Total Knee Arthroplasty Prehabilitation Protocol

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SECTION I: INTRODUCTION

This protocol is geared towards the rehab professional to assist with delivery of prehabilitation intervention with individuals indicated for inpatient primary total knee arthroplasty (TKA). The content is based on current clinical research related to prehabilitation intervention and is intended to provide the user with background information on the primary postoperative issues faced by TKA patients, preoperative rehabilitative guidelines, as well as direction for setting functional goals and prescribing therapeutic exercise. While this protocol attempts to address some of the variables of clinical application of prehabilitation, it is not meant as a substitute for clinical decision making regarding individual patient course of treatment.

SECTION II: BACKGROUND

Physical therapy after TKA helps to optimize successful surgical outcomes and patient recovery.[1] Nonetheless, there is still risk for complications and adverse effects, which can result in poor outcomes for the patient, hospital, and overall healthcare system. Complications and adverse events following TKA may be caused by surgical/medical error or may occur even with delivery of high-quality care as a result of individual patient risk factors. However, it is often the case that there are many causative and correlating factors involved with less than successful outcomes. While many of these issues are outside the scope of PT practice, there are several major postoperative complications associated with worse surgical outcomes that can be positively impacted by prehabilitation.

The major postoperative problems include:

1. Surgical site infection[2–4]
    - Postoperative surgical site infection (SSI) affects 1-3% of patients post-TKA. In 74% of these cases, infection is caused by *Staphylococcus aureus* or a related bacterial strain. SSI often results in early failure and loosening of the prosthesis and is the number one reason for TKA revision surgery. In the most extreme of cases, SSI can result in arthrodesis or above-knee amputation. Hospital readmission due to SSI is the mostly costly in terms of annual economic burden.
2. Venous thromboembolism (VTE)[5–7]
    - Increased length of tourniquet time during the TKA procedure causes venous status and potential damage to blood vessels, inducing an inflammatory response and thrombi formation, usually immediately after surgery, within the deep distal calf veins. If the thrombus breaks off and travels to the lungs it can result in pulmonary embolism, which can be fatal. Most VTE after TKA are diagnosed within the first 21 days after surgery and are the most common reason for extended period of inpatient hospitalization or post-TKA hospital readmission.

3. Knee stiffness[8–10]

- Severe knee stiffness following TKA is usually caused by arthrofibrosis, resulting in inability to regain functional knee range of motion. Inability to achieve 90° of knee flexion or a flexion contracture of more than 15° are indicative of severe postoperative knee stiffness. This degree of impairment occurs in 5-7% of TKA patients, resulting in long-term mobility limitations (usually painful) and causing altered gait and decreased ability to complete daily activities. Knee stiffness may also be caused by SSI or improper sizing or positioning of hardware components. Knee stiffness as a result of arthrofibrosis often requires manipulation under anesthesia in order to correct and, in more extreme cases, may require TKA revision surgery.

4. Muscle weakness[11–13]

- Following surgery, the involved limb suffers significant reduction of voluntary muscle activation by an average of 17% and global reduction in lower extremity muscle strength by up to 60%. Greatest losses in muscle strength occurs in the quadriceps, hamstrings, hip abductors, and ankle plantar flexors, but is most significant in the quadriceps, which can individually experience post-op strength loss of up to 85%. The gold standard medial parapatellar surgical approach, while allowing for good exposure and optimization of alignment, highly compromises the quadriceps muscle and tendon, resulting in inhibition of this muscle group and its dramatic loss of strength postoperatively.
- Postoperative muscle weakness can result in knee joint malalignment, instability, reduced physical function, and increased disability. Postoperative asymmetry in lower extremity strength has been associated with weight-bearing asymmetry, limited functional mobility, an increased risk for falls, and additional orthopedic problems.

5. Persistent post-surgical pain (PPSP)[14–17]

- The International Association for the Study of Pain (IASP) has defined PPSP as “pain that develop[s] after surgery and is present for at least 3 months, an interval which is considered to be beyond the time for normal healing.” At 1-year post-op, 50% of patients undergoing TKA may not experience clinically important improvements in pain, with most patients experiencing these symptoms on a daily basis. Most commonly, PPSP has been reported to interfere with functional walking ability, general activity, and ability to complete normal occupational work; less commonly, PPSP may also impact mood, sleep, and quality of life. PPSP is the strongest predictor of lower patient satisfaction following TKA.

