-125	<b>Alignment (Varus &amp; Valgus)</b> <input type="radio"/> 0 <input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 - 10 <input type="radio"/> 11 <input type="radio"/> 12 <input type="radio"/> 13 <input type="radio"/> 14 <input type="radio"/> 15 <input type="radio"/> Over 15°
<b>Stability (Maximum movement in any position)</b> <b>Antero-posterior</b> <input type="radio"/> <5mm <input type="radio"/> 5-10mm <input type="radio"/> 10+mm	
<b>Mediolateral</b> <input type="radio"/> <5° <input type="radio"/> 6-9° <input type="radio"/> 10-14° <input type="radio"/> 15°	

**Figure 6. Joint score section of Knee Society Score questionnaire (Insall 1989)**

<b>Walking</b> <input type="radio"/> Unlimited <input type="radio"/> >10 blocks <input type="radio"/> 5-10 blocks <input type="radio"/> <5 blocks <input type="radio"/> Housebound <input type="radio"/> Unable
<b>Stairs</b> <input type="radio"/> Normal Up and down <input type="radio"/> Normal Up down with rail <input type="radio"/> Up and down with rail <input type="radio"/> Up with rail, down unable <input type="radio"/> Unable
<b>Walking aids used</b> <input type="radio"/> None used <input type="radio"/> Use of Cane/Walking stick deduct <input type="radio"/> Two Canes/sticks <input type="radio"/> Crutches or frame

**Figure 7. Function score section of Knee Society Score questionnaire (Insall 1989)**

Success rates in patients following total knee replacement surgery are assessed using the Knee Society Score (KSS). The KSS is split into two parts: first, the joint score, which is based on pain level, range of flexion, extension lag, alignment, and stability, (Figure 6); and second, the function score, which is based off of the ability to walk, use stairs, and the use of walking aids, (Figure 7) (Insall 1989). The score is based on 100 possible

points for each part, and the KSS is an average from the joint score and the function score. A KSS score of 80 to 100 is considered excellent success, 70-79 is good success, 60-69 is fair success, and under 60 is poor success (Insall 1989).

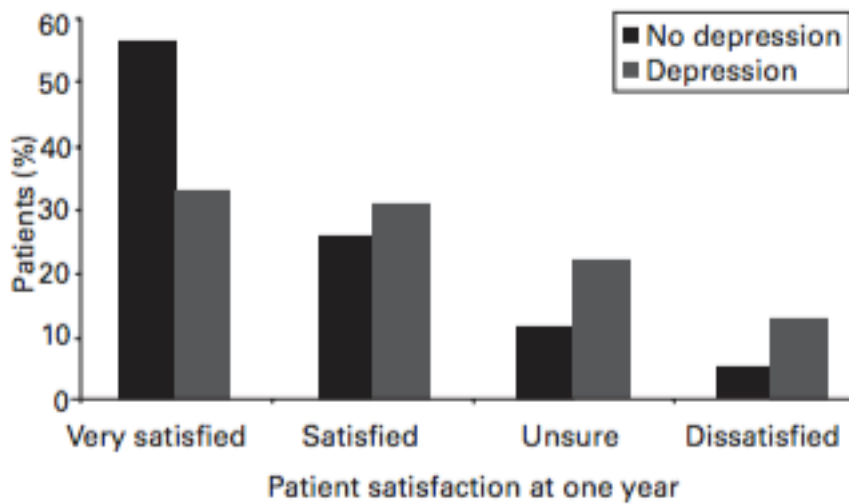
Following arthroplasty, non-obese patients average a KSS of 97 (Hamoui 2006).

Obese patients tend to have lower numerical KSS scores than their non-obese

**Table 5. Affect of obesity on total knee replacement Knee Society Score (Spicer 2001)**

<b>Body Mass Index (kg/m<sup>2</sup>)</b>	<b>Joint Score</b>	<b>Function Score</b>	<b>Overall KSS Score</b>
<b>Obese</b>			
>40	85.5	59.8	72.9
35-39.9	89.4	65.8	77.9
30-34.9	88.9	64.9	77.2
<b>Non-Obese</b>			
>30	90.5	67.9	79.5

counterparts following arthroplasty. On average, obese patients tend to score 5% less than obese patients on the KSS questionnaire (Hamoui 2006). Spicer et al. (Spicer 2001) studied the affect of obesity on total knee replacements. The success rates were recorded using the KSS, and the results are shown in **Table 5** (Spicer 2001).



**Figure 8. Dissatisfaction of knee joint following arthroplasty correlated with depression (Scott 2010)**

Low KSS scores are associated with patient dissatisfaction following total knee replacement surgery. On average, 20% of patients are dissatisfied with their outcome and recovery success rates,

which is correlated with pain in joint, decreased regular activity, unmet expectations, and the need for a revision (Scott 2010). Furthermore, dissatisfaction is related to increased depression rates, as seen in **Figure 8** (Scott 2010). Because patients with low KSS scores tend to have lower function and higher pain, they are unable to be physically active or complete activities that they were able to do prior to onset of joint pain and osteoarthritis (Scott 2010). Additionally, because of their depressed state and lack of ability to be active, obese patients tend to gain weight, further enhancing their depression and limited functionality in the joint (Scott 2010).

