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Original Article

Evaluation of the Success of Using a Manual Stretching Approach to Promote Knee Extension Following Total Knee Replacement

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ABSTRACT

Background and Objectives: Total knee arthroplasty is an advanced surgical method for patients with severe knee disorders, including osteoarthritis and rheumatoid arthritis. Knee arthroplasty is effective in managing pain and restoring extension for better function. This study focuses on manual stretching techniques, following total knee arthroplasty, to improve knee extension and the aim is to decrease back pain and improve the physical quality of life of patients by restoring maximum possible mobility.

Methods: A quasi-experimental study (pretest-posttest) design was conducted to evaluate the quality of life of 110 patients with an age range spanning from 40 to 75 years, who were recruited for the research between October 2024 and April 2025. The method for data collection was meticulous and multifaceted. Prior to the rehabilitation program, a thorough baseline assessment was carried out for each participant. This initial evaluation included precise measurement of the knee's extension range of motion using a standard goniometer and a quantitative assessment of pain intensity via the Visual Analogue Scale.

Result: The analysis of the collected data revealed overwhelmingly positive and statistically significant results, affirming the intervention's efficacy. The primary outcome, knee extension range of motion, showed a remarkable improvement, with the cohort's average measurement increasing from 156.1 degrees pre-intervention to a near-full extension of 172.2 degrees postintervention. This marked increase in joint mobility was strongly correlated with a significant decrease in patient-reported pain levels.

Conclusions: Manual stretches can be a significant technique for improving the rehabilitation of knee extension following surgery. However, manual stretching on its own is not a panacea for every patient, especially those with advanced knee osteoarthritis, obesity, or knee flexion contractures, which potentially would result in severe knee stiffness.

Keywords: Total knee arthroplasty; Manual stretching techniques; Knee extension.

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INTRODUCTION

Total knee arthroplasty (TKA) is an important surgery for knee-intended individuals mainly having osteoarthritis or rheumatoid arthritis. postoperative rehabilitation in manual stretching to gain the potential improvement of knee extension and mobility after knee surgery [1]. In recent years, rehabilitation strategies have been investigated by researchers to improve postoperative results, and targeted manual stretching has been recommended [2]. TKA is accompanied by several obstacles and manual stretching techniques when provided in conjunction with other rehabilitative measures have handily assisted patients in overcoming these obstacles [3]. Telerehabilitation has grown to be an alternative that is feasible for both preoperative and postoperative therapy could have a significantly positive effect on the improvement of muscle strength, ranges of motion (ROM) and other functional outcomes [4]. Though this study focuses on interventional strategies before surgery, that stands out with the effectiveness of manual therapy combined with exercises as opposed to using exercises alone in TKA patients [5]. The longitudinal results of the concentration on rehabilitation aspects demonstrate the positive impact of the targeted rehabilitation strategies in much research after lateral opening wedge distal femoral osteotomy and reported the individual patient's needs and included manual stretching to facilitate favorable results years after surgery [6]. The patient's background and experiences with TKA before the surgery may also have an impact on the progress of the rehabilitation process. The complication rate requiring MUA after TKA in those patients has been found to be almost 14 times higher. This shows the importance of providing individual rehabilitation programs, which may include stretching to minimize complications [7]. Consequently, the effectiveness of certain surgical techniques correlates to the patient's rehab progress. Their observations make it evident that post-operative stretch exercises to facilitate biomechanical aspects in such cases should be part of the recovery [8]. Retaining the TKA functioning is another area where resistance exercises have been useful. After TKA, a meta-analysis and systematic review of the evidence on the role played by progressive resistance training in the early postoperative. Exercises such as knee extension may help improve overall function [9]. Stretching soft tissues, such as muscles, tendons, ligaments, ECM (scar tissue), as well as capsules, every 24 hours is necessary to allow therapy to be effective [10]. Nevertheless, constraints in public and private healthcare resources seldom permit physiotherapy sessions to do effective manual stretching daily [11]. As tissues adapt and undergo remodeling, resistance to stretching diminishes, resulting in plastic deformation. This employs the biomechanical principles of 'stress-relaxation' by the application of progressively increasing continuous displacements, sometimes referred to as 'static progressive stretch' (SPS) [12].