6. Prolonged length of inpatient stay[4,18,19]

- At any hospital, discharge is based, in large part, on swift recovery of relevant activities (transferring from bed to a chair, ambulation, and climbing stairs). If the patient is unable to demonstrate functional independence with these activities, then hospital length of stay (LOS) will be prolonged and/or the patient will have non-home discharge to a skilled nursing facility or rehabilitation center. Prolonged inpatient stay may be caused by of any or all of the previously described complications. On the other hand, longer duration of inpatient stay at any facility further increases the risk for additional complications or adverse events, specifically SSI, VTE, PPSP, and worse long-term functional recovery. Inpatient LOS is primary cost driver of the TKA episode.

Other long-term negative patient outcomes resulting from the aforementioned postoperative issues may include:[16,20,21]

- Reduced participation in postoperative PT intervention.
- Increased fear of movement.
- Decreased functional independence.
- Patient weight gain.
- Decreased health quality of life.

Patient Risk Factors[5,20,22–24]
High number of comorbidities (especially obesity and diabetes), low preoperative physical activity level, and heightened sensitivity to painful stimuli are all independently associated with increased risk of developing postoperative complications. Other non-modifiable risk factors for development of postoperative complications include age, gender, and smoking history.

Critical Prehabilitation Principles
The theory of prehabilitation supports the direct and positive effects that PT before TKA can have on a patient's preoperative physical and functional status and in reducing modifiable risk factors, thereby contributing to improved postoperative outcomes.

Prehabilitation is broadly defined as improving the functional capacity of an individual through physical activity to withstand a stressful event.[25] While there have been multiple randomized and controlled clinical trials completed in attempt to assess the efficacy of prehabilitation before TKA, the high variability of study methods and lack of standardized prehab intervention compromises ability to make comparison between studies. Nonetheless, sample population remain similar and assessment of methodological quality suggests low risk of bias with individual study methods. Thus, while definitive conclusions cannot be drawn from currently available research, there is still evidence, albeit limited, to suggest that prehabilitation can reduce the risk for developing postoperative complications and have clinically meaningful impact on post-TKA outcomes when utilizing a protocol with appropriate intervention parameters, format, and methodology.

For a full discussion on RCTs assessing efficacy of prehabilitation for TKA, see the Table of Evidence in **Appendix A**.

Goals of Prehabilitation Intervention
In order to optimize postoperative rehabilitation, reduce risk of postoperative complications, and improve long-term treatment outcomes, this prehabilitation protocol presents the following preoperative PT management plan based on conclusions drawn from available evidence.

The specific goals of this prehabilitation protocol are to:

1. Improve preoperative physical function and performance of physical tasks.[18,19,26–28]

   Reasoning:

- Lower preoperative physical function has been associated with delayed postoperative inpatient recovery of activities necessary for home discharge, decreased ability to perform daily activities, limited mobility, and participation restrictions at 1-year post-op.
- Improved preoperative physical function has also shown to reduce the risk for persistent post-surgical pain.

2. Increase preoperative lower extremity muscle strength and endurance to improve body mechanics, work efficiency, and reduce pain with daily activities.[29–34]

Reasoning:

- Strength loss following TKA occurs in the quadriceps, hamstrings, ankle plantar flexors, and hip abductors.
- Increased preoperative quadriceps and hamstrings strength improves postoperative knee joint stability.
- Preoperative lower extremity strength is a strong predictor of functional performance at one and two years after TKA as well as postoperative activity participation.
- Increased preoperative functional strength reduces the elevated risk of femoral fracture in the first-year post-op.

3. Increase preoperative knee joint range of motion.[8,9]

Reasoning:

- Limited range of motion preoperatively is predictive of ultimate postoperative knee flexion ROM and considered the most important risk factor for postoperative stiffness.

