The Benefit of Prehabilitation Prior to Knee Arthroplasty

Evidence is building with publication of recent studies that prehabilitation before surgery can aid in rehabilitation after surgery

The American College of Rheumatology recommends that aerobic, range-of-motion and muscle-strengthening exercises, along with physical therapy and assistive devices for walking all be included in the management of osteoarthritis (OA) of the hip and knee.[1] Because the number of people with OA is expected to increase dramatically over the next 10 years, and because most of these people will not require surgery, a pressing need is development of nonoperative care that will relieve pain, improve function, and delay progression of the disease.[2] But for those who do need surgery, recent studies are showing that preoperative exercise programs help to prepare patients for surgery by strengthening the affected knee and improving functional ability.[3]

These programs have been termed "prehabilitation."[4] The primary goal, based on the concept that a stronger, more functional knee before surgery will accelerate a person's recovery after surgery, is to increase knee strength and functional ability while reducing pain.[3] Programs can consist of a combination of exercises including walking, chair rises, and stair climbing and descending. Models have been developed that could improve outcomes after total knee arthroplasty (TKA), with one described in a previous issue of *Lower Extremity Review*.[3] However, evidence of the benefits of prehabilitation is limited, but is still building. A PubMed search, for instance, on the term "prehabilitation" alone without date limits produced only 44 publications as of early October of this year.

One study found that improving knee strength, range-of-motion, and the ability to perform functional tasks, coupled with reducing overweight and obesity among patients, before TKA may contribute to higher function levels after TKA.[5] Yet another study found little evidence that preoperative exercise improved functional ability after surgery.[6] A third study recommends that future research should focus on improving strength, range of motion, and functional task performance prior to TKA to improve functional performance after TKA.[7]

A 2009 review of literature from 1998 to 2008 found that only three studies met criteria of using preoperative exercise as the only intervention studied.[8] The author concluded that more research is needed and that only a "pragmatic" recommendation could be made for prehabilitation for total hip or knee arthroplasty.

Case and Smaller Studies

A newly published case study report points to likely benefits that can be derived from such programs.[9] Brown et al reported in the August issue of *Physiotherapy Theory and Practice* that one 69-year-old female patient whose left TKA was preceded by a prehabilitation intervention had a 30% improvement in functional ability, compared to a previous right TKA preceded by usual care. Prompting the patient to go ahead with the surgeries were knee pain, joint stiffness, and decreased functional ability. The prehabilitation program consisted of four weeks of exercises designed to improve performance on functional tests including a six-minute walk, sit-to-stand chair rises completed in 30 seconds, and the time to ascend, then descend two flights of 11 stairs each.

During prehabilitation, measurements were taken four weeks prior to TKA, again just prior to TKA, then one month and three months following TKA. Results show that she experienced more than a 50% gain in extension strength in both knees and a 34% (left) and 54% (right) gain in flexion strength just prior to the second surgery compared to four weeks prior to surgery. Following the second surgery, she maintained the strength in her right leg but not in the left. Although the patient experienced higher pain levels during prehabilitation, she returned to lower pain levels three months after the left TKA.

Jaggers et al reported on a similar case study in a 2007 article in the *Journal of Strength and Conditioning Research.*[10] That study compared the results of a 62-year-old woman who participated in a four-week prehabilitation program prior to a right TKA to those of a 57-year-old woman who underwent usual care prior to having a right TKA. The prehabilitation protocol emphasized resistance training, flexibility, and step training. Functional testing evaluated distance covered in a six-minute walk, number of chair rises in 30 seconds, proprioception, and pain and function as measured using the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index. The prehabilitation patient experienced a 26% improvement in six-minute walk distance and a 1100% improvement in perceived pain 12 weeks after surgery compared with five weeks before surgery, while the usual care patient experienced a 2% decline in six-minute walk distance and a 350% improvement in perceived pain. The authors suggest that prehabilitation could reduce the length of hospital stay and the amount of rehabilitation after surgery, and it could help to reduce the cost of overall care for TKA patients.

Rooks et al reported on a study involving 108 men and women scheduled for total hip arthroscopy (THA) or TKA in a 2006 article in *Arthritis & Rheumatism.*[11] Patients were randomized to an intervention group that performed six weeks of exercise prior to surgery or to a control group that received education only. The patients in the prehabilitation group exercised three times a week for six weeks prior to surgery. The first three weeks of exercise consisted of repeating single-joint movements while standing chest-deep in a pool. The next three weeks focused on the total body and included cardiovascular, flexibility, and strength exercises. Of the 49 patients who completed the study, 65% of the exercisers went directly home after inpatient surgery stays and 35% went into inpatient rehabilitation, compared with 44% of the control group going home after surgery and 56% going into inpatient rehabilitation. Also, 76% of the exercisers walked on the third day of inpatient care, compared to 61% of the control group. For hip and knee patients, the prehabilitation intervention reduced the odds of needing post-surgery inpatient rehabilitation by 73%. However, the TKA patients in the prehabilitation group experienced a worsening of pain during the intervention prior to surgery. And the TKA exercisers did not improve in function levels as well as THA exercisers, although both groups increased their lower extremity muscle strength prior to surgery.