METHOD

A total of 110 patients aged between 40 and 75 years participated in this quasi-experimental (pretest-posttest) study. Based on the clinical assessments, the majority of the cases were diagnosed with osteoarthritis by the orthopedic surgeon. Most of subjects fell into the overweight category based on body mass index (BMI) and proceeded to total knee arthroplasty surgery. Participants were primarily recruited from Zheen International Hospital, CMC hospital, Par hospital and Hawler Teaching Hospital Informed consent was obtained from all participants,

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and no compensation was provided. The survey was hosted on Kobo Toolbox and conducted between (October 2024 and April 2025). The method for data collection was meticulous and multifaceted. Prior to the commencement of the rehabilitation program, a thorough baseline assessment was conducted for each participant. Inclusion criteria included: Participants were generally aged between 40 and over 75 years. (Most candidates are over 50 years old). Surgery Type: undergoing either partial knee arthroplasty (PKA) or total knee arthroplasty (TKA). Medical Clearance: Permission from a physician to engage in rehabilitation. Functional Status: Capacity to engage in therapy and adhere to instructions. Patients who had bilateral or unilateral TKA with OA and RA were included. Clinical outcomes: the main ones were pain, knee flexion and extension, knee motion range (ROM), effective management of comorbid conditions, normal vision and hearing, voluntary participation in the postoperative rehabilitation program with the surgeon's prior consent, no cognitive impairment, and good communication skills. Exclusion criteria: medical instability, such as an unstable cardiovascular status or uncontrolled hypertension and arrhythmia. Inflammatory arthritis; a planned TKA revision; history of knee surgery within the last six months; neurological conditions, such as stroke and Parkinson's disease; and lower extremity neurological damage. Cognitive Impairment: The inability to comprehend or adhere to rehabilitation guidelines. Three weeks following the TKA procedure, the postoperative telerehabilitation intervention was carried out. As a result, tests were conducted twice. Baseline measurements were obtained on the first postoperative day, and post-intervention data were collected three weeks later. The frequency of the stretching intervention was held for three weeks (three sessions per week) following the procedure; follow-up was conducted. The goal of the study was briefly discussed during the first patient visit, and everyone's consent was acquired. First, make a note of the patient's medical history. Second, use a goniometer to measure the range of motion in the knee joint to record the degree of extension. Next, ask the patient to complete the Baseline Assessment Questionnaire (QLD) and provide their visual analogue scale (VAS) pain score (0–10). These two measurement points were used to see how the postoperative intervention affected the patients' pain, range of motion, and a detailed functional assessment using a standardized questionnaire to evaluate the patient's capacity to perform Activities of Daily Living (ADL). Questionnaires were applied to gather data that included sociodemographic characteristics of the patient, including age, medical history, occupation, chief complaint, residence, and their body mass index (BMI), operation type, religion. Daily activities for a better quality of life after total knee arthroplasty. The physical therapy program after the surgery started the day after TKA and was done every day. It included cold pack therapy and continuous passive motion exercises. After the drain was removed and compression stockings were applied, cryotherapy and manual therapy were introduced as part of the patient’s physical therapy. On the second day after surgery, they started to bear weight with the help of a walker. During the first and second weeks, the patients did knee ROM exercises, ankle pumping, straight leg raises, self-passive knee extension, balance training, and gait training while using a walker. Strength training, endurance exercise, and walking up and down stairs were added in the third week. The protocol of the postoperative rehabilitation program is described as each session including warming-up, mobility,

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flexibility, strength, balance, and cool-down exercises. Therapy protocol, Timing: Perform stretching after warming up the knee with light activity (e.g., walking, using a continuous passive motion device for 30 minutes, and then having the patient to sit for gentle range-of-motion exercises such as knee flexion, putting a small bottle underfoot to roll it actively about 30 to 50 times; then ankle dorsiflexion 15-20 reps; hip flexion, 10-15 reps; and knee assistive extension, 10-15 reps). Positioning: Sit or lie down in a comfortable position with the leg supported. A common position is lying supine (on your back) with the heel propped on a rolled towel or a pillow to allow gravity to assist in extension during the rest of the day as much as possible. Relaxation: Ensure the patient is relaxed, especially the quadriceps and hamstrings, to avoid resistance during stretching. Techniques for Manual Stretching; Passive Knee Extension Stretch, Position: Lie on your back with the heel propped on a ball (should be smooth between 18 and 21 cm) to allow gravity to assist in extension stretching. Intensity was applied Gently press down on the thigh just above the knee to the end range of motion without causing severe pain while allowing the knee to straighten. Hold for 30–60 seconds (3–5 reps at a time), gradually increasing the duration of stretching applied to the end range of motion. Formal ethical approval from the Ethical Committee of the Erbil Health and Medical Technical College at Erbil Polytechnic University on August 10,2025, with the number of (25/079 HRE). The official approval was taken from the general directorate of health; all participants were informed about the purpose and procedures of the study, and oral informed consent was obtained prior to participation.

