Prehabilitation Improves Physical Function of Individuals with Severe Disability from Hip or Knee Osteoarthritis

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ABSTRACT

Purpose: To evaluate the effects of prehabilitation (enhancing physical capacity before total hip or knee joint arthroplasty) on pain and physical function of adults with severe hip and knee osteoarthritis (OA). **Methods:** Consecutive patients ($n = 650$) from 2006 to 2008 with hip or knee OA awaiting total joint arthroplasty (TJA) attended a hospital outpatient clinic for a prehabilitation assessment. All participants completed self-report (Lower Extremity Functional Scale [LEFS] and visual analogue scale for pain [VAS]) and functional performance measures (self-paced walk [SPW], timed stair, and timed up-and-go [TUG] tests). A subset of 28 participants with severe disability participated in a structured outpatient prehabilitation programme. Between-group differences were assessed via independent t -tests; paired Student's t -tests and Wilcoxon signed rank tests were used to compare changes in pain and function following the prehabilitation programme. **Results:** A total of 28 individuals (16 female) with mean age 67 (SD 10) years and BMI 33 (8) kg/m² awaiting TJA (10 hips, 18 knees) participated in a prehabilitation programme of 9 (6) weeks' duration. Relative to baseline, there was significant improvement in LEFS score (mean change 7.6; 95% CI, 1.7–13.5; $p = 0.013$), SPW (mean change 0.17 m/s; 95% CI, 0.07–0.26; $p = 0.001$), TUG (mean change 4.2 s; 95% CI, 2.0–6.4; $p < 0.001$), and stair test performance (mean change 3.8 s [SD 14.6]; $p = 0.005$) following prehabilitation. **Conclusion:** This study presents preliminary evidence that prehabilitation improves physical function even in the most severely compromised patients with OA awaiting TJA.

Key Words: arthroplasty; exercise; osteoarthritis; physical therapy specialty; rehabilitation.

RÉSUMÉ

Objectif : Évaluer l'effet, en termes de douleurs et d'incapacités, d'un programme de pré-réadaptation ayant pour but d'optimiser la condition de patients souffrant d'arthrose sévère en attente d'une arthroplastie totale de la hanche ou du genou. **Méthode :** Une cohorte de 650 patients consécutifs souffrant d'arthrose de la hanche ou du genou en attente d'une arthroplastie ont subi une évaluation préchirurgicale dans une clinique externe. L'évaluation des participants comprenait des mesures auto-rapportées telles que l'échelle fonctionnelle des membres inférieurs (ÉFMI), des mesures de douleurs à l'aide d'échelles visuelles analogues (EVA) et des mesures de performance fonctionnelle (test de marche à vitesse libre, test chronométré des escaliers, test chronométré assis-debout [TUG]). Un sous-groupe de 28 participants souffrant d'incapacités sévères a participé à un programme structuré de pré-réadaptation. Des tests de t de Student indépendants ont été utilisés pour évaluer les différences entre les deux groupes. Des tests de t de Student et des tests Wilcoxon pour mesures appariées ont été utilisés pour comparer les changements en termes de douleurs et d'incapacités suivant le programme de pré-réadaptation. **Résultats :** Au total, 28 individus (16 femmes, 12 hommes) avec un âge moyen (écart-type : ET) de 67 (10) ans et un IMC moyen de 33 (8) kg/m² en attente d'une arthroplastie (10 hanches, 18 genoux) ont participé au programme de pré-réadaptation d'une durée moyenne de 9 (6) semaines. Suivant l'intervention, des changements significatifs ont été observés en termes d'incapacités fonctionnelles mesuré par l'ÉFMI (changement moyen de 7,6; IC 95%, 1,7–13,5; $p = 0,013$), au test de marche à vitesse libre (changement moyen de 0,17 m/s; IC 95%: 0,07–0,26; $p = 0,001$), au test TUG (changement moyen de 4,2 s; IC 95%, 2,0–6,4; $p < 0,001$) et au test chronométré des escaliers (changement moyen de 3,8 s [ET :14,6]; $p = 0,005$). **Conclusion :** Cette étude présente des évidences préliminaires qu'un programme de pré-réadaptation, chez des patients souffrant d'arthrose, en attente d'une arthroplastie du genou ou de la hanche, peut améliorer la fonction physique même chez les patients les plus sévèrement atteints.

