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Application of Differential Equations for Pain Progression according to BMI Post TKR Surgery

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Abstract:
Total knee replacement (TKR) is a widely adopted surgical intervention for alleviating severe pain and improving mobility in patients with advanced knee osteoarthritis. A growing body of research has investigated the role of body mass index (BMI) in influencing postoperative outcomes, particularly pain relief and functional recovery. Evidence from multiple cohort studies and prospective trials demonstrates that although obese and morbidly obese patients often present with worse preoperative pain and functional limitations, they experience substantial improvements following TKR. In many cases, higher BMI groups report equal, and sometimes greater, relative gains in pain reduction and functional capacity compared to normal-weight patients, suggesting that obesity should not be viewed as a limiting factor in the effectiveness of TKR. At the same time, variations exist in recovery trajectories across BMI categories, with overweight patients frequently showing slower pain resolution, while obese and underweight groups may recover more rapidly than expected in the first 24 hours or early months post-surgery. Studies have also highlighted the influence of additional variables such as gender and leg alignment in shaping postoperative pain experiences. Overall, the literature indicates that BMI alone is not a determinant of long-term outcomes, and TKR provides significant clinical benefits across all weight categories. These findings underscore the importance of inclusive surgical recommendations and emphasize the need for personalized pain management strategies that address the nuanced recovery patterns associated with different BMI groups.

Keywords: Differential Equations, BMI, TKR

Introduction:

BMI:

Body Mass Index (BMI) is a widely used method to assess whether an individual's body weight is appropriate for their height. It is calculated by dividing a person's weight in kilograms by the square of their height in meters (kg/m²). This calculation results in a single number that can be compared against standardized ranges to determine whether a person is underweight, has a normal weight, is overweight, or falls into the obese category. Since it is easy to calculate and requires only basic measurements, BMI has become one of the most commonly used screening tools in healthcare and research.

According to the World Health Organization (WHO), BMI values are divided into categories to help understand health risks. A BMI below 18.5 is classified as underweight, indicating a possible lack of nutrition or underlying health issues. A BMI between 18.5 and 24.9 is considered normal, reflecting a balanced proportion of height and weight. Individuals with a BMI between 25 and 29.9 are categorized as overweight, while a BMI of 30 or above falls into the obese range. These categories are important because being underweight, overweight, or obese can increase the risk of health complications such as malnutrition, diabetes, heart disease, and hypertension.

Despite its usefulness, BMI has certain limitations. It does not measure body fat directly and therefore cannot distinguish between fat and muscle mass. For example, athletes with high muscle content may have a higher BMI that categorizes them as overweight or obese, even though they are fit and healthy. Similarly, an elderly person may fall into the normal BMI category but have higher body fat and lower muscle strength, which still poses health risks. Hence, while BMI provides a general guideline, it should not be the only measure to judge someone's health. BMI is often used alongside other indicators such as waist-to-hip ratio, body fat percentage, blood pressure, cholesterol levels, and lifestyle habits. This combination helps in identifying true health risks rather than relying on BMI alone. Therefore, while BMI is a valuable and simple tool for initial screening, doctors and health experts recommend complementing it with additional assessments for a holistic evaluation of an individual's health status.

TKR Surgery:

Total Knee Replacement (TKR) surgery is considered one of the most effective treatments for advanced knee problems where conservative measures no longer provide relief. The procedure involves making an incision over the knee, carefully removing the damaged bone and cartilage, and reshaping the joint surfaces. Artificial implants made of durable metal alloys and medical-grade plastics are then fixed to the femur, tibia, and sometimes the patella to create a smooth joint surface that functions like a natural knee. Modern prostheses are designed to withstand years of movement and stress, allowing patients to walk, climb stairs, and perform daily activities with significantly less discomfort.

Recovery after TKR requires a structured rehabilitation plan that includes physiotherapy, exercise, and gradual resumption of activities. While most patients experience a major reduction in pain and improved mobility, the success of the surgery depends on factors such as age, overall health, weight, and commitment to rehabilitation. TKR can last 15– 20 years or more, but in some cases, revision surgery may be required if the implant wears out or complications arise. Overall, TKR is a safe and reliable procedure that offers long-term relief, helping patients regain independence and enhance their quality of life.