### Summary and Implications for Physical Therapist:

Osteoarthritis begins developing in the joint upon articular cartilage degradation, and it is well established that obese patients are at an increased risk for osteoarthritis. The increased risk of osteoarthritis is due to the altered bone structure and joint integrity, as well as the increased mechanical loading due to increased weight. Additionally, the increased secretion of pro-

inflammatory cytokines from pathologic adipose tissue in obese patients increases inflammation systemically, including within the joint, leading to further degradation. There are several treatment options for osteoarthritis; however, arthroplastic surgery is the most common for obese patients. Following arthroplasty, obese patients are at an increased risk of short- and long-term complications. Short-term complications include intra-operative complications, such as increased risk for mortality and longer operative times, and post-operative complications, such as increased drainage and longer length of stay in the hospital. Moreover, obese patients are more than twice as likely to develop an incisional infection (Yuan 2013). These complications can affect the patient's rehabilitation, both inpatient and outpatient. Prior to discharge from the hospital, obese patients score lower on the functional independence measure (FIM) test than their non-obese counterparts. After obese patients have transitioned into outpatient physical therapy and are discharged from their therapist, only 7% are able to flex their knee to the goal range of 120° (Chiu 2002). Obese patients experience increased pain and stiffness, as well as decreased functionality of the joint. Furthermore, the increased mechanical loading on the prosthetic joint and inflammation increases bone resorption and osteolysis. Because of this, obese patients are at a high risk for revision surgery. This translates to an average of more than 5% of obese patients need an arthroplastic revision compared to less than 3% in non-obese patients (Kerkhoffs 2012). Following revision, obese patients tend to have a lower knee society score (KSS), which tests joint functionality. Additionally, 20% of obese patients are dissatisfied with their surgical outcomes and recovery rates (Scott 2010). Dissatisfaction is correlated with joint pain and stiffness, which increases their risk of depression and weight gain, furthering their joint complications.

The physical therapist plays several roles throughout the process of developing osteoarthritis to undergoing arthroplastic revision. When an obese patient undergoes preoperative physical therapy, the therapist's goal is to manage the symptoms of osteoarthritis. By developing programs to strengthen the muscles surrounding the knee joint, degradation rates slow and the joint is better supported (Rodgers 1998). Furthermore, pre-operative physical therapy may decrease hospital stay length, as well as postoperative function rates, such as flexion and extension range of motion (Rodgers 1998). However, the physical therapist's main role follows arthroplasty, where the therapist assists the patient in recovery in either an inpatient or an outpatient setting. The goal of inpatient rehabilitation is to send the patient home safely, while also working on joint range of motion to avoid stiffness and scar tissue buildup (Jones 2003). The goal of outpatient rehabilitation is to achieve the functionality present prior to onset of osteoarthritis. Outpatient rehabilitation occurs in a variety of settings, including an outpatient clinic, home health, and a skilled nursing facility. Ideally, the patient will have standard range of motion, meaning 120° flexion and 0° extension, prior to discharge from the therapist (Chiu 2002).

The physical therapist may also play a similar role following revision. After a patient has undergone revision surgery, it is the goal of the therapist to achieve standard range of motion quickly, while strengthening the surrounding muscles (Jones 2003). Following revision, the patient will see the physical therapist three to five times per week, in comparison to two to three visits per week following primary arthroplasty (Denis 2006). The average obese patient stays in outpatient therapy approximately two times longer than non-obese patients (Chiu 2002). The physical therapist may face challenges when treating obese patients. For example, their reduced ability to walk long distances hinders the therapist's ability to improve their cardiovascular



endurance, as well as their muscular strength. Additionally, the weight of their limbs presents the therapist with a challenge in mobilizing the joint due to the therapist's inability to freely lift the leg. There also may be excess subcutaneous fat around an obese patient's limbs, making it difficult for the therapist to feel and treat the joint due to the thicker skin layer.

There is still a great deal to be learned about how to help obese patients maximize recovery from tibiofemoral arthroplasty. There is potential for weight loss to be beneficial in obese patients pre- and post-operative (Dowsey 2010). It is not anticipated that weight loss would prevent surgery after osteoarthritis has developed; however, it is possible that weight loss could produce better recovery rates, such as lower pain levels and better KSS scores (Dowsey 2010). Post-operative weight loss may improve recovery rates, as well as decrease the risk for a revision (Lachiewicz 2008). It is not yet known if weight loss increases the longevity of the artificial joint. In addition to the potential to integrate weight loss, there are few studies comparing the success rate of outpatient rehabilitation locations. It is unknown whether an outpatient clinic, home health, or skilled nursing facility produces better results in obese patients following arthroplasty. It is important for more studies to be completed in this area to better treat obese patients undergoing joint replacement surgery.

Based on this review of the existing literature, our hypothesis was confirmed that obese patients face a greater incidence of short- and long-term complications after undergoing total knee arthroplasty and present unique challenges to physical therapists during rehabilitation of the joint. It is possible that tibiofemoral joint replacement surgery can be improved for obese patients through pre- or post-operative weight loss; however, studies are needed to determine if weight loss is realistic and whether the weight loss has positive outcomes. The physical therapist plays a crucial role in recovery following arthroplastic surgery due to their ability to work with

patients to increase their range of motion to the joint and decrease symptomatic pain and stiffness. While obese patients are at a disadvantage compared to non-obese patients pre- and post-operative, the physical therapists have the capability to help combat these disadvantages by restoring functionality to the joint.

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