RESULTS

Table1 shows the descriptive statistics for demographic characteristics. Most of the patients are aged between 65–74 years (48.2%), followed by those aged 55–64 (29.1%), 75+ (15.4%), and 45–54 (7.3%), respectively, with a mean age of 67 years (SD ± 8.26), The majority were Muslim (88.2%) and housewives (56.4%), with others being retired (31.8%) or employed (11.8%). The mean BMI was 29.25 (SD ± 4.20), with 47.3% classified as overweight, 38.2% as obese, and only 14.5% within a normal range. Common medical issues included hypertension (70.9%), diabetes (28.4%), and thyroid problems (0.7%). The primary complaint was osteoarthritis (96.4%), with a small proportion (3.6%) suffering from rheumatoid arthritis. Regarding surgical treatment, 54.5% underwent right total knee replacement and 45.5% underwent left total knee replacement.

Table 1: Descriptive Statistics for demographic characteristics.

Variable	Category	n (%)
Age (years)	45–54	8 (7.3)
	55–64	32 (29.1)
	65–74	53 (48.2)
	≥ 75	17 (15.4)
	Total	**110 (100)**
	Mean ± SD	67 ± 8.26
Medical issues	Hypertension	78 (70.9)
	Diabetes mellitus	31 (28.4)
	Thyroid disorders	1 (0.7)
Chief complaint	Osteoarthritis	106 (96.4)
	Rheumatoid arthritis	4 (3.6)
Occupation	Retired	35 (31.8)
	Housewife	62 (56.4)
	Employee	13 (11.8)
BMI (kg)	Normal	16 (14.5)
	Overweight	52 (47.3)
	Obese	42 (38.2)

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Table 2 presents the results indicating a statistically significant difference in the mean values before and after three weeks of physiotherapy treatment because its p-values (<0.001) is less than the significant level of α=0.05, Specifically, the mean score after the physiotherapy intervention (M = 172.20) was notably higher than the mean score before the intervention (M = 156.10). This improvement has a positive effect on the physiotherapy sessions.

Table 2: Comparison of Knee Extension Range of Motion before and After 3 Weeks of Physiotherapy.

Variable	Before physiotherapy (Mean ± SD)	After 3 weeks (Mean ± SD)	t-value	p-value
Knee extension range of motion (°)	156.10 ± 7.11	172.20 ± 4.00	-27.04	<0.001

Table 3 shows the results indicating a statistically significant difference in the knee extension range of motion associated with pain after three weeks of physiotherapy because its p-values (<0.001) is less than the significant level of α=0.05, For example, the mean pain-related score decreased substantially, from 3.46 before the intervention to 1.53 afterward, reflecting a marked reduction in pain intensity or restriction during knee extension movements. In this context, lower scores represent better outcomes, such as improved joint mobility and reduced pain symptoms. These results underscore the effectiveness of the physiotherapy program in alleviating pain and improving functional movement.

Table 3: Comparison of Knee Extension Range of Motion Before and After 3 Weeks of Physiotherapy for Pain.

Variable	Before physiotherapy (Mean ± SD)	After 3 weeks (Mean ± SD)	t-value	p-value
Pain score	3.46 ± 0.30	1.53 ± 0.67	30.19	< 0.001

In Table 4, the descriptive statistics of knee extension range of motion for the degree of difficulty in ADL prior to and following physical therapy are displayed. Prior to treatment, most patients had severe ADL (14.5%), moderate ADL (0.9%), and extreme ADL (84.5%), while none had light or no ADL (0%). ADL scores significantly improved after physiotherapy, with most patients reporting mild ADL (51.8%) and moderate ADL (41.8%). Fewer people had severe ADL (5.5%) and extreme ADL (0.9%). These results showed that physical therapy significantly lowered the ADL score.

