7 Postoperative Rehabilitation Part II: Strategies for Successful Return to Physical Activities and Athletics in Postoperative Weeks 13–52

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7.1 Introduction

This is the second of two chapters that detail our total knee arthroplasty (TKA) postoperative rehabilitation program, whose overall goal is to return patients to an active lifestyle to enhance their overall quality of life. Chapter 6 discusses the protocol for the first 12 postoperative weeks and includes important concepts to avoid complications, such as limitations in range of motion (ROM) and severe muscle strength deficits. At the end of this time period, patients should be pain-free with activities of daily living and preparing to return to light work and low-impact aerobic activities such as walking, bicycling, and swimming over the course of the next few months. Because TKA is performed in many younger patients, the desire to return to more strenuous activities is important to these individuals. These patients have high preoperative expectations [1–3] that correlate strongly with postoperative patient satisfaction [2, 4, 5], as detailed in Chap. 12. In our experience, additional strengthening and conditioning exercises are usually required in order to safely prepare them to participate in activities such as doubles tennis, light jogging, hiking, and skiing.

We conducted a systematic review of studies published from 2005 through 2015 to determine what routine sports and physical activities patients participated in after TKA [6]. The review also determined if participation in these activities caused knee symptoms such as pain and swelling. In addition, the effect of postoperative rehabilitation on achieving fitness and sports goals was analyzed. Nineteen studies met the study criteria. There were 5179 knees (mean age, 67.5 years) followed a mean

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of 4.8 years postoperatively. Marked variability was found in the percent of patients who resumed recreational activities (34% to 100%). A low range (0–16.5%) of patients met American Heart Association (AHA) guidelines for aerobic physical activity (see also Chap. 10). Few studies determined if symptoms or limitations were experienced, and none described rehabilitation exercises or factors that would influence patients' ability to return to recreational or fitness activities.

Kuijet et al. [7] conducted a review of studies published from the inception of several databases to March 2017 to determine the effect of exercise-based rehabilitation on return to work and sports after TKA. The search resulted in 3788 studies, none of which evaluated the study purpose. These authors stated the same concerns that we expressed in this near complete lack of information and noted that most published rehabilitation programs lasted no longer than 6–12 weeks postoperatively. This indicates that many patients may not receive additional support for the safe and successful return to recreational activities. In addition, the lack of additional strengthening and conditioning measures could play a major role in the high rate of variability of patients who return to physical activities and who have later complaints of knee pain or instability, and in the very low rate of patients who meet AHA physical activity guidelines.

7.2 Strengthening and Conditioning

Our rehabilitation program for postoperative weeks 13–26 (3–6 months) is shown in Table 7.1. In our experience, patients require this program during this time period to prepare them for return to recreational sports and other more strenuous activities. Return to sports is then usually accomplished 6–12 months postoperatively, provided the patient passes our criteria (which is detailed in the next section of this chapter), and there are no symptoms of pain or swelling with activity.

Progression of weight and the amount of time spent in aerobic conditioning is individualized and based on the final activity (or activities) the patient desires to return to and if recurrent pain or joint effusion occurs. Symptoms necessitate modification of the program until the problems are resolved. Fitness center training is eventually recommended two to three times per week and includes 20 minutes of strengthening, 30 minutes of cardiovascular exercise, and 10 minutes of flexibility. This is a realistic goal for our TKA patients and provides a reasonable level of fitness. There is a higher goal for more active patients, recommended by the AHA guidelines, to achieve up to 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity [8, 9]. For aerobic fitness, the patient is instructed on the options available, including the exercise bicycle. Rowing or eclipse machines are ideal because both the upper and lower extremities are exercised. A program of brisk walking on the treadmill is an option; however, jogging activities involve impact loads that may increase prosthetic loosening over the long term and are not recommended. At the time of writing, the most recent activity recommendations following TKA by the American Association of Hip and Knee Surgeons were

Table 7.1 Noyes Knee Institute rehabilitation protocol for total knee arthroplasty (postoperative weeks 13–26)

