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The Decision Process Model of Exercise of Physical Therapy-Literature Empirical Study and Take TKR Patients as Example

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ABSTRACT
The exercise of physical therapy (PT) is not only for a simple form of rehabilitation. It's a complete retraining process, involving muscles, lower limb nerves, and the endocrine system. For athletes recovering from injury or surgery, it's not just about reducing pain and replacing knee implants; more importantly, it's about restoring athletic ability, strength, and even confidence and courage. The total knee replacement patients are a good model for observing exercise due to postoperative patients have been shown in the literature to have a great need for exercise of PT to improve their ability to move healthily and effective. In sports, these muscle abilities relative to whether an athlete wins a championship. Previous researches did not find any decision process model of EPT. This research proposed decision process model of exercise of PT and pseudocode of evaluation of patient inner factor. In the research results, the PT would easy know every possibility by decision tree plan, and offered a decision support. This study tries to identify all EPT independent and dependent variables. It would offer more smart decision support system in future.

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I. INTRODUCTION

The exercise of physical therapy (EPT) is not only for a simple form of rehabilitation. It's a complete retraining process, involving muscles, lower limb nerves, and the endocrine system. For athletes recovering from injury or surgery, it's not just about reducing pain and replacing knee implants; more importantly, it's about restoring athletic ability, strength, and even confidence and courage. It's not just about the ability to run, jump, squat, and walk.

The total knee replacement (TKR) patients are a good model for observing exercise due to postoperative patients have been shown in the literature to have a great need for EPT to improve their ability to walk healthily and effective. In sports, these muscle abilities are crucial to whether an athlete wins a championship.

In general, instruments in PT include electrotherapy (TENS, interferential current), thermotherapy (infrared, paraffin therapy, ultrasound), cryotherapy (ice packs), phototherapy (low-level laser), hydrotherapy (whirlpool bath), traction therapy, and shockwave therapy. They are mainly used for pain relief, promoting circulation, reducing spasms, and accelerating tissue repair. However, this study only focused on EPT. Rehabilitation exercises for knee joint patients usually focus on strengthening the lower limbs. Thus this research emphasized the EPT of the knee. By the way, the origins of rehabilitation exercises can be traced back to the aftermath of World War II, when a large number of soldiers needed rehabilitation for spinal cord injuries or disabilities. In 1944, British physician Sir Ludwig Guttmann founded a spinal cord injury center, proposing that exercise was an important means of treatment. From that time, EPT has since become an important method in rehabilitation medicine. The history of computer-aided medical decision making (CMDM) can be traced back to rule-based expert systems in the 1960s and 1970s. In original approach, statistical models was applied, then machine learning involved, and more recently, deep learning or artificial intelligence were gradually adopted. Nowsaday, medicine field only wants a clear and explicit white-box decision-making process.

II. LITERATURE REVIEW

The ankle pump exercises, quadriceps contractions, straight leg raises, knee flexion and extension, seated extensions, standing balance exercises, and walking training with a walker were common PT exercise for TKR patients. These exercises promoted blood circulation, reduced swelling, maintained joint range of motion, and strengthened lower limb muscles (Chimei. 2025). If there was no exercise applied to PT of TKR, it maybe occur joint stiffness (limited knee angle, affecting sitting and walking), muscle weakness (weakness in the lower limbs, increasing the risk of falls), blood clot formation (lack of circulatory movement may lead to deep vein thrombosis), and reduced quality of life (inability to walk independently or perform basic movements)(Li et al., 2025).