Table 4. Descriptive Statistics of Knee Extension Range of Motion for ADL Before and After Physiotherapy.

Severity Level	Before physiotherapy n (%)	After physiotherapy n (%)
Mild	0 (0)	57 (51.8)
Moderate	1 (0.9)	46 (41.8)
Severe	16 (14.5)	6 (5.5)
Extreme	93 (84.5)	1 (0.9)

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Table 5 shows the changes in back pain levels before and after physiotherapy. The data indicates that physiotherapy was mainly provided to individuals who experienced moderate to extreme levels of back pain, as there were no cases reported in the no or mild pain categories before treatment. Among those who initially had moderate pain, a small number showed improvement (0.9%) shifted to mild pain, and another (0.9%) remained at the same level. The most significant change was seen in patients who started with severe pain: after therapy, (41.8%) improved to mild pain and 32.7% to moderate, while only 9.1% still reported severe pain, and none remained in the extreme category. Similarly, patients with extreme pain before treatment showed progress, with 7.3% moving to mild, 5.5% to moderate, and just 0.9% reporting severe pain afterward. Overall, the data suggests that physiotherapy helped reduce back pain for most participants, especially those with higher initial pain levels.

Table 5: Comparison between back pain Before and After Physiotherapy.

Back Pain Before	Non n (%)	Mild n (%)	Moderate n (%)	Severe n (%)
Moderate		1(0.9)	1 (0.9)	
Severe	1 (0.9)	46 (41.8)	36 (32.7)	10 (9.1)
Extreme		8 (7.3)	6 (5.5)	1 (0.9)

Figure 1 illustrates how physical therapy successfully decreased the severity of symptoms while enhancing knee function and mobility. Prior to receiving treatment, most patients reported experiencing knee pain often (89.1%), always (7.3%), and occasionally (3.6%). However, there is a noticeable improvement during physiotherapy, with a large shift toward the sometimes (90%) and some of them become rare. After receiving physical therapy, none of the patients reported constant (always) symptoms, and symptoms frequently (often) decreased to 7.3%.

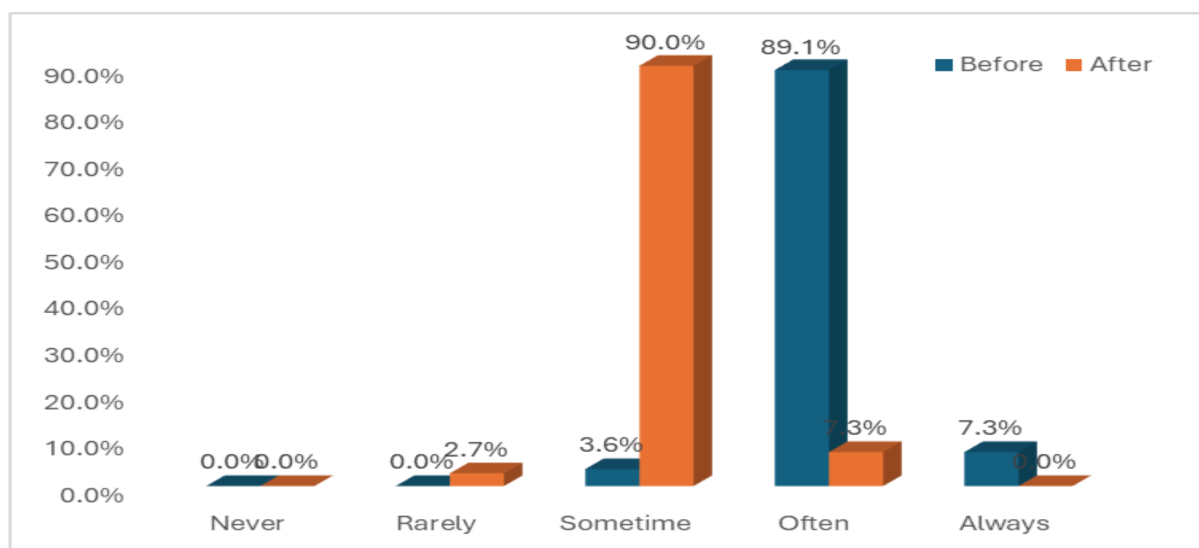

Figure 1. Percentage of Knee Extension Range of Motion for Symptoms Before and After Physiotherapy.