Modalities: Pain/edema management (cryotherapy)
Stretching: hamstring, gastrocnemius-soleus, gluteal, iliotibial band, quadriceps
Strengthening:
Straight leg raises
Closed chain: wall sits, mini squats
Closed chain: toe/heel raises
Knee flexion hamstring curls (0°–90°)
Knee extension quadriceps (90°–0°)
Hip abduction-adduction, multi-hip
Leg press (80°–10°)
Upper body weight training
Core training
Balance/gait/proprioceptive training:
Band walking (diagonal, monster walk), Y-balance reaching, perturbation training
Conditioning:
Stationary bicycling (high seat, low resistance)
Aquatic program (water walking, depth at thigh or waist)
Stair machine (low resistance, low stroke)
Ski machine (short stride, level, low resistance)
Elliptical machine
Swimming (kicking)
Walking
Fitness center training (2–3 ×/week):
25 minutes strengthening, 25 minutes cardiovascular training, 10 minutes flexibility
Achieve AHA guidelines.[a] Monitor for swelling, pain

[a]American Heart Association guidelines: physical activity per week: 150–300 minutes moderate intensity or 75–150 minutes vigorous intensity. Strengthening all major muscle groups ≥2 days/week

Table 7.2 Activity recommendations after TKA from the American Association of Hip and Knee Surgeons[a]

Activities allowed	Activities not allowed
Walking	Jogging
Climbing	Sprinting
Bicycling on level surfaces	Skiing on difficult terrain
Swimming	Singles tennis
Doubles tennis	
Golfing	

[a]From Swanson et al. [10]

published in 2009 (Table 7.2) [10]. Based on the results of 139 completed surveys from the 2007 annual meeting, consensus was reached for low-impact activities such as walking, climbing stairs, bicycling on level surfaces, swimming, doubles tennis, and golfing. Activities that were consistently discouraged included jogging, sprinting, skiing on difficult terrain, and singles tennis.

In addition, muscle-strengthening exercises of moderate or greater intensity that involve all major muscle groups should be performed at least 2 days per week. This

strength program should be inclusive of the lower extremity, torso, core, and upper extremity muscle groups.

Our experience has found that the preoperative review of patient goals and prior athletic participation are important in order to establish realistic expectations regarding postoperative activities. For instance, if a patient played doubles tennis or cross-country skied before surgery, they potentially will be more successful in returning to these activities postoperatively than if they did not participate. There exists the problem that active younger patients recall, prior to the onset of knee arthritis, the ability to perform strenuous recreational activities such as singles tennis, jogging, softball, and other running sports. After TKA, these activities are not advised, and modification of athletic activities and realistic patient expectations need to be established in preoperative counseling.

Once patients satisfy our Biodex strength and function testing goals (described in the next section), progression to light agility and sports-specific drills may begin. Discussion, planning, and implementation of exercises and drills should be included as a component of functional progression to return to full activity. For example, a person returning to light doubles tennis may begin short-distance light jogging in a straight line and lateral directions. This may be followed by four-square surface agility moves in straight planar directions, then multidirectional patterns, and, finally, train with the racket on ground strokes. If the patient demonstrates apprehension or difficulty with any of these activities, remedial rehabilitation exercises using elastic resistance bands could be implemented to progress muscle strength and functional pattern simulations.

7.3 Recommended Testing for Return to Sports Training

As our patients begin training for recreational sports, they must pass specific criteria shown in Table 7.3. There must be no pain or swelling with the strengthening and fitness training program or in any other activities the patient is performing. The patient must demonstrate good patellar mobility and symmetrical gait. Muscle strength may be tested according to the equipment available. In our center, a Biodex test of isometric quadriceps and hamstring strength is performed (Fig. 7.1). Test scores are evaluated for bilateral comparisons, quadriceps peak torque-to-body weight ratios (adjusted based on age and sex), and agonist-to-antagonist ratios. Males aged 55–65 are expected to generate ≥60% of their body weight, and those aged >65 are expected to generate ≥50% of their body weight. Females aged ≥55 are expected to generate ≥50% of their body weight. For both genders, hamstring-to-quadriceps ratios are expected to be approximately 60%. These test scores relate to this higher functioning patient population and represent the strength component of the evaluation process. We established goals based on peak torque comparisons with the contralateral side for quadriceps and hamstrings of 70% to begin interval running, 80% to begin light agility work, and 90% for return to activity. Hip abductor strength may be tested either manually or with a handheld dynamometer.