Choi (2023) included 36 patients. The half of them underwent TKR, the research found TKR group body strength, body balance, muscle power and walk ability were less than control group. It showed that TKR group should do more PT to improve the body whole function. Gür, O. and S. Başar (2023) found virtual reality (VR) exercise had a statistically significant difference in the intensity of pain at rest, at night, and during the Timed Up and Go Test (TUG), kinesiophobia, pain catastrophizing, active knee flexion, the TUG, and the stair-climb test scores. The research included 21 TKR patients in Turkey and adapted Wilcoxon and Mann-Whitney U test. The reason maybe pain, kinesiophobia, and function of VR vs. real exercise. Núñez-Cortés et al. (2024) studied resistance training of PT (RTPT) on TRK patients. They included 40 patients for their research in Spain. The RTPT used elastic resistance strengthening and performed three sessions in the hospital at 24, 48, and 72 hrs after TRK. The research found proposed method improved physical function, perceived pain, psychosocial variables, and inflammatory markers. Yokochi et al. (2024) stated self-care foam rolling (FR) exercise would reduce pain, improve knee joint range of motion (ROM) & muscle function and balance body in patients who underwent TKR in Japan. There were 15 patients in their study. The PT method were 10 meters walk, TUG, and one-leg stand for 3 weeks.

Zenooz et al. (2024) stated 31 patients who had undergone TRK were included, including 6 males and 27 females. Four standing balance tests were conducted using a balance beam of Wii device. Liu et al. (2024) telerehabilitation (TELE) in TKR has become a hot trend since 2020. They included 4402 patients from 25 RCT papers and found TELE proved more effective recovery than traditional PT rehabilitation in TKR patients. Ge et al. (2025a) adapted Open Pose software and X-ray imaging to 50 TKR patients. There was a good correlation (R^2= 0.814) rate between them. It let PT would be easy applied into monitor recovery process. Ge et al. (2025b) said that TKR surgery was an intervention, it can not replace the PT. The patients should do exercise after the surgery. Mazzei et al. (2025) found that exercise therapy would effectively cost down the medical cost, avoiding OA and Re-TKR. Leow et al. (2025) found there was no difference between 19 golfers and 144 non-golfers performance after TKR. It showed maybe golf sport would not direct related to TKR. Sever et al. (2025) found tumor in knee was very few after TKR. In the postoperative rehabilitation, we should focus on PT, not in medicine. There were 118 patients included into their study.

Ran et al. (2026) stated that the patients needed rehabilitation exercises for recovery after TKR surgery. Rehabilitation exercise prescriptions can reduce the incidence of deep vein thrombosis within TKR patients and shorten hospitalization stays. Qin et al. (2025) proposed that exercise and PT reduced pain score, range of motion and knee function compared to control. White et al. (2025) included 120 over 45 years old adults, following a unilateral TKR and seeking outpatient PT. A physical therapist-administered intervention, finding over 6 months PT after TKR, the patients would increase moderate to high intensity physical activity. Grønfeldt et al. (2025) included 445 TKR Denmark adult patients from 2023 to 2024. Upon discharge, patients were encouraged to engage in physical exercise and were randomly assigned to either an exercise group or a non-exercise group in a 1:1 ratio. The results found exercise-based rehabilitation would be possible as a method of recovery.

Ahmadi et al. (2025) proposed that home-based exercise and physical therapy exercises have no difference in rehabilitation effects in TKR patients; besides, the number of participants was 80, the duration was one month, and the statistical p-value was 0.078. Docking et al. (2024) analyzed exercise therapy for knee osteoarthritis in Australia; there were 61394 patients included into the research from database. Structured education and exercise therapy intervention provided by physiotherapists. The comparator was usual nursing care. All patients undergo TKR without accessing the program in the first year. The results showed that exercise therapy can reduce plain scores. Zinno et al. (2025) stated that THR and TKR can effectively treat osteoarthritis; however, some of patients face low quality of life, need more exercise for rehabilitation. There were 18 participants included to their research. The research results showed PT significant improvements in lower limb strength. The Timed Up and Go & 30-Second Chair Stand Test improved in both groups. No adverse events were reported. Coetzee et al. (2025) took research on end-stage osteoarthritis (ESOA) in patients with disease in South Africa. They found PT can improve gait and weight, central pain and muscle weakness and range of motion. Besides, weight management, pain management, psychological support from a rehabilitation therapist, and planned exercise were significantly effective. Henke et al. (2025) transferred tibiofemoral kinematics loads

to a six-degree-of-freedom (6-DOF) simulator. These were level walking, downhill walking, stair descent, squat, and sit-to-stand-onto a six-degree-of-freedom. This technique can assess the impact of posterior cruciate ligament removal on joint dynamics and the appropriate PT.