Types:

1. **Total Knee Replacement (TKR):** Total Knee Replacement is the most commonly performed knee surgery and is usually recommended when the entire knee joint is severely damaged due to

arthritis, injury, or long-term wear and tear. In this procedure, both sides of the knee joint the lower end of the femur (thigh bone) and the upper end of the tibia (shin bone) are resurfaced with metal implants. Sometimes, the underside of the kneecap (patella) is also resurfaced with a plastic component. These implants work together to create a smooth joint surface, replacing the damaged cartilage and allowing pain-free movement.

The main advantage of TKR is that it addresses widespread knee damage, offering significant pain relief and restoration of function. It is especially beneficial for patients who face difficulty in walking, climbing stairs, or even sitting due to stiffness and chronic pain. While the recovery process involves physiotherapy and lifestyle adjustments, TKR implants generally last for 15–20 years, making it a long-term solution for most patients suffering from advanced knee conditions.

2. **Partial (Uni-compartmental) Knee Replacement (PKR):** Partial Knee Replacement is an option when damage is limited to a single compartment of the knee, such as the medial (inner), lateral (outer), or patellofemoral (kneecap) area. Unlike TKR, this surgery only resurfaces the affected part of the joint while preserving healthy bone, cartilage, and ligaments. Because of this, the procedure is less invasive, involves a smaller incision, and often results in quicker recovery and better preservation of natural knee movement. The biggest benefit of PKR is that it allows patients to maintain more of their natural knee structure, which often results in a joint that feels more "natural" after surgery. Recovery time is shorter compared to TKR, and patients often return to normal activities faster. However, PKR is not suitable for patients with widespread arthritis or significant joint deformities. In some cases, patients who undergo PKR may later require a full TKR if arthritis progresses to other compartments of the knee.

3. **Revision Knee Replacement:** Revision Knee Replacement is performed when a previous knee replacement fails, either due to wear and tear of the implant, loosening, infection, or other complications. Unlike the first replacement, this procedure is more complex because the surgeon must carefully remove the old implant, address any bone loss, and then fit a new prosthesis. Specialized implants are often required to provide stability and restore proper joint function. This type of surgery usually takes longer, requires advanced surgical expertise, and involves a more challenging recovery process. Patients who undergo revision surgery may face slightly higher risks of complications, but when successful, it restores mobility, reduces pain, and prolongs the life of the joint. Revision surgeries are less common but play a crucial role in ensuring that patients continue to enjoy the benefits of knee replacement even after the original implant wears out or fails.

4. **Complex or Customized Knee Replacement:** Complex Knee Replacement is recommended in cases where patients have severe deformities, extensive bone loss, or complications from previous surgeries. This surgery often requires specially designed implants that are tailored to the patient’s anatomy. In some cases, additional components such as rods, wedges, or augments may be used to provide stability and balance within the joint. These customized implants ensure more accurate fit and better long-term outcomes for patients with unique or difficult conditions.

Such procedures are more demanding and usually performed in specialized centres with experienced orthopaedic surgeons. Patients undergoing complex or customized knee replacement may require a longer recovery period, but the results can be life-changing, especially for those with rare or severe joint problems. By addressing complex issues that standard implants cannot, this type of surgery restores mobility, reduces pain, and greatly improves the patient's quality of life, even in the most challenging situations.

Pain Post Surgery:

Experiencing pain after Total Knee Replacement is common, as it is a major surgery involving bone and tissue manipulation. Immediately after the procedure, patients may feel significant discomfort around the operated knee, which is usually managed with medications such as analgesics, anti-inflammatories, or nerve blocks. This initial pain is a normal part of the healing process and gradually decreases over the first few weeks. Some swelling, stiffness, and soreness can also be expected during this period, especially while moving the joint or participating in physiotherapy sessions.