Table 7.3 Noyes Knee Institute criteria for return to recreational sports training after total knee arthroplasty

Criteria/test	Goal
Pain	None, ≥6 Cincinnati Knee Rating Pain scale
Swelling	None visible and ≥6 Cincinnati Knee Rating Pain scale
Patellar mobility	Good
Gait	Symmetrical
Muscle strength	Manual test: 5/5
Quadriceps, hamstrings	Isometric handheld dynamometer: ≥80% of opposite side
	Isometric peak torque on Biodex: goals compared with opposite side are 70% for interval running, 80% for light agility work, and 90% for return to activity
Muscle strength	Manual test: 5/5
Hip abductors	Isometric handheld dynamometer: ≥80% of opposite side
Single-leg squat test	No knee valgus, medial-lateral movement, or pelvic tilt
Stair-climbing test	10 steps, up and down, can use rail: <13 secs
6-minute walk test	Aged 60–69 years: male ≥521 meters (0.32 mile), female ≥497 meters (0.31 mile)
	Aged 70–79 years: male ≥478 meters (0.29 mile), female ≥440 meters (0.27 mile)
	Aged 80–89 years: male ≥356 meters (0.22 mile), female ≥345 meters (0.21 mile)
Y-balance test	Anterior, posterolateral, posteromedial: ≥90% of opposite side. Normalize each distance by patient's leg length
Fitness training	Can be performed with no pain or swelling
PT/MD	Cleared for initiation of recreational sports

Several well-known objective clinic tests are also conducted (see also Chap. 9). A single-leg squat test is conducted in which the patient is instructed to squat down to 45° and return to single-leg stance without losing their balance (Fig. 7.2a, b). The head and eyes should remain focused straight ahead. The patient performs five consecutive trials, and the clinician notes the overall trunk control and the position of the hip, knee, and foot throughout the test. A stair-climbing test is performed using ten steps, with the goal of ascending and descending the flight in less than 13 seconds. The 6-minute walk test is done on a treadmill. The goals for this test according to gender and age are shown in Table 7.3.

The Y-balance test is performed in the anterior, posterolateral, and posteromedial directions (Fig. 7.3). This is a simplified version of the Star Excursion Balance test that requires the subject to maintain a stable base by balancing on one leg while reaching out with the other leg to push a block as far as possible in the anterior, posteromedial, and posterolateral directions. A detailed description of this test is provided in Chap. 9.

Fig. 7.1 Biodex test setup for isometric evaluation of quadriceps and hamstring muscle strength

Fig. 7.2 Single-leg squat test as viewed from the front (**a**) and side (**b**)

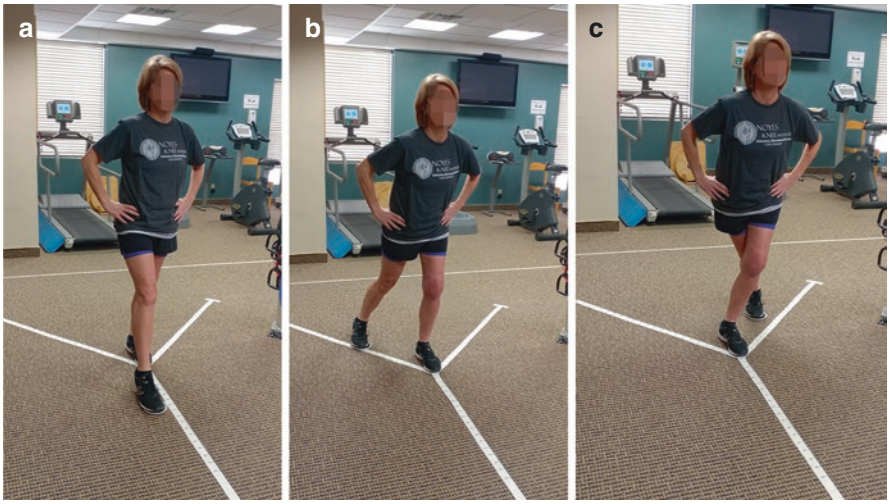

Fig. 7.3 The Y-balance test is performed in the (**a**) anterior, (**b**) posterolateral, and (**c**) posteromedial directions