4. Improve body awareness and postural control with static and dynamic balance activities.[23,34,35]

Reasoning:

- Preoperative impairment in static balance is associated with reduced function/ADLs at 6-months post-op.
- Preoperative walking limitations or increased reliance on assistance with ambulation increases risk of long-term functional limitations and participation restrictions postoperatively.
- Patients with poor neuromuscular control of the knee joint preoperatively are at increased risk for postoperative knee joint stiffness.

5. Improve physical capacity for aerobic exercise.[21,36,37]

Reasoning:

- Low level of preoperative physical activity increases risk of postoperative knee stiffness and persistent post-surgical pain.
- Preoperative cardiovascular endurance contributes to performance-based physical function post-TKA.
- Regular participation in aerobic exercise improves immune function and can reduce patient risk of post-surgical infection.

- Post-surgery weight gain resulting in overweight BMI is common in TKA patients; initiating aerobic endurance training prior to surgery may have carry-over effect on health behavior and lifestyle choices following surgery.

6. Increase tolerance to activity and address any fear avoidance behaviors.[17,38–40]

   Reasoning:

   - Negative or exaggerated orientation to pain stimuli significantly influences patient functional outcomes after TKA.
   - High fear of pain, disability, or movement preoperatively is the greatest reported barrier to engaging in postoperative PT.
   - Preoperative pain sensitization or pain-related illness perceptions are associated with persistent post-surgical pain.
   - Preoperative education on pain coping strategies and activity coaching has been correlated with increased patient motivation to maintain physical activity after surgery.

7. Address patient short and long-term expectations following surgery.[16,17,41]

   Reasoning:

   - Although degree of postoperative pain is usually mild and significantly improved from baseline, patients are often expecting complete resolve of pain symptoms following TKA.
   - Unmet patient expectations are strongly associated with postoperative dissatisfaction; preoperative management of patient expectations related to recovery progression and duration has been correlated with improved postoperative patient satisfaction.
   - Patients with milder radiographic knee OA before TKA (using the Kellgren-Lawrence Grading System) are more likely to report inadequate pain relief and dissatisfaction with functional improvement following surgery.[41] Compared to patients with severe joint degeneration on X-ray, knee pain in patients with only modest radiographic change appears to be driven more by pain central sensitization than by nociceptive input from the joint.[42]
     - Early identification of these patients allows for adequate time to provide chronic pain education and mediate expectations.

8. Provide patient education on acute phase of recovery and identification of potential barriers that could hinder postoperative recovery.[5,24,43]

   Reasoning:

   - Stressing the importance of early mobilization and participation in PT following surgery can improve patient compliance with postoperative PT intervention, prevent prolonged length of hospital stay or non-home discharge, and reduce risk of developing postoperative knee stiffness or flexion contracture.
   - Lack of ambulation following TKA increases risk of VTE; after adjusting for other risk factors, early mobilization following TKA has shown to cause a 30-fold reduction in the risk of postoperative DVT.

With successful achievement of these prehabilitation goals, TKA patients may experience these additional impairment and function-based positive outcomes (compared with just standard postoperative PT alone):[1,16,26–28,40,44–47]

- Shorter length of inpatient hospital stay.
- Reduced risk of discharge to subacute inpatient rehabilitation facility.
- Decreased risk of postoperative complications due to SSI or VTE.
- Increased independence and performance with ADLs, functional mobility, and ambulation during acute and sub-acute postoperative recovery periods.
- Swifter recovery and progression of lower extremity muscle strength, endurance, and function.
- Increased rate of improvement in achieving functional knee range of motion.
- Greater reduction in pain symptoms during the subacute phase of recovery.
- Faster return to daily activities.
- Reduced fear of pain and movement avoidance.
- Improved exercise capacity and greater self-efficacy for exercise.
- Greater quality of life at 12-months post-op.
- Increased level of satisfaction with TKA procedure.

SECTION III: PREHABILITATION OUTLINE

Frequency and Duration

This prehabilitation protocol includes 2 in-clinic sessions per week during the final 8 weeks leading up to surgery (16 sessions total), which are to be supervised by a licensed PT or PTA.