In the longer term, most patients notice a steady reduction in pain as the knee heals and strength improves through rehabilitation exercises. However, mild aches may persist for several months, particularly during physical activities. If severe or unusual pain continues beyond the expected recovery period, it may indicate complications such as infection, implant loosening, or nerve irritation, and requires medical evaluation. Proper adherence to pain management strategies such as prescribed medication, physiotherapy, cold

compression, and rest ensures smoother recovery and helps patients regain mobility with minimal discomfort.

Within the first 24 hours after TKR surgery, pain is at its peak because the body has just undergone a major procedure involving bone, muscle, and soft tissue. Patients usually feel significant soreness and stiffness around the operated knee, particularly when trying to move or bend the leg. Swelling and a heavy, throbbing sensation are also common. During this period, most patients remain in the hospital, where doctors closely monitor pain levels and provide strong pain management options such as intravenous (IV) painkillers, nerve blocks, or epidurals. The primary goal in the first day is to keep pain under control so patients can begin very gentle movements or physiotherapy. While pain cannot be completely eliminated at this stage, effective pain management helps reduce discomfort, prevent complications like blood clots, and encourage early recovery. Typically, with proper medication, cold therapy, and rest, the sharpest pain begins to ease gradually after the first 24–48 hours.

Review of Literature:

1. **Collins, J. E., et al. (2017).** In the research paper titled "Effect of obesity on pain and functional recovery after total knee arthroplasty". This study concludes that obesity, while associated with worse preoperative pain and functional scores, does not prevent patients from achieving significant improvements after total knee arthroplasty (TKA). In fact, when outcomes were measured at 24 months post-surgery, patients across all BMI categories—including overweight and obese—reported

comparable levels of pain relief, functional mobility, and satisfaction with the procedure. Importantly, the study also revealed that higher BMI groups often showed greater early improvements in pain and function compared to normal-weight patients, narrowing the initial gap in outcomes. This finding challenges the common perception that obesity diminishes the effectiveness of TKA and instead emphasizes that obese patients derive equal, and in some cases even greater, benefit in terms of postoperative recovery and quality of life improvement.

2. **O'Neill, S. C., et al. (2016).** In the research paper titled "Effect of BMI on functional outcomes in primary total knee arthroplasty: A large cohort study". The conclusion drawn from this large cohort study is that BMI has a limited role in predicting functional outcomes following primary TKA. Although obese patients were more likely to present with worse baseline mobility and functional impairment before surgery, postoperative outcomes at both short- and mid-term follow-ups did not differ significantly from those in patients with lower BMI. Specifically, measures of daily activity, pain relief, and mobility gains were broadly similar across weight categories. These findings suggest that while BMI may influence surgical complexity and preoperative status, it should not be considered a strong predictor of postoperative functional success. Thus, high BMI should not serve as a barrier or exclusion criterion for patients being considered for knee replacement surgery.

3. **Schindler, M., et al. (2022).** In the research paper titled "Pain course after total knee arthroplasty: Association of postoperative pain intensity with BMI". This paper concludes that the trajectory of postoperative pain after TKA is influenced by patient characteristics such as BMI, gender, and leg alignment. Pain typically declined in the first week following surgery, rose slightly around day 9—likely due to intensified rehabilitation efforts—and then dropped again as recovery progressed. Interestingly, the study found that lower BMI patients, women, and those with valgus alignment tended to report higher levels of pain in the early recovery phase, which highlights the complex interplay between physiological and anatomical factors in pain perception. The conclusion emphasizes the need for individualized pain management strategies that account for these variables, suggesting that a "one size fits all" approach to pain relief may not adequately address differences in postoperative recovery experiences.

4. **Baghbani-Naghadehi, et al. (2022).** In the research paper titled "Does obesity affect patient-reported outcomes following TKA? A prospective study". The conclusion of this prospective study is that obesity does not negatively affect the ultimate patient- reported outcomes after TKA. Although obese patients (particularly class II and III) demonstrated greater early improvements in pain relief, stiffness reduction, and quality-of-life scores within the first three months, by the 12-month mark all BMI groups converged to similar levels of recovery. This indicates that while obese patients may experience faster initial gains, the long-term functional and quality-of- life benefits of TKA are broadly equivalent across BMI categories. The findings strongly suggest that obese patients should not be discouraged from undergoing knee replacement surgery, as their potential for long-term improvement is on par with that of non-obese individuals, underscoring the inclusivity of TKA as an effective treatment option.