7.4 Results of Studies From the Authors' Clinic

In 2016, we initiated an ongoing prospective study at our center in patients 65 years of age or younger who expressed the desire to return to recreational sports and/or work activities. Serial objective testing is conducted at 3, 6, 12, and 24 months after TKA. Several patient-reported outcomes are collected at 12 and 24 months postoperatively. The objective test battery includes the single-leg squat test, 6-minute walk test, stair-climb test (ten steps), Biodex isometric testing of quadriceps and hamstring strength, and Y-balance test. This study was devised based on the hypothesis that noteworthy deficits in strength and function are present at 3 months postoperatively, which is the time period the majority of TKA rehabilitation programs conclude. This problem demonstrates the necessity for extending the program to correct muscle weakness and conditioning deficits and allow patients to return to a physically active lifestyle.

Data on the results of objective testing for 50 patients (mean age at TKA, 57.5 ± 6.5; range, 45–69) are shown in Table 7.4. At 3 months postoperatively, less than 50% of the patients passed test goals for the single-leg squat test, 6-minute walk test, quadriceps strength, and Y-balance posteromedial test. In addition, only 21% had at least 130° of knee flexion. These individuals had undergone a mean of 21 ± 8 postoperative physical therapy visits in addition to their home exercise program. All were counseled to continue with the home and fitness center program as detailed in this chapter. At 6 months postoperatively, major improvements were noted in the percent that passed all of the tests with the exception of the single-leg squat.

Table 7.4 Results of authors' prospective study of objective testing after TKA

Test	Goal	3 months po		6 months po		12 months po	
		N tested	% Passed	N tested	% Passed	N tested	% Passed
6-minute walk	See Table 7.2	50	22%	44	39%	37	49%
Stair-climb test	<13 secs	50	64%	44	79%	36	94%
Biodex quads	≥70% of opposite side	48	54%	43	81%	28	78%
Biodex hams	≥70% of opposite side	48	85%	43	88%	28	86%
Both quads and hams	≥70% of opposite side	48	46%	43	74%	28	75%
Y-balance: anterior	≥90% of opposite side	50	60%	44	70%	35	74%
Y-balance: posterolateral	≥90% of opposite side	49	77%	44	66%	35	86%
Y-balance: posteromedial	≥90% of opposite side	50	28%	44	91%	35	86%
Single-leg squat	"Good" rating	48	10%	42	2%	34	32%
ROM active extension	0° or hyperextension	33	91%	38	92%	37	97%
ROM active flexion	≥130°	33	21%	38	74%	37	81%

ROM range of motion

We conducted a study to determine, in a historical younger group of patients (TKA 2013–2015) with high physical activity expectations after TKA, the ability to return to recreational sports and work activities without symptoms or functional limitations. A second purpose was to determine the ability of these patients to achieve aerobic fitness guidelines. There were 51 patients (54 knees, mean age of 58 ± 7 years) who were evaluated in a mean of 4.4 ± 0.5 years (range, 3.4–5.6 years) after TKA. Our TKA registry included the patient-reported outcome measures (PROMs) of the Knee Injury and Osteoarthritis Outcome Joint Replacement Survey (KOOS JR) seven-item score; questions from the Cincinnati Knee Rating System related to the overall knee condition, pain, and swelling [11]; selected questions from the VR-12 Health Survey [12]; questions about general fitness level; and questions regarding patient expectations before and after surgery. Patients were also asked to list all physical, recreational, and work activities they participated in after surgery.