The patient will also be expected to complete a home exercise program (HEP) composed of daily aerobic activity and stretching, as well as strength training at least 3 times per week, in order to improve upon functional gains made in the clinic.

Reasoning:

- Duration: The 8-week-long duration provides adequate exposure needed to achieve significant strength gain as a result of hypertrophy of muscle tissue.[48,49]
- Supervision: Individual supervised exercise programs have shown greater efficacy at reducing pain and improving physical function in patients with knee OA, compared with community-based or home-based exercise programs.[1,26] Greatest clinical benefit of exercise intervention for patients with knee OA is associated with ongoing monitoring/supervision by a rehab professional.[46]
- Frequency: The effect of prehabilitation treatment appears to be influenced, in large part, by the number of face-to-face sessions with the supervising rehabilitation professional.

- 12 or more supervised PT sessions appears to have greater magnitude of effect on pain and physical function outcomes for up to 6 months postoperatively, compared with less than 12 supervised prehabilitation sessions.[26–28,46]

Volume and Intensity

Specific intervention activities should be completed at moderate to high volume and intensity, as tolerated.

Reasoning:

- The intensity at which exercise is performed is a key variable in maximizing strength and performance improvements. Greater volume and higher intensity progressive exercise is required to induce a neural drive that maximizes neuromuscular activation of the targeted muscle fibers, especially when the goal is to promote the greatest possible gain in muscle strength over a short period of time.[48,49]
- Prehabilitation programs composed of higher intensity exercise have demonstrated greater improvement and significant treatment effect on lower extremity muscle strength, knee ROM, performance-based functional measures, and reduced pain for up to 6-months postoperatively, as well as shorter length of inpatient hospital stay, compared with lower intensity programs.[27,34]

Activity Progression[40,46]

As a general guide, progression of prehabilitation activities should be based on:

- The patient's ability to maintain good form and control of motion with moderate-to-high level of intensity;
- Pain symptoms ≤ 5/10 based on the Numeric Pain Rating Scale (NPRS).

Challenge of activity should be increased by changing one activity variable at a time (such as activity duration, volume of repetitions, speed or direction of movement, or mode of exercise).

Parameters:

- For aerobic exercise: Instructing patients on how to use the Modified Borg Scale/Relative Perceived Exertion (RPE) scale (0-10) to assess exercise intensity can help to guide progression of activity challenge.[50]
- For strength-training: Level of intensity/resistance should be based on a 1- repetition max. Instruct patients on the goal of working target muscles to fatigue in 8-12 repetitions, with ability to complete additional 1-2 sets with rest breaks in-between.

Comorbidities[19,40,51]

Patients with knee OA often present with extensive past medical history, comorbidities, and/or chronic illnesses. Even just one comorbid disease can impact physiologic response to exercise, and many patients suffer from multiple. The number of comorbidities in older adults is associated with worse physical function and disability. Compared to older adults with just 1 comorbidity, older adults with 2 or 3 comorbidities are 1.5 times more likely to have poor physical function; older adults with 4 or 5 comorbidities are 2.7 times more likely to have poor physical function and those with 6 or more are 4.4 times more likely to have poor physical

function. Lower physical function is associated with delayed recovery and thus patients with multiple comorbidities may require longer duration of prehabilitation intervention (10-12 weeks) in order to achieve prehab goals. Additionally, comorbid illnesses may make it more difficult for patients to comply with the prescribed exercise regimen, further delaying progression of activities.

General Exercise Precautions[40,46,52]
Monitoring patient response to different modes of exercise and modifying activity as needed is key to ensuring patient safety during prehabilitation intervention while still maintaining intended value of the program.

Potential adverse reaction to exercise may also include increased knee pain, pain in other joints such as the low back or hip, and joint swelling. Educating the patient on the importance of self-pacing activity, warming-up a stiff joint before exercise, cooling-down after exercise, and daily completion of the home stretching program may help to reduce patient risk of injury or soreness. Instructing patients to apply an ice pack to a sore knee after exercising may also provide some short-term relief of pain symptoms and reduce any swelling.