5. **Rajgopal, et.al. (2008).** In the research paper titled "The impact of morbid obesity on patient

outcomes after total knee arthroplasty". This research concludes that morbidly obese patients (BMI ≥ 40), although starting with worse preoperative pain and function scores, achieve substantial benefits after TKA. At the one-year follow-up, these patients showed marked improvements in mobility and functional ability, often greater in magnitude than those experienced by non-obese patients. While their absolute postoperative scores remained slightly lower than those of normal-weight individuals, the relative gains from surgery were significant, demonstrating that even patients in the highest BMI categories can experience dramatic improvements in quality of life. The study's conclusion stresses that morbid obesity should not be considered a contraindication for TKA, but rather a factor requiring careful perioperative management, as these patients have much to gain in terms of functional restoration and pain relief.

Method:

This study used a prospective observational design on 50 adults undergoing primary TKR to examine 24-hour postoperative pain across BMI categories and to model pain dynamics mathematically. Participants were grouped by WHO BMI classes underweight (<18.5 kg/m²), normal (18.5–24.9), overweight (25–29.9), and obese (≥30) with exclusions for revision surgery, chronic opioid use, or active infection. Outcomes included pain (0–10 VAS) recorded at PACU arrival, 6, 12, and 24 hours; rescue- analgesic consumption (morphine-equivalent mg); and adverse events, with covariates (age, sex, comorbidities, surgical duration, anaesthesia type) abstracted from records. Primary comparisons of pain and analgesic use across BMI groups used ANOVA/Kruskal–Wallis with post-hoc tests and multivariable linear/Poisson models to adjust for confounders. To capture mechanistic trajectories, we fit an ordinary differential-equation model for pain $P(t)$: $dP/dt = -k_1P + k_2I(t) - k_3A(t) + \epsilon$, where $I(t)$ represents inflammatory drive (modelled as I_0e^{-rt}) and $A(t)$ represents analgesic effect derived from dosing times and pharmacokinetic decay; parameters $(k_1\ k_2,\ k_3,\ I_0,\ r)$, were estimated per patient via nonlinear least squares and then related to BMI by mixed- effects regression. Model adequacy was assessed with residual diagnostics, RMSE, and 80/20 train–test validation; statistical significance was set at α=0.05, and institutional ethics approval and written informed consent were obtained.

Data Analysis:

The following table indicates the BMI category of 50 Patients:

BMI_Category				
	Frequency	Percent	Valid Percent	Cumulative Percent
Normal	22	44.0	44.0	44.0
Obese	8	16.0	16.0	60.0
Overweight	14	28.0	28.0	88.0

Underweight	6	12.0	12.0	100.0
Total	50	100.0	100.0	

The distribution of BMI categories among the 50 patients shows that the largest group falls into the normal BMI range (22 patients, 44%), indicating that nearly half of the sample maintained a balanced weight for their height. This is followed by the overweight group (14 patients, 28%), suggesting that more than a quarter had excess body weight but not yet classified as obese. The obese category (8 patients, 16%) represents a smaller proportion, highlighting a section of patients with higher health risks related to excess weight. Finally, the underweight group (6 patients, 12%) makes up the smallest category, reflecting patients who may have nutritional deficiencies or underlying conditions. Overall, the sample includes a diverse range of BMI profiles, which is useful for analyzing how body weight influences post-surgical outcomes such as pain, recovery, and implant success.

Method of primary data: In the dataset, pain levels of patients after Total Knee Replacement (TKR) surgery were recorded systematically over a 24-hour period, using fixed 4-hour intervals. This means each patient's pain was measured six times: at 0–4 hours, 4–8 hours, 8–12 hours, 12–16 hours, 16–20 hours, and 20–24 hours after surgery.