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DISCUSSION

This study aimed to evaluate the effectiveness of stretching and strengthening exercises in the management of knee extension after total knee arthroplasty. The findings revealed that manual stretching exercises demonstrated greater improvements in both pain reduction and activities of daily living (ADL) compared to stretching and strengthening exercises. The results of this study show that, when compared to combined stretching and strengthening exercises, manual stretching exercises resulted in larger gains in pain reduction and activities of daily living (ADL). These findings are in line with those of [9]. Several limitations. Variations in manual extension and stretching may have influenced outcomes. The short follow-up period limits assessment of long-term effects. Differences between unilateral and bilateral procedures, and variations in pain tolerance, may have affected patient performance. Future studies with longer follow-up and standardized protocols are needed. The relatively short-to-medium follow-up duration and limited sample size may constrain the generalizability of the results. However, these findings show areas where postoperative treatment has to be improved and offer insightful information about functional recovery[13] "which found that flexibility-oriented therapies greatly improved pain alleviation, joint mobility, and functional performance when included in postoperative knee rehabilitation. For pain assessment, we used the Visual Analog Scale (VAS) while measuring knee Range of motion measured by using (Goniometer). Variations in pain and range of motion (ROM) outcomes reported across different studies may be partly attributable to methodological differences. In the current study, the use of standardized assessment tools, namely the Visual Analog Scale (VAS) for pain and goniometry for ROM, facilitated direct comparisons with prior investigations, including those by [9] and [14]. Nonetheless, discrepancies in results across studies may also reflect differences in assessor expertise, the intensity or frequency of stretching interventions, and the overall duration of rehabilitation programs. The demographic analysis showed that based on evidence involving 110 patients grouped between ages (45 - up to 75), respectively, with a mean age of 67 years, the majority were Muslim (88 percent). Most of them were housewife (56.4%), with others (31.8%) being retired and (11%8) employed. It remains unclear which rehabilitation program should be offered to patients who have undergone TKA or what specific attributes of programs are most effective in achieving optimal patient outcomes. Studies had moderate risk of bias at best, largely due to the challenge of blinding of rehabilitation interventions. Although there was no discernible difference in the revision rate or mortality rate between the ages of 70 and 80, this systematic review demonstrates that the patient-reported outcome measurement (PROM) was good when TKA was performed on patients between those ages of 70 and 80. However, mortality following TKA tended to rise with age. Consequently, it may be suggested that the best time to have TKA is in the early 70s[15]. In knee OA, pain is the primary symptom and a major factor in determining knee flexion and extension. As a result, it is now one of the primary issues that TKA must resolve. This study also revealed that OA patients who had never exercised believed it would harm their joints. Preoperative rehabilitation, on the other hand, can help them manage their anxiety, identify coping mechanisms for their discomfort, and continue exercising following surgery to enhance their overall quality of life [16].

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In this meta-analysis, pain was the main outcome. This study found that preoperative rehabilitation did not increase postoperative pain after total knee arthroplasty (TKA) in terms of the VAS scores at the 6th or 12th week postoperatively, which was in line with previous research [17]. The majority of researches on mortality were consistent, indicating that the risk of death increases with the patient's age at the time of TKA. The primary conclusions of this systematic analysis are that, in comparison to younger [16] patients (less than 80 years old), older patients (≥ 80 years old) undergoing total knee arthroplasty (TKA) had greater rates of surgical and medical problems, as well as higher mortality. Therefore, these results disprove the theory that the results of TKA for older patients are comparable to those for younger individuals. While there are conflicting results for PROs, the literature also suggests higher LoS for elderly individuals. While some research indicated worse PROs in older patients and fewer studies revealed greater PROs for older patients, most studies found no change in PROs between the two age groups. It is important to note that three studies found conflicting patterns for certain PRO [18, 19]. Most research consistently indicates that younger patients undergoing TKA have a higher likelihood of requiring revision surgery over their lifetime, with many studies using 65 or 70 years of age as the reference standard for comparison of revision rates. Therefore, there was consensus that the revision rate tends to increase in younger patients, but there is no significant difference in patients > 70 years of age. The results, according to body mass index (BMI) classified as overweight 47%, 38.2% as obese, and only 14% within a normal range. Common medical issues included hypertension 70% and diabetes (28.4%). The primary complaint was severe pain for a long duration which was diagnosed by the orthopedic specialist as osteoarthritis, with a small proportion (3.6%) suffering from rheumatoid arthritis. Regarding surgical treatment, 54.5% underwent right total knee replacement and 45.5% underwent left total knee replacement, most of them female. Revision procedures have been more common in the USA over the past few decades because of an increase in the percentage of obese patients following primary TKA. However, this hasn't been the case in Sweden, where during the past ten years, the percentage of patients with a BMI of ≥35 who get a knee arthroplasty has somewhat declined (9.3%, 2019). [20] According to findings indicating a statistically significant difference in knee extension range of motion, the mean values before and after three weeks of physiotherapy treatment because its p-values (0.000) are less than the significant level of $\alpha=0.05$, Specifically, the mean score after the physiotherapy intervention ($M = 172.200$) was notably higher than the mean score before the intervention ($M = 156.100$). This improvement suggests a positive effect of the physiotherapy sessions in restoring normal extension range post-operation rehabilitation. Standard and modified rehabilitation programs were compared for active knee extension and flexion range of motion.