Kantha et al. (2025) followed TKR patients, began high-intensity exercises at the 2-month mark. Fifteen studies involving 1,160 TKR patients were included. They found sitting ability, going up and down stairs, knee flexor strength, knee extension angle were effective improved. The study showed EPT was necessary for TKR patients recovery. Schulle et al. (2025) found different physical therapy rehabilitation exercises resulted in significantly different knee joint loads after three weeks. Chen et al. (2025) included 151 patients and studied impact of a cloud-based follow-up exercise prescription (CBEP). They found CBEP underwent postoperative (for one month) showed better knee joint function and quality of life than the control group.

Based on above literatures, previous researches were fewer discussed data science model and did not find any decision process model of EPT. Most research focused on how to cure the patients using EPT. Thus this study designed and discussed from this way.

III. PROBLEM FORMULATION

Model checking is a formal verification method and discusses whether properties belong to this model. Suppose a novel virus exists, about which we know very little. Doctors, based on experience, recommend two viable drugs. What is the optimal treatment plan that will yield the best therapeutic effect for the patient after taking both drugs. In this kind of topics, we need decision process model (2024). Khan et al. (2023) used decision process model to respiratory monitoring of bedridden patients. Zhou et al. (2025) used reduced order Markov decision process model to process deep reinforcement learning and introduce safety constraints, the challenges of insufficient data were overcome, significantly improving medical safety issue.

Santos and Garcia (2025) showed a decision model of decision making, technology assessment and health technology incorporation. It helped clinical departments manage and organize clinical data and medical engineering data, enabling efficient and rational utilization and integration.

In this section, it would separate three sub parts to discuss.

3.1 Decision process model

Physical therapists were not easily known the relationship among decision variables and dependent variables about EPT. Now we try to build a decision process model, which use TKR patients as an example.

e_j : an EPT factor *j* for a patient whom after TKR, a dependent variable
S_j: standard days of EPT, which means a patient no need for regular, frequent visiting to the clinic
m_i: an inner factor of the patient *i*, extra days of EPT due to the deterioration of physical condition, historical injury or illness, a decision variable
d_i : PT days of the patient *i*, a dependent variable
$d_i = f(S_j, m_i, e_j)$
D: sum of d_i , it represents a clinic goal

This research adapted non-linear programming. It would illustrate as follows:

min D (1)

A physical therapist hopes as less days as d_i of patient *i* due to clinic capacity or it would be better for a patient *i* recovery. Until now, we haven't a golden rule to know m_i due to age, gender, strength, etc. Even machine learning techniques, it would not easy point out muscles' level recovery of m_i.

3.2 Pseudocode of evaluation of patient inner factor

From section 3.1, we proposed model (Eq.(1)), it would know some patients need m_i for recovery. In this section, we described the evaluation algorithm.

L/R/B: TKR foot, left, right or both
Age: age ; **Gender**: male, female; **OP date**: Surgery date; **Comp**: complications; **Pain**: pain score;
Hel: helpers; **Mo**: motivation; **Mi**: conscious; **ROM**: ROM; **Ed**: edema; **Mm**: manual muscle testing; **Fm**: functional mobility; **Gp**: gait pattern; **Sw**:sweat; **Mv**: move ability; **Li**: lower limb muscle endurance; **Ad**: assistive devices; **Ba**:bandage; **Ql**: quality of life; $\mathbf{e_j}$: EPT *j*

In Figure 1, this study proposed an evaluation of patient inner factor algorithm. In this algorithm, PT choice EPT by Doctor's orders is important. To analyze $\mathbf{S_j}$ by historical record and using *decision tree method* to know $\mathbf{e_j}$ and $\mathbf{d_i}$. Finally**,** it would consider the clinic *capacity constraints* and output the schedule.