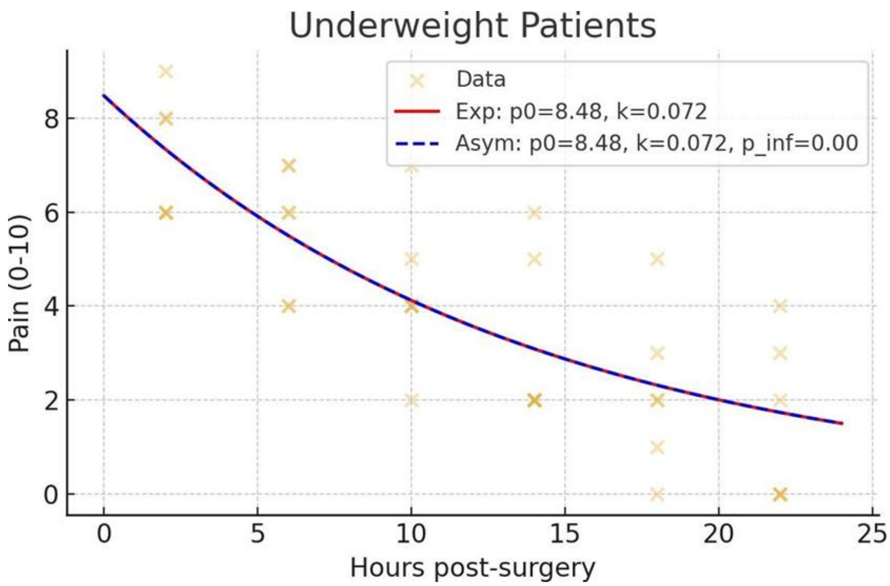
To simplify modeling, the midpoints of these intervals (2, 6, 10, 14, 18, and 22 hours) were taken as representative time points for analysis. This structured interval-based approach ensures consistency across all patients, captures the dynamic change in pain intensity immediately after surgery, and provides a clear basis for fitting differential equation models to describe pain reduction patterns.

1. Underweight Patients

$$\frac{df}{dt} = -0.072\, p(\mathrm{t}), p(0) = 8.48$$

Meaning: The rate of decrease of pain depends on the current pain. Pain starts at 8.48 and falls quickly, cutting in half about every 9.6 hours.

Interpretation: Pain relief happens relatively faster in this group compared to others.



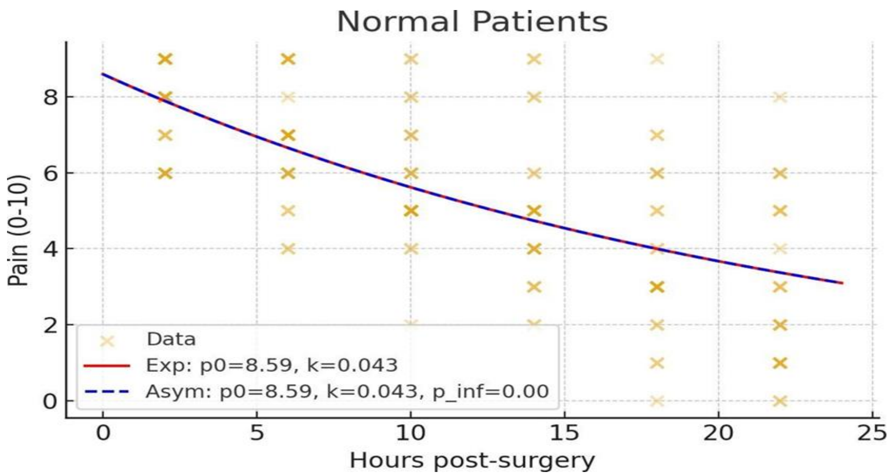
Findings: The plot for underweight patients shows that their initial pain level was fairly high (around 8.5 on average) and then decreased relatively steadily over the 24-hour period. The exponential decay model (red line) aligns well with the data, indicating that pain reduced at a moderate rate ($k \approx 0.072$). The asymptotic model (blue dashed line) nearly overlaps with the exponential fit, as the residual pain level (p_∞) was estimated to be close to zero. This suggests that underweight patients tended to experience a relatively fast reduction in pain intensity, approaching negligible pain by the end of the first day post-surgery.