CONCLUSION

Incorporating manual stretching, encompassing both passive and active-assisted techniques with low-load stretching, proves to be a highly effective strategy for promoting knee extension following total knee arthroplasty (TKA). This comprehensive approach directly targets the elongation of shortened soft tissues, which is critical for restoring optimal joint mechanics. By enhancing joint alignment, patients achieved a more normal gait cycle,

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experienced less pain, and ultimately made significant strides towards functional recovery. The integration of these manual stretching techniques is therefore essential for maximizing patient outcomes and improving quality of life after TKA.

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REFERENCES

[1] Agrawal A, Raj JKG, Chellamuthu A, Jayaraman SK. Radical Posterior Release for Severe Flexion Contracture of Knee Following Total Knee Arthroplasty: A Case Report. *J Orthop Case Rep.* 2024;14(7):145-9. https://doi.org/10.13107/jocr.2024.v14.i07.4608

[2] Akhtar M, Razick D, Seibel A, Asad S, Shekhar A, Shelton T. Outcomes of Early Versus Delayed Manipulation Under Anesthesia for Stiffness Following Total Knee Arthroplasty: A Systematic Review and Meta-Analysis. *J Arthroplasty.* 2024;39(11):2872-9. https://doi.org/10.1016/j.arth.2024.05.059

[3] Al Ramlawi A, Issa M, Nassar JE, Naja AS, Saghieh S. VY quadricepsplasty for knee stiffness post total knee arthroplasty: A case report and literature review. *Journal of Orthopaedic Case Reports.* 2024;14(6):83. https://doi.org/https://doi.org/10.13107/jocr.2024.v14.i06.4512

[4] An J, Ryu HK, Lyu SJ, Yi HJ, Lee BH. Effects of Preoperative Telerehabilitation on Muscle Strength, Range of Motion, and Functional Outcomes in Candidates for Total Knee Arthroplasty: A Single-Blind Randomized Controlled Trial. *Int J Environ Res Public Health*. 2021;18(11):6071. https://doi.org/10.3390/ijerph18116071

[5] Karaborklu Argut S, Celik D, Kilicoglu OI. The Combination of Exercise and Manual Therapy Versus Exercise Alone in Total Knee Arthroplasty Rehabilitation: A Randomized Controlled Clinical Trial. *PM R.* 2021;13(10):1069-78. https://doi.org/10.1002/pmrj.12542

[6] Cance N, Batailler C, Lording T, Schmidt A, Lustig S, Servien E. Ten-year minimal follow-up of lateral opening wedge distal femoral osteotomy for lateral femorotibial osteoarthritis: Good survivorship and high patient satisfaction. *Knee Surg Sports Traumatol Arthrosc.* 2025;33(2):675-85. https://doi.org/10.1002/ksa.12404.