Topp et al reported on a study to examine effects of prehabilitation on functional ability, knee pain, and quadriceps strength among TKA patients before and after surgery in a 2009 article in *Physical Medicine & Rehabilitation.*[12] Of the 54 patients recruited for the study, 28 were randomized to a control group and 26 to a prehabilitation group. The prehabilitation protocol included resistance training, flexibility, and step training three times a week for a minimum of four weeks. Prior to surgery, the prehabilitation group exhibited a significant improvement in sit-to-stand ability and a nonsignificant trend toward improvement in three other tasks, as well as a trend toward improved quadriceps strength. The control group reported greater pain just before surgery, compared with baseline levels, while walking and doing sit-to-stand exercises, and showed a nonsignificant trend toward declining performance in functional tasks

decreased knee strength prior to surgery. One month after surgery, the prehabilitation group maintained improvement in sit-to-stand and had no other changes. The control group showed a decreased performance in walking and a decrease in quadriceps strength in the surgical knee compared with baseline. The authors suggest that these and other study findings support the efficacy of prehabilitation but also show a need for further research.

Limitations

Limitations to these studies point to how to improve future research. The Brown study[9] authors suggest that a more aggressive prehabilitation intervention that lasts more than four weeks, perhaps for six to 12 weeks, prior to TKA would produce more improvement in strength. Authors of the Jaggers study recommend research be conducted on a much larger scale. Rooks et al[11] recommend focusing in more on TKA patients rather than multiple joint replacements and looking at the cost effectiveness of prehabilitation programs for TKA patients, as well as making future studies as convenient as possible for participants. Authors of the Topp study[12] suggest that the self-selected participants in their study may have had positive expectations that led them to clandestinely participate in other types of exercise or increase their physical activity before surgery. Also, the study did not track consumption of pain medication. Standardization of prehabilitation sessions prior to surgery would also be beneficial, Topp et al concluded.

One limitation of prehabilitation interventions to date is that patients with osteoarthritis symptoms severe enough to necessitate surgery may also find that their pain impairs their ability to perform exercises, so that they may not realize the full potential benefit of a prehabilitation protocol. The fact that Brown[9] and Rooks[11] both reported that patients experienced increased pain during prehabilitation underscores this issue and raises the possibility that prehabilitation patients in both studies might have experienced even more positive outcomes if their pain during exercise could have been managed more effectively.

Bracing and prehabilitation

Knee braces that unload the affected compartment and improve underlying malalignment have the potential to address this problem. Research has shown that malalignment of the leg is the most influential factor in load distribution across the medial compartment of the knee.[17] Research suggests that so-called "unloader" braces, which typically employ a three-point bending mechanism, can decrease pain and increase function in patients with knee osteoarthritis, although the degree of efficacy observed varies between studies, and comparative studies of different types of braces are limited.[14,15,16]

Pollo et al tested 11 patients in 2002 and reported that during gait, bracing effectively reduced medial compartment load, reduced pain, and improved knee function in OA patients.[17] Another study by Pollo and Jackson showed that bracing significantly increases function and reduces pain when used in managing OA.[18] A 2006 analysis by Dennis et al suggested that unloading knee braces vary in effective treatment for unicompartmental knee OA.[19] Draganich et al compared the use of self-adjustable custom braces with off-the-shelf models and concluded that, while patients with varus gonarthrosis can experience at least short-term benefit from any of the braces, the custom braces produced added benefit over and above off-the-shelf braces.[20] Rannou et al recommended in a 2010 paper that braces be included in treating knee OA, and that the various types be adapted to the symptomatic knee compartment, but also called for good clinical trials into the modalities.[21]

The improvement in symptoms associated with OA bracing is thought to result from a valgus moment applied by the brace in patients with medial compartment OA, which counteracts the elevated external varus moment typically seen during gait in this patient population. Several studies have demonstrated that valgus OA bracing reduces knee adduction moment during walking by as much as 33% and during running by up to 11%, depending upon the valgus angulation of the device.[17,22-26]

The typical unloader brace used in such studies features upper and lower thermoplastic cuffs and a diagonal strap that provides the third point in the leverage mechanism. However, a 2009 finite element analysis study suggests that a different type of brace design, featuring soft conforming materials and a pneumatic leverage system of air bladders, could potentially offset varus loading to an even greater extent.[22]

A computer model was developed to assess the unloading effects of a pneumatic OA brace in 45-year-old men and women, using anatomical data taken from the literature. The brace in the model consists of a sock that conforms to the shape of the leg, three inflatable bladders, and a strap that goes around the knee. When the bladders are inflated, the strap tenses, and the combination is designed to produce greater force at three strategic knee points than other valgus unloader braces. The model predicted that in women, the unloading moment of the brace would exceed the excessive adduction moment during gait at a given level of bladder air pressure. Similar results were predicted in men, though the unloading moment was closer to 90% of the excessive adduction moment.