Input: **L/R/B, Age**, **Gender**, **OP date**, **Comp**, **Pain**, **Hel**, **Mo**, **Mi**, **ROM**, **Ed, Mm, Fm, Gp, Sw**, **Mv**, **Li, Ad, Ba, Ql.**
Output: $\mathbf{e_j}$, $\mathbf{S_j}$, $\mathbf{d_i}$

To **list** historical record
To **Calculate** a *general* $\mathbf{S_j}$
To **Analyze** each d_i by *decision tree method*
To **Calculate** clinic *capacity constraints*

Output: $\mathbf{e_j}$, $\mathbf{S_j}$, $\mathbf{d_i}$ **&** D

Figure 1: Algorithm of evaluation of patient inner factor

In this algorithm, it relied on *decision tree method*. The list of historical record in local clinic was vita important due to sub racial characteristics. This study found its very hard to know this knowledge from academic paper database. Most of them were showed regression variables, or pure machine learning results and proved the system was work.

3.3 A flowchart of decision process

From the pseudocode of evaluation of patient inner factor. In Figure 2, it illustrated how proceed this algorithm. In the beginning, the procedure was collected the basic information and data. Then calculated $\mathbf{S_j}$; after that, PT had to determine the initial schedule. Let *decision tree method* help PT choosing feasible solution. Lately, deciding clinic goal optimal; finally, output all EPT plans and a clinic schedule.

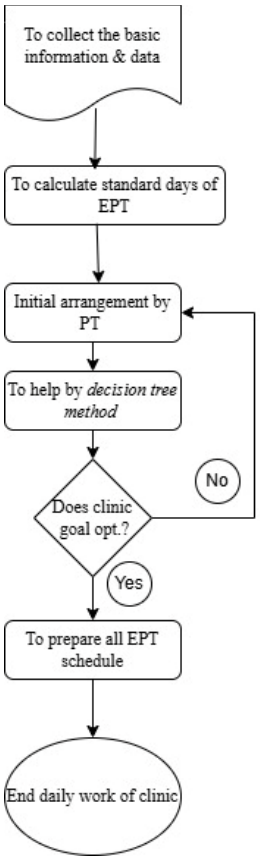

Figure2: Flowchart of decision process

IV. RESULTS

This research aimed at decision process model proposed. In our approach, the software was semi automatic and short stop at evaluation of patient inner factor sub procedure due to medical law and regular wound not agree machine make a decision fully by itself. In non-emergency situations, such as shock or severe muscle spasm, immediately cut off the power supply to the electrotherapy machine.

In the research results, the PT would easy know every possibility by decision tree plan, and offered a decision support. However in Figure 3, it illustrated the concept to explain the difficulties. Within *decision tree*, Gate sequence won't the same in each time. Due to NP-hard theory, it depends on random generator and historical data in clinic database. Besides, the optimal recovery days suggestion could not be the first choice by PT because too many reasons.

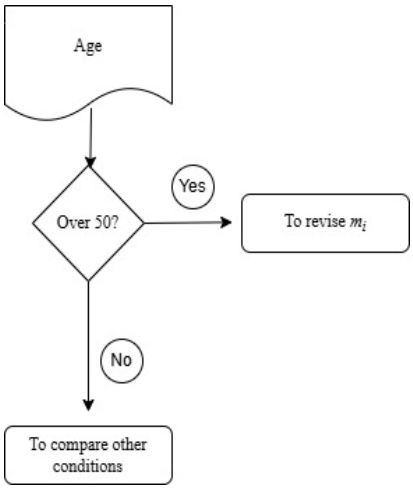

Figure3: Concept of decision tree

V. CONCLUSION

Most of previous related literature would less discuss the decision process. A clear and modifiable decision-making process is very important for PT and patient. This study tries to identify all EPT independent and dependent variables. It would offer more smart decision support system in future. Valuable clinic data has a little chance to reuse these data in clinic environment. If we can search out more rules in academic database, it would improve the EPT choice, and not only believe the Black Box in pure machine learning techniques.

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