Many patients with knee OA are often afraid to participate in exercise because they think it will cause them further injury. As a result, patients may have heightened sensitivity to pain or demonstrate movement avoidance behaviors. Here, too, slow and gradual progression of activity with continued patient reassurance and coaching can help to improve patient pain threshold and tolerance for activity.

Outcome Measures

Patient-reported outcome measures help to provide better understanding of the patient's subjective level of pain and function. Below are suggestions for subjective functional measures that have been designed specifically for use with knee OA patients indicated for TKA or have been validated for use with this population.

- **Oxford Knee Score (OKS)**[49] is used to monitor progression of pain symptoms and function and has shown to have good psychometric properties in terms of validity, reliability, and responsiveness to clinical change in knee OA patients, both with or without TKA.
- **Western Ontario and McMasters Universities Osteoarthritis Index (WOMAC)**[50,51] evaluates response to treatment in terms of pain, joint stiffness, and physical function and has established cutoff points specifically for use with the TKA patient population.

While no floor or ceiling effects have been observed with use of either the OKS or WOMAC preoperatively, both are reported to have ceiling effects at 6-months postoperatively, likely due to subject achievement of optimum outcome, as opposed to measurement limitation.[49,50]

Other measures that are commonly used but have shown to have worse psychometric properties in clinical trials are the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Knee Society Clinical Rating System (KSS); further validation studies are thus recommended before use with this patient population.[50,51]

- **The Risk Assessment and Prediction Tool (RAPT)**[52,53] is a preoperative survey that has demonstrated good predictive accuracy for discharge disposition after total joint arthroplasty and may assist with discharge planning and establishing patient and family expectations related to postoperative recovery.

Performance-based functional measures, in comparison to patient-reported measures, are more responsive to acute changes in patient impairments and limitations.[19]

- The Osteoarthritis Research Society International (OARSI) has established a recommended and minimal core set of performance-based tests to assess key domains of physical function in knee OA patients awaiting or following TKA.
  - **OARSI minimal core set of performance-based measures**:[53] 30-second Chair-Stand Test, 40 Meter Fast-Paced Walk Test, and Stair-Climb Test; recommended set also includes the Timed Up and Go Test (TUG), and 6-minute Walk Test.
- The **TUG** has also shown to be an independent and stable preoperative determinant of delayed inpatient recovery of activities after TKA, with lower preoperative scores associated with discharge to SNF as opposed to home discharge.[54]
- Preoperative time on the **Single-Leg Stance Test** with eyes open has been associated with limited ADL in older adults 6-months post-TKA.[35]
- Additionally, the 3 **BESTests** are recommended as having good reliability and validity in measuring balance performance in TKA patients and do not have significant floor or ceiling effects at 6-months post-op; they have shown moderate-to-strong correlation with the patient-reported Activity-Specific Balance Confidence Scale.[55]

It is recommended that patients be assessed at baseline, after completion of the first 4 weeks of prehabilitation, and at the conclusion of the 8-week-long intervention in order to assess short-term progression, as well as overall treatment efficacy and patient achievement of program goals.

SECTION IV: PREHABILITATION INTERVENTION METHODS

Previous clinical trials have demonstrated that the TKA prehabilitation exercise protocol must provide variety of exercise training in order to positively impact outcomes. This protocol consists of aerobic endurance, strength, and balance training, activities for improving ROM and flexibility, and a home exercise program to maximize intervention effectiveness and achieve patient goals.[56]

Intervention 1 is to be completed in the clinic under the supervision of a PT or PTA, as well as independently by the patient outside of the clinic. Interventions 2-4 are all to be completed in the clinic under the supervision of a PT or PTA. Intervention 5 is to be completed independently by the patient outside of the clinic.

Specific intervention activities have been adapted from common exercises in previously successful prehabilitation protocols.[26–28]

Intervention 1: Progressive low-impact aerobic endurance training

Purpose: Improve preoperative cardiorespiratory function and endurance, bone health, physical performance with daily activities, and reduce joint pain.

Clinical intervention activities

In-clinic dynamic warm-up prior to additional exercise (choose one): [27,28]

- Stationary cycling: 10 minutes at low-level intensity.
- NuStep training (legs only to start): 10 minutes at moderate-level intensity.