The patients underwent a mean of 14 ± 6 supervised postoperative physical therapy sessions (range, 4–28) in additional to a home exercise program. There were no significant complications, pulmonary embolism, infection, or prosthetic loosening. The final physical examination showed no evidence of knee instability or knee arthrofibrosis. There were no significant differences between genders for any of the outcome factors analyzed. The mean KOOS JR score improved from 43 ± 18 points preoperatively to 87 ± 18 postoperatively ($p < 0.0001$). The mean change was

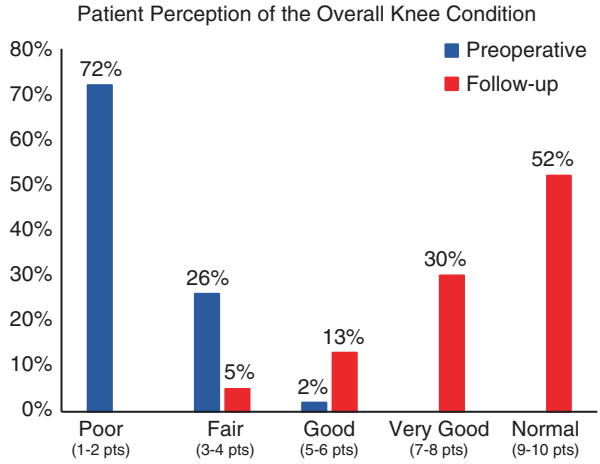

Fig. 7.4 The improvement in the patient-reported outcome of their overall knee condition is before and after TKA and was statistically significant ($p < 0.0001$). Pts points

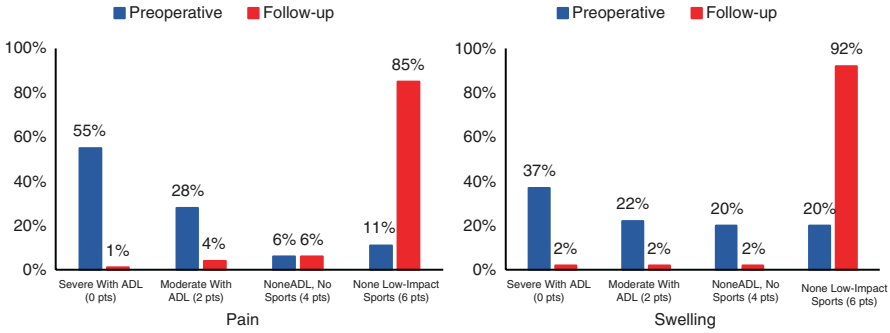

Fig. 7.5 The improvements in patient-reported pain and swelling scores related to patient activity between the preoperative and follow-up time periods are shown ($p < 0.0001$). Pts points

44 ± 24 points, and 48 knees (89%) achieved a minimal clinically important change in this score of ≥14 points [13]. There were significant improvements from preoperative to follow-up in the Cincinnati Knee Rating scores for the patient perception of the overall knee condition (2.0 ± 1.1 and 8.2 ± 1.9 points, respectively; $p < 0.0001$, Fig. 7.4), pain (1.4 ± 2.0 and 5.4 ± 1.6 points, respectively; $p < 0.0001$), and swelling (2.5 ± 2.3 and 5.7 ± 1.1 points, respectively; $p < 0.0001$, Fig. 7.5).

Overall, 44 of 51 patients (86%) were able to resume physical activity and work with no or only minor symptoms or limitations. Participation in sports and recreational activities was determined in 41 patients, of whom 91% resumed low-impact activities and 9% returned to higher-impact athletics. Only three patients had symptoms; one had occasional pain after scuba diving, and two complained of mild

tightness after high-impact activities that were not recommended. Before surgery, 33 of the 51 patients were working (six were disabled, 11 were retired, and one did not work). At follow-up, 28 patients were employed, including seven patients who had retired before surgery and returned to the workforce. Only three patients reported symptoms and limitations with work.

There were significant improvements in the patient responses to the aerobic fitness level (Fig. 7.6a). Before surgery, 15 patients (28%) were able to take a brisk 20-minute walk 5 days per week, while at follow-up, 46 (85%) were able to do this activity ($p < 0.0001$). Before surgery, 18 patients (34%) were able to perform 20 minutes of vigorous activity 3 days per week, while at follow-up, 46 patients (85%) were able to do so ($p < 0.0001$; Fig. 7.6b).