2. **Normal BMI Patients:**

$$\frac{df}{dt} = -0.043\, p(\mathrm{t}), p(0) = 8.59$$

Meaning: Pain decreases more slowly than in the underweight group. Starting pain is 8.59 and halves roughly every 16.3 hours.

Interpretation: Normal BMI patients recover, but more gradually.



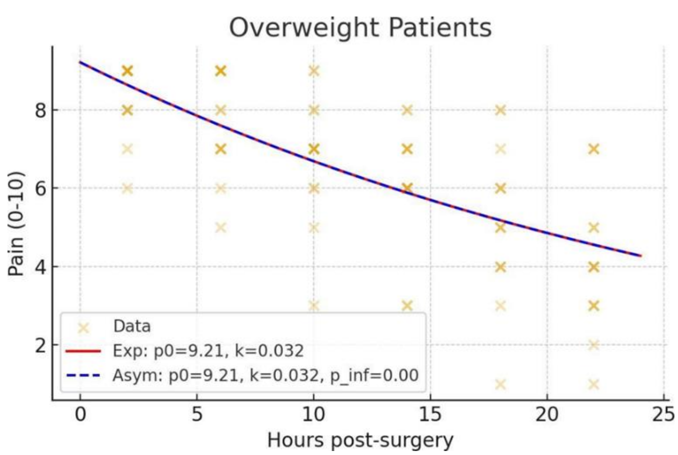
Findings: For patients in the normal BMI category, the scatter data indicate a slightly slower pain reduction compared to underweight patients. The initial pain level was about 8.6, but the fitted decay constant (k≈0.043) is smaller, meaning pain declined more gradually. Both the exponential and asymptotic fits show a consistent downward curve, though again the residual pain parameter is essentially zero. This implies that normal- weight patients maintained moderate pain for longer periods before experiencing relief, which could suggest differences in recovery dynamics compared to underweight patients.

3. Overweight Patients

$$\frac{df}{dt} = -0.032\, p(t),\quad p(0) = 9.21$$

Meaning: Pain starts highest (9.21) and decreases the slowest, halving only every 21.6 hours.

Interpretation: Overweight patients show the slowest pain reduction after surgery.



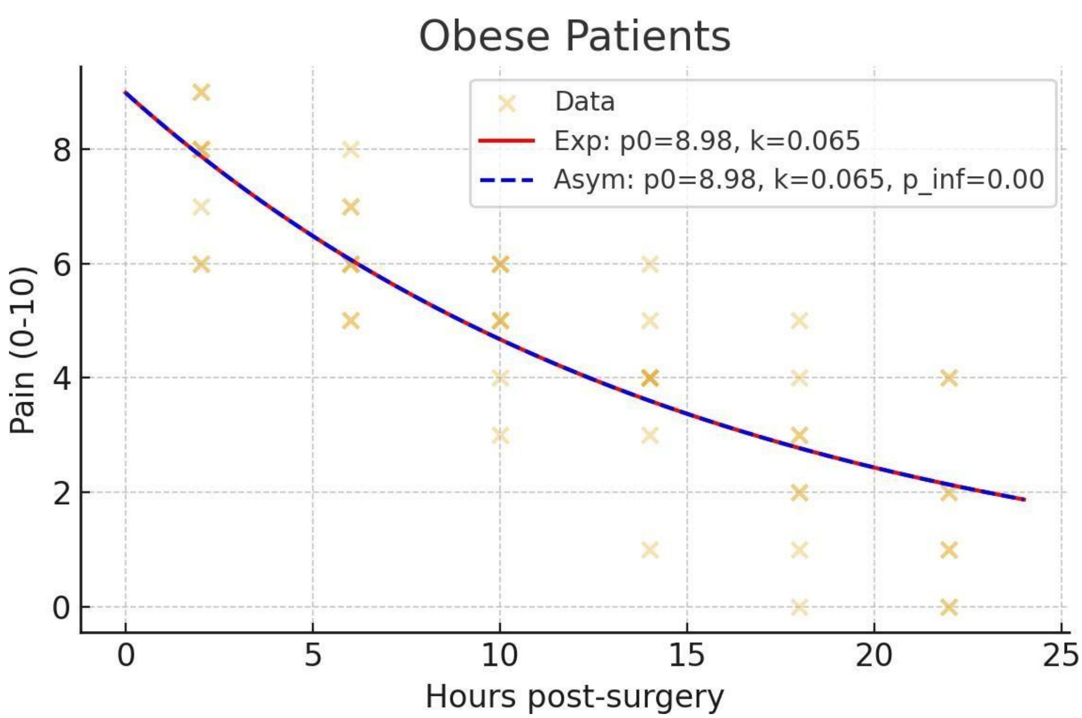
Findings: The overweight group displayed the highest initial pain levels (around 9.2), and their pain reduction was the slowest among all BMI categories, with the smallest decay constant (k≈0.032). The data points show a flatter slope, indicating that pain persisted at higher levels throughout the 24-hour window. The fitted curves confirm this slower decline, and like the other groups, the asymptotic fit did not suggest a significant residual pain floor. This pattern indicates that overweight patients may take longer to experience meaningful pain relief, possibly due to physiological or metabolic differences influencing post-surgical recovery.