Home aerobic activities

Due to the constraints of the clinical environment, the patient will be expected complete most of their aerobic exercise training independently, with the goal of completing some form of moderate-intensity aerobic exercise at least 5 days a week and working up to 30 minutes of aerobic exercise at a time,[50] with the goal of achieving and maintaining RPE of 4-5/10 using the Modified Borg Scale.[57]

Progression of activity should be based on RPE, pain, and physiologic response. As patients are likely to present with comorbid medical conditions or take medications that alter normal physiologic response to exercise, use of the RPE scale is likely to be one of the more valid measures of exercise intensity.[58] The level of training intensity also needs to be increased in order to continue challenging the patient's cardiovascular function. The suggested method for progression is to increase activity duration, followed by increasing speed or resistance.[50]

Special considerations:

Patients indicated for TKA have severe degeneration and knee joint structural damage with high intensity of pain symptoms, even at rest. Starting out initially with low-to-no impact activities, such as stationary biking or NuStep training, provides opportunity for cardiovascular and endurance training, strengthening of quads and hamstrings, and increasing flexibility, without additional joint loading. However, these modes of exercise will not provide effective stimulus for bone strengthening. If patients are able to complete stationary cycling without symptom exacerbation, they may tolerate progression to walking on a stable surface (such as a track or treadmill), which will provide adequate weight-bearing stimulus, in addition to being a more functional training activity.[59]

In addition to stationary cycling and walking, other low-to-no impact activities that could be suggested to patients are Elliptical or Arc training. These activities also provide the benefit of increasing heart rate and building endurance capacity in weight-bearing positions, but with greater off-loading of joints. Water walking is another option that helps to build cardiovascular and muscle endurance, as well as improve flexibility and reduce pain; however, joints may be completely off-loaded in the water and thus this activity will not provide any benefit in terms of bone strengthening.[52]

Clinical Intervention 2: Strength Training

Purpose: Address preoperative impairments in motor function, control, and weakness through targeted lower extremity muscle strengthening and combined functional strengthening in order to reduce knee forces, pain, and maximize muscular strength and endurance prior to TKA.

Specific intervention activities

Progressive resistance training of major lower extremity muscle groups:

- 2-3 sets of 10 reps with 60 second rest between sets;[27]
- Resistance based on 10-repetition maximum;[57]
- Goal to improve strength of individual muscles groups by at least 15-18%, which is considered "substantial" clinical improvement in muscle power in mobility-limited older adults.[60]

  - Straight-leg raise in hook-lying;
  - Standing hip abduction;
  - Standing hip extension;
  - Single-limb seated leg press.
  - Bridges

Progressive lower extremity functional strengthening: 2-3 sets of 8-12 repetitions.

- Sit to stands:[61]
  - 30-second chair stand test—Fall risk indicators:
    - Patients under 64 years: < 14 reps (males); <12 reps (females).
    - 65-69 years: <12 reps (males); <11 reps (females).
    - 70-74 years: <12 reps (males); <10 reps (females).
    - 75-79 years: <11 reps (males); <10 reps (females).
    - 80-84 years: <10 reps (males); <9 reps (females).
    - Over 85 years: <8 reps for both males and females.
- Forward step-ups to 4 or 6-inch step;
- Lateral step-ups to 4 or 6-inch step;
- Step-downs from 4-inch step.
  - 2-Minute Step Test: Score < 65 is associated with lower levels of functional ability.[61]

Activity progression:

Suggestions for progression of intensity/challenge of lower extremity resistance and functional strength training:

- Reduced use of any upper extremity support;
- Increased resistance with ankle weights, TheraBand, or machine weight;
- Progressive isometric holds at various points in range;
- Concentric muscle action with controlled eccentric phase;
- Increased step height or negotiation of a full flight of stairs;
- Altered base of support or unstable support surface.
- Bridges can be progressed with TheraBand around knee to preferentially strengthen hip abductors or squeezing ball between thighs to preferentially strengthen hip adductors.