A pneumatic brace that is the subject of ongoing research[27] by another group features adjustable, customizable joint unloading and contoured air bladders to provide varus or valgus unloading of the knee, depending on a patient's condition and unique anatomy. The brace provides for adjustment in gait correction during swing phase through an elastic tensioning system and is lighter and easier to apply than traditional unloader braces. Its skeletal system is designed to dynamically conform to the knee's shape, minimizing brace migration during walking. In unpublished case studies over the past two years, patients using the brace have experienced less pain, increased their leg muscle mass, and improved their gait biomechanics.

The swing assist mechanism may also enhance rehabilitation following TKA, as it can be adjusted incrementally to allow greater range of motion over time. Anecdotally, patients have reported experiencing no pain after discontinuing the use of the brace.

A pilot study is under way to investigate the ability of the brace to improve gait kinematics, strengthen knee flexor and extensor muscles, improve clinical outcomes, and look into whether the using the brace prior to surgery can improve the outcome of rehabilitation after TKA. Few studies have looked at the ability of bracing to accomplish these goals.

Ten patients with symptomatic, severe (Kellgren-Lawrence grade 3 or 4) medial compartment knee OA will comprise a single treatment arm, including use of the brace and acetaminophen and/or nonsteroidal anti-inflammatory medications. Patients will use the brace while walking for two to three months, depending on symptom severity, then will be asked to stop using it and then return after an additional two months. All will have the option of undergoing TKA at any time. All patients will be followed for at least one year. The end point will be TKA, but patients will be followed for an additional three months of postoperative rehabilitation.

Other options

Additional interventions under study to augment model exercise programs for OA patients include a biomechanical device applied to the feet of OA patients and preoperative neuromuscular electrical stimulation to the quadriceps muscle. Adding psychological interventions, exercising both knees, and conducting concurrent weight-loss programs also have been recommended.[25]

A study in Israel by Bar-Ziv et al evaluated the application of a biomechanical device to the feet of knee OA patients in reducing pain and improving function.[29] The device was designed to incorporate the offloading strategies of valgus bracing and other orthotic interventions,[30-34] along with other strategies designed to challenge and improve neuromuscular control in the affected limb.[35-37] It features two half-spheres attached to the underside of the patient's foot, one under the forefoot and one under the rearfoot, via a platform designed to facilitate customized positioning of the two elements for each patient.

In the Bar-Ziv study, 57 bilateral knee OA patients enrolled in active and control groups, with the device individually calibrated to patients in the active group and patients in the control group receiving an identical platform for the foot but without the biomechanical elements. After the eight-week end point, the active group showed a mean improvement from baseline of 64.8% in perceived pain and a mean improvement of 31.4% in function, compared to no improvement in the control group.

Given the importance of improving quadriceps strength in patients with OA,[38] other researchers have explored the use of preoperative neuromuscular electrical stimulation (NMES) on quadriceps strength after TKA.[39] Studies have indicated that NMES can strengthen quadriceps and improve functional performance[40] and can be as effective as exercise therapy.[41]

Walls et al[39] analyzed nine patients who received eight weeks of the NMES stimulation to the quadriceps femoris muscle (QFM) of the affected limb in a home-based, unsupervised setting prior to TKA, compared to five control patients. The stimulator was portable, battery-powered, and garment-based. From baseline to pre-surgery, patients in the NMES group increased peak torque of the QFM by 27.8%, compared to a 12.1% increase for patients in the control group. QFM strength decreased in both groups after surgery, but improved between six and 12 weeks post-surgery only in the NMES group. Cross sectional area at 12 weeks post-surgery improved to 3.7% below baseline levels in the NMES group but remained 12% below baseline levels in the control group.

Summary

Prehabilitation is not a candidate for some patients, notably patients with major trauma or an acute catastrophic medical conditions, for which a slight increase in physical activity can be a health risk.[4] But for likely candidates, prehabilitation can prepare a patient for the anticipated TKA stressors by improving functional capacity before the surgery.[2]

Exercise interventions in general are likely underused in the management of knee OA, even though moderate exercise does not accelerate OA progression and patients who exercise appear to gain improved physical function and reduced pain.[42]

Osteoarthritis TKA: At a glance[3]

Osteoarthritis is one of the most common chronic health problems, and its impact is projected to increase with an aging society and a growing obesity epidemic.[3,43]

59% of adults over age 65 are affected by OA.

OA disables about 10% of people over the age of 60.

OA accounts for 55% of all arthritis-related hospitalizations and costs about $60 billion a year.

Treated pharmacological at first, knee OA often progresses to the level of requiring TKA

Knee and hip replacements represent 35% of arthritis-related hospitalization procedures, with estimated costs running $7.9 billion in 1997.

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