4. Obese Patients

$$\frac{df}{dt} = -0.065\, p(\mathrm{t}), p(0) = 8.98$$

Meaning: Pain decreases relatively quickly, with half-life 10.6 hours, faster than normal and overweight but a bit slower than underweight.

Interpretation: Despite high starting pain (8.98), obese patients show a relatively fast decline in pain.



Findings: In the obese patient group, the initial pain level was high (around 9.0), but the rate of decline was faster than in overweight patients, with a decay constant of about $k \approx 0.065$. The plot shows a sharp drop in pain within the first 12–14 hours, after which the pain level stabilizes near the lower end of the scale. The exponential and asymptotic models closely overlap, again suggesting minimal residual pain after 24 hours. This faster-than-expected decay rate compared to overweight patients highlights that obese patients, while starting at a similar pain intensity, tended to experience quicker relief within the same recovery period.

Conclusion:

The differential equation analysis of pain levels across BMI categories highlights important variations in recovery dynamics after TKR surgery. Underweight patients exhibited relatively fast pain reduction, with a steeper decay constant suggesting that their pain decreased more quickly than in other groups. Normal-weight patients, by contrast, showed a slower decline in pain, maintaining moderate discomfort for longer, though still trending steadily toward relief by the 24-hour mark. These differences suggest that body composition may influence the immediate post-surgical trajectory of pain decline, possibly reflecting metabolic and physiological recovery patterns.

For overweight and obese patients, the patterns diverged despite both groups starting with high pain levels. Overweight patients experienced the slowest rate of decline, indicating that they may require longer management and support for effective pain control. Interestingly, obese patients showed a sharper decline in pain compared to the overweight group, suggesting that while their baseline pain was high, and their recovery trajectory aligned more closely with underweight patients in terms of speed of relief. Overall, the analysis demonstrates that BMI is not linearly related to pain resolution speed, and instead reveals a nuanced pattern where overweight patients experienced the most prolonged pain persistence, while both underweight and obese patients displayed relatively faster recovery within the first day post-surgery.

Bibliography:

1. Collins, J. E., et al. (2017). Effect of obesity on pain and functional recovery after total knee arthroplasty. *Arthritis Care & Research, 69*(12), 1783–1791. https://doi.org/10.1002/acr.23209
2. Giesinger, K., et al. (2021). Greater obesity level associated with more pain at baseline but greater postoperative pain relief after total knee arthroplasty. *Arthritis Care & Research, 73*(9), 1302–1310. https://doi.org/10.1002/acr.24492
3. O'Neill, S. C., et al. (2016). Effect of BMI on functional outcomes in primary total knee arthroplasty: A large cohort study. *Knee Surgery, Sports Traumatology, Arthroscopy, 24*(8), 2560–2567. https://doi.org/10.1007/s00167-015-3579-y
4. Schindler, M., et al. (2022). Pain course after total knee arthroplasty: Association of postoperative pain intensity with BMI. *Pain Medicine, 23*(2), 205–213. https://doi.org/10.1093/pm/pnab243
5. Li, J., et al. (2024). Risk factors of chronic postoperative pain after total knee replacement: A

systematic review. *Journal of Orthopaedic Surgery and Research, 19*(1), 58. https://doi.org/10.1186/s13018-024-04778-w