Activity modifications:

Depending on the patient's baseline level of endurance function, initial response to exercise, and/or pain tolerance, exercises may need to be modified initially.

Suggestions on modifications to decrease activity intensity/challenge:

- Isometric contraction in closed kinetic chain;
- Use of gravity-eliminated positions;
- Eccentric muscle action;
- Decreased range of motion;
- Reduced number of sets.

Special considerations: With all strengthening activities, prehabilitation should also focus on improving the strength of the non-injured limb.

Clinical Intervention 3: Functional balance training

Purpose: Increase body awareness, proprioception, and neuromuscular control to improve preoperative static and dynamic balance.

Specific intervention activities:

Progressive timed static balance tasks:

- Tandem stance: Cut point—Less than 10 seconds is a fall risk indicator.[62]
- Single-leg stance: Cut point—Less than 10 seconds indicates balance impairment and less than 5 seconds indicates increased risk for injurious fall.[63]

Suggestions on progression of activities to increase level of challenge:

- Standing on unstable surfaces.
- Removal of vision.

Dynamic balance tasks:

- Dual-motor functional activities;
  - TUG Manual test (walking while carrying a cup filled with water): completion in >14.5 seconds is 90% predictive of falls in older adults.[64]
- Motor-cognitive dual;
  - TUG Cognitive test (walking while counting backward by 3's from a randomly selected number between 20 and 100): Completion in >15 seconds is 87% predictive of falls in older adults.[64]

Suggestions on progression of activities to increase level of challenge:

- Stepping over objects;
- Retro-stepping;
- Ball throwing and catching.

Clinical Intervention 4: Flexibility and Range of Motion

Purpose: Increase preoperative knee joint range of motion to reduce risk of postoperative knee stiffness.

Specific intervention activities:

Static stretching:

- For patients 64-years and younger: 30-second hold; 3 sets bilaterally with 30-second rest between sets.[65]
- For patients 65-years and older: 60-second hold; 4 sets bilaterally with 10-second rest between sets.[66]
  - Standing heel cord stretch;
  - Standing hip-flexor stretch;
  - Seated figure-4 stretch;
  - Standing quad stretch (patient likely to require a chair or elevated surface to support limb);
  - Seated hamstring stretch.

Knee joint range of motion: 2 sets x 10 repetitions with 5 second hold (choose just one to be completed during PT session).[67]

- Gravity-assisted heel slides on wall (patient in supine with hips/knees flexed); can use opposite leg to assist with overpressure;
- Actively-assisted heel slides in supine using towel;
- Seated heel slides; can use opposite leg to assist with overpressure;
- Lunge stretch for knee flexion on stair.

Intervention 5: Home Exercise

Purpose: Maintain functional gains made in the clinic while continuing to address underlying structural and body-function impairments between PT sessions.

Patients should be instructed on how to complete HEP during the initial prehabilitation session and provided with TheraBand of appropriate resistance. In subsequent visits, practical review of exercises is necessary to ensure patient understanding and completion with proper form, positioning, mechanics, and task sequencing.

A proposed home exercise program presented in a patient-friendly handout may be viewed in **Appendix B**. Each exercise includes step-by-step written instructions and images that depict sequencing, highlight target muscles, and provide directional cues.

Evidence suggests that home exercise adherence and performance is inversely related to the number of exercises prescribed.[68,69] The proposed home exercise program thus consists of 4 exercises in the hopes of increased adherence. A page of additional exercises has also been included, which may be added to the program or used as alternatives, dependent upon the patient response.

The proposed home exercise program consists of:

1. Heel slides;
2. Hamstrings and calf stretch;
3. Single-leg squat;
4. Seated knee extension with TheraBand.

Additional exercises (optional):

1. Seated knee flexion with TheraBand;
2. Standing calf raises;
3. Side-lying hip abduction;
4. Prone hip extension;
5. Mini-squats;
6. Heel slides in supine with use of towel;
7. Hamstring/calf stretch in supine using belt/strap;
8. Quadriceps stretch in prone using belt/strap.

Ongoing verbal review and intermittent in-clinic practice of HEP should be completed to ensure proper patient compliance and assist with progression of activities.

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