Before surgery, 91% of patients expected a normal or almost normal ability to do activities of daily living (ADL), and 76% expected the same for recreational activities (Table 7.5). At follow-up, 24% indicated their expectations had not been met for ADL, and 22% expressed the same for recreational activities. Still, 96% were satisfied and expressed that the operation was worthwhile, and 85% believed their overall knee condition was a great deal improved compared with their preoperative symptoms (Fig. 7.7).

In conclusion, active younger patients who desire a return to recreational activities first require realistic expectations and goals established preoperatively. Otherwise, patients may express dissatisfaction after surgery because they expected a nearly normal knee and ability to perform unrealistic activities such as impact sports that involve running and turning or twisting. Even with preoperative counselling, patients may maintain unrealistic expectations after TKA. The disuse and strength deficits that patients have going into surgery may be pronounced after many years of declining activity, particularly in patients that delayed TKA until even walking activities up to 30–60 minutes became limited. After TKA, there exists a minimum of 6 months to restore adequate muscle strength and conditioning, and most patients require up to 12 months to achieve the ability to perform recreational activities without symptoms. The team approach is required of the surgeon and therapist working with the patients in an individualized manner, with encouragement and understanding of the patients' goals. Often it is necessary to substitute or modify athletic pursuits to achieve patient satisfaction of the final clinical outcome. The objective tests provided in this chapter establish light posts for the patient to achieve these gains and the ability to return to activities in a safe manner without symptoms.