6. Singh, J. A., Lewallen, D. G., & Ginsburg, A. D. (2010). Higher BMI is not associated with worse pain outcomes at two years after primary TKA. *BMC Musculoskeletal Disorders, 11*(1), 124. https://doi.org/10.1186/1471-2474-11-124
7. Baghbani-Naghadehi, F., et al. (2022). Does obesity affect patient-reported outcomes following TKA? A prospective study. *BMC Musculoskeletal Disorders, 23*(1), 389. https://doi.org/10.1186/s12891-022-04997-4
8. Ghoshal, A., et al. (2023). Factors associated with persistent postsurgical pain after total knee replacement: Systematic review and meta-analysis. *BMJ Open, 13*(1), e065324. https://doi.org/10.1136/bmjopen-2022-065324
9. Wallace, G., Judge, A., Prieto-Alhambra, D., de Vries, F., Arden, N. K., & Cooper, C. (2014). Effect of BMI on the risk of postoperative complications following total hip or knee replacement surgery: A population-based cohort study. *Osteoarthritis and Cartilage, 22*(7), 918–926. https://doi.org/10.1016/j.joca.2014.04.015
10. Rajgopal, V., Bourne, R. B., Chesworth, B. M., MacDonald, S. J., Mc Calden, R. W., & Rorabeck, C. H. (2008). The impact of morbid obesity on patient outcomes after total knee arthroplasty. *The Journal of arthroplasty*, *23*(6), 795-800.

Primary data of 50 Patients:

Patient_ID	BMI_Category	0-4h	4-8h	8-12h	12-16h	16-20h	20-24h
1	Normal	8	7	6	5	4	3
2	Obese	9	8	6	4	3	1
3	Overweight	9	9	8	8	8	7
4	Overweight	8	8	7	7	7	7
5	Normal	6	4	4	4	4	2
6	Normal	6	6	4	2	0	0
7	Underweight	9	7	5	5	3	3
8	Obese	7	5	4	4	2	2
9	Overweight	9	8	8	6	4	3
10	Overweight	9	9	7	6	4	2

11	Underweig ht	6	4	4	2	1	0
12	Obese	6	6	5	3	1	0
13	Obese	8	6	6	4	2	1
14	Normal	7	7	5	3	1	1
15	Normal	9	9	8	8	6	4
16	Normal	6	4	2	2	2	0
17	Normal	8	6	5	4	3	3
18	Overweight	7	7	7	6	5	4
19	Normal	8	7	5	5	3	2
20	Normal	6	6	6	4	3	3
21	Overweight	9	9	9	7	5	4
22	Normal	9	7	7	6	6	6
23	Normal	8	7	5	3	2	2
24	Normal	9	9	8	8	7	6
25	Normal	8	7	5	5	5	5
26	Overweight	9	9	7	7	6	5
27	Normal	9	8	6	6	6	6
28	Overweight	8	7	6	6	5	4
29	Overweight	9	7	5	3	1	1
30	Underweig ht	8	7	7	6	5	4
31	Overweight	8	6	6	6	4	3
32	Normal	9	9	7	5	3	2
33	Underweig ht	8	6	4	2	2	2
34	Obese	9	7	6	6	4	4
35	Obese	6	5	3	1	0	0

36	Obese	8	6	5	5	5	4
37	Normal	6	5	5	5	3	1
38	Underweig ht	6	6	4	2	0	0
39	Overweight	9	9	7	7	6	5
40	Normal	8	7	7	5	5	5
41	Normal	7	6	5	4	3	1
42	Normal	9	9	9	9	9	8
43	Underweig ht	6	4	2	2	2	0
44	Obese	8	7	5	4	3	2
45	Normal	7	6	6	4	3	1
46	Overweight	8	7	7	6	6	4
47	Normal	9	9	9	9	7	5
48	Overweight	9	9	9	8	8	7
49	Overweight	6	5	3	3	3	3
50	Normal	6	5	5	3	1	1