[7] Chandi SK, Hawes JD, Kolin DA, Debbi EM, Ast MP, Haas SB, et al. Nearly 14-Fold Increased Risk of Manipulation Under Anesthesia After Total Knee Arthroplasty When Previous Contralateral Total Knee Arthroplasty Required Manipulation Under Anesthesia. *J Arthroplasty*. 2024;39(9S2):S449-S53. https://doi.org/10.1016/j.arth.2024.05.073

[8] Chen Q, Cao L, Li YC, Wulamu W, Zhang XG. [Outcomes of total knee arthroplasty combined with the modified "overlap" technique in the treatment of knee osteoarthritis with permanent patellar dislocation]. *Zhonghua Wai Ke Za Zhi.* 2024;62(9):856-63. https://doi.org/10.3760/cma.j.cn112139-20240426-00211

[9] Chen X, Li X, Zhu Z, Wang H, Yu Z, Bai X. Effects of progressive resistance training for early postoperative fast-track total hip or knee arthroplasty: A systematic review and meta-analysis. *Asian J Surg.* 2021;44(10):1245-53. https://doi.org/10.1016/j.asjsur.2021.02.007

[10] Jacobs CA, Sciascia AD. Factors that influence the efficacy of stretching programs for patients with hypomobility. *Sports Health*. 2011;3(6):520-3. https://doi.org/10.1177/1941738111415233

[11] Gu A, Michalak AJ, Cohen JS, Almeida ND, McLawhorn AS, Sculco PK. Efficacy of Manipulation Under Anesthesia for Stiffness Following Total Knee Arthroplasty: A Systematic Review. *J Arthroplasty*. 2018;33(5):1598-605. https://doi.org/10.1016/j.arth.2017.11.054

[12] Taniguchi M, Sawano S, Kugo M, Maegawa S, Kawasaki T, Ichihashi N. Physical Activity Promotes Gait Improvement in Patients With Total Knee Arthroplasty. *J Arthroplasty.* 2016;31(5):984-8. https://doi.org/10.1016/j.arth.2015.11.012

[13] Kolisek FR, Gilmore KJ, Peterson EK. Slide

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and flex, tighten, extend (SAFTE): a safe, convenient, effective, and no-cost approach to rehabilitation after total knee arthroplasty. *J Arthroplasty.* 2000;15(8):1013-6. https://doi.org/10.1054/arth.2000.16505

[14] Moon M, Oh EG, Baek W, Kim YM. Effects of Nurse-Led Pain Management Interventions for Patients with Total Knee/Hip Replacement. *Pain Manag Nurs*. 2021;22(2):111-20. https://doi.org/10.1016/j.pmn.2020.11.005.

[15] Lee SH, Kim DH, Lee YS. Is there an optimal age for total knee arthroplasty?: A systematic review. *Knee Surg Relat Res.* 2020;32 (1):60. https://doi.org/10.1186/s43019-020-00080-1

[16] Calatayud J, Casana J, Ezzatvar Y, Jakobsen MD, Sundstrup E, Andersen LL. High-intensity preoperative training improves physical and functional recovery in the early post-operative periods after total knee arthroplasty: a randomized controlled trial. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(9):2864-72. https://doi.org/10.1007/s00167-016-3985-5

[17] Yeung P, Zhang W, Wang XN, Yan CH, Chan BP. A human osteoarthritis osteochondral organ culture model for cartilage tissue engineering. *Biomaterials.* 2018;162:1-21. https://doi.org/10.1016/j.biomaterials.2018.02.002

[18] Yun ST, Kim BK, Ahn BM, Oh KJ. Difference in the degree of improvement in patient-reported outcomes after total knee arthroplasty between octogenarians and sexagenarians: a propensity score matching analysis. *Aging Clin Exp Res*. 2018;30(11):1379-84. https://doi.org/10.1007/s40520-018-0913-1

[19] Cher EWL, Tay KS, Zhang K, Tan SB, Howe TS, Koh JSB. The Effect of Comorbidities and Age on Functional Outcomes After Total Knee Arthroplasty in the Octogenarian: A Matched Cohort Study. *Geriatr Orthop Surg Rehabil.* 2018;9:2151459318769508. https://doi.org/10.1177/2151459318769508

[20] Lewis PL, A WD, Robertsson O, Lorimer M, Prentice HA, Graves SE, et al. The effect of patient and prosthesis factors on revision rates after total knee replacement using a multi-registry meta-analytic approach. *Acta orthopaedica.* 2022;93:284-93. https://doi.org/10.2340/17453674.2022.1997

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