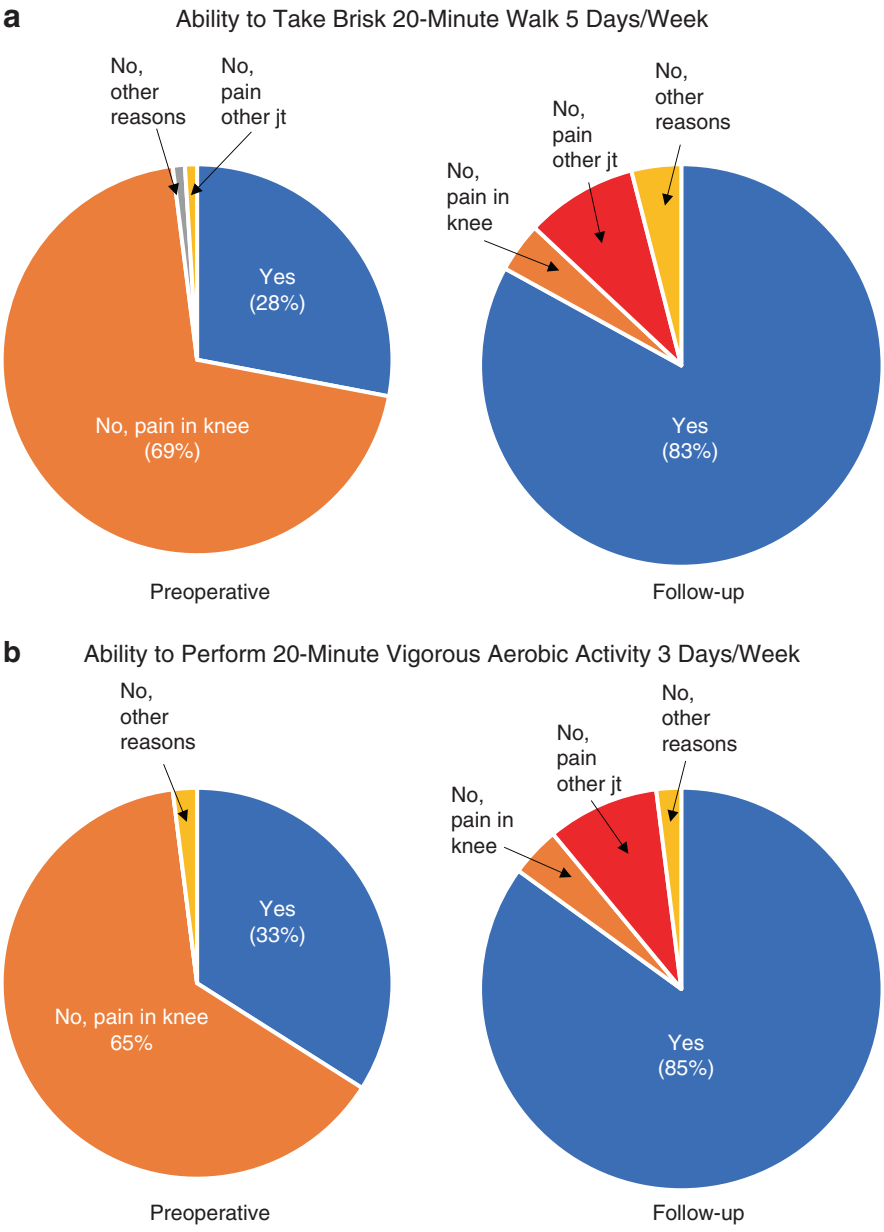

Fig. 7.6 (**a**) Significant improvements were reported in (**a**) the ability to take a brisk 20-minute walk 5 days per week ($p < 0.0001$) and in (**b**) the ability to perform 20 minutes of vigorous aerobic activity 3 days per week ($p < 0.0001$). Jt, joint

Table 7.5 Patient expectations

	Normal, no limitations	*Almost normal, some limitations*	*Improved, some problems*	*Improved, but bothersome problems*	*Not possible or not interested*
Preoperative					
I expect that after surgery, activities such as walking, stairs, and kneeling to be:	22 (41%)	27 (50%)	5 (9%)	0	NA
I expect that after surgery, my recreational activities such as bicycling, hiking, golf, and light tennis to be:	19 (35%)	22 (41%)	6 (11%)	0	7 (13%)
Postoperative					
	Just right, my expectations were met	*Too low, I'm a lot better than I thought*	*Too low, I'm somewhat better than I thought*	*Too high, I'm somewhat worse than I thought*	*Too high, I'm a lot worse than I thought*
My expectations for being able to do my normal activities of daily living after surgery were:	31 (57%)	8 (15%)	2 (4%)	12 (22%)	1 (2%)
My expectations for being able to do my leisure, recreational, or sports activities after surgery activities were:	31 (57%)	8 (15%)	3 (5%)	11 (20%)	1 (2%)

NA not applicable

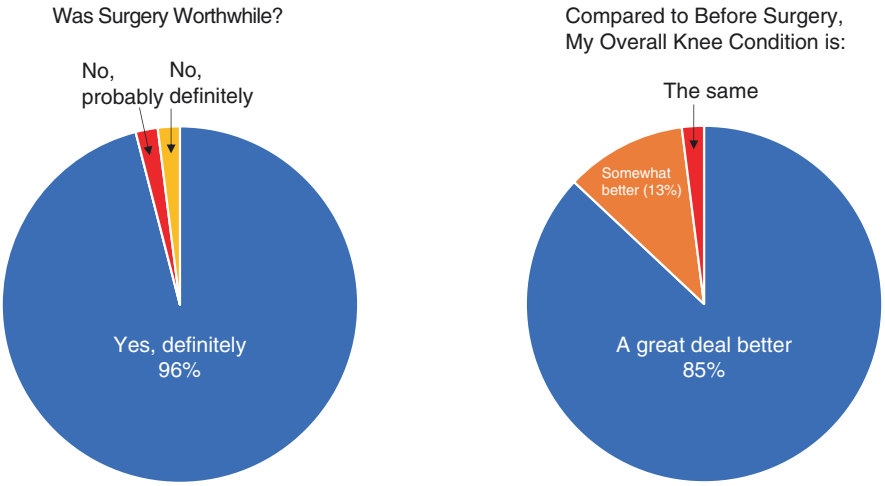

Fig. 7.7 The patient-reported overall opinion as to the surgery being worthwhile and compared to the preoperative state of the amount of improvement. Jt joint

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