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Osteoarthritis (OA), the most common type of arthritis, affects one in eight Canadians (13%), and that proportion will increase to one in four within a generation.¹ OA is a progressive disorder of unknown cause that results in joint pain and reduced function. As there is no definitive cure for OA, management strategies are aimed at reducing pain and improving function. When conservative management fails, total joint arthroplasty (TJA) becomes the treatment of choice.² Unfortunately, there continue to be long wait times to access surgery, and function has been shown to decline in adults with hip and knee OA awaiting TJA.³ This is a problem, in part because poor preoperative function reduces the magnitude of postoperative functional recovery. These deficits in strength, physical function, and quality of life have been shown to persist 6 months to 3 years after TJA.^{4–7} There is no clear indication as to whether prehabilitation programmes (i.e., programmes that offer education and rehabilitation to people waiting for TJA) can mitigate this decline, especially in people who are more severely disabled.

The final report of the Canadian Federal Advisor on Wait Times recommended adopting best practices for wait-time management, including the use of prehabilitation programmes to ensure fitness for surgery.⁸ This practice has not been widely adopted, however, particularly because the recommendation coincided with cutbacks in funding for outpatient rehabilitation. Because preoperative physical function is a major determinant of postoperative physical function, minimizing deterioration in function and worsening of pain in people awaiting TJA is important to maximize the potential benefit of the procedure. Although some studies have reported no benefit of such pre-surgery interventions,^{9–11} others have demonstrated that prehabilitation programmes for people awaiting TJA have positive effects on patients' health status and may also lead to better postoperative outcomes.^{12–15} The reasons for these differences remain unclear, but the type of exercise programme, and whether it is standardized or personally tailored to address patients' specific needs, may influence the outcomes. Other factors, such as the intensity and duration of the programme and exercise supervision or feedback given, may also be important in explaining these discrepancies in treatment effectiveness.

Prehabilitation for people whose function and mobility are more severely compromised as a result of hip or knee OA may represent an even greater rehabilitative challenge, as this patient group is thought to be more difficult to enrol in pre-surgery care and prehabilitation programmes. It is our experience that while those with the greatest disability are most in need of treatment of their condition, they may derive less benefit from an education and rehabilitation programme. To our knowledge, however, there is no research evidence to support this affirmation. This prospective observational study was

designed to evaluate the effect of prehabilitation (education and exercise) on pain and function in people with severe OA awaiting TJA who present with more compromised health and functional status. A secondary objective was to evaluate whether the physiotherapists could triage clients with OA into those with minimal, moderate, and severe disability, reflecting the intensity of prehabilitation required.

METHODS

Participants

Consecutive patients ($n = 650$) from January 2006 to December 2008 with advanced OA from the Hamilton–Wentworth Region in Ontario, Canada, were referred by their orthopaedic surgeon for assessment at a specialized prehabilitation programme for pre-arthroplasty patients. The clinic was located in the outpatient hospital rehabilitation department where the TJA surgery was to take place. All participants had a comprehensive musculoskeletal review by a physiotherapist and completed self-report measures of pain and function as well as physical performance measures of function. The study was approved each year by the Hamilton Health Sciences and McMaster Research Ethics Board. All participants gave informed consent. The purpose of the initial prehabilitation assessment was to triage participants into three streams, reflecting the need for minimal (Stream 1), moderate (Stream 2), or maximal (Stream 3) intensity of surgical preparation. The treating physiotherapists were asked to base their triage on the guidelines presented in Box 1, but could also use their clinical judgment to assign a patient to a different stream if he or she felt that the person would benefit from a more or less intense programme. Although formal validity of the stream triage tool has not yet been established, the tool was developed using a consensus approach with input from the involved administrators, health professionals (physiotherapists, nurses, and occupational therapists), and research team; we sought feedback from the referring orthopaedic surgeons and incorporated it into the final tool. Those of the most severely compromised participants in Streams 2 and 3 who agreed and were able (i.e., lived within a 40 km radius) to attend the hospital's outpatient prehabilitation programme and to be reassessed at the end of the intervention formed the sub-group of patients whose results were analyzed to determine the effects of the programme.

Outcome Measures

Cognitive assessment

Executive cognitive function was assessed using the Clock Draw test.¹⁶ Participants were asked to draw in the numbers on a clock face without erasures, then instructed (both orally and in writing) to indicate the time as 10 minutes after 11. The drawing produced was scored

Box 1 Criteria for Preoperative Triage of Participants into Stream 1, 2, or 3

Criteria	Stream 1	Stream 2	Stream 3
Safety	Safe ambulation and self-care	Ambulation/transfer issue able to be resolved with input	Any one of the following: Ambulation/transfer issues not able to resolve quickly
Falls	None in past 6 months	One in past 6 months	≥2 in past 6 months
Functional status	Good (e.g., LEFS >40, TUG <20 s)	Moderate (e.g., LEFS 25–40, TUG 20–30 s)	Poor (e.g., LEFS <25, TUG >30 s)
Exercise	Able to learn programme and do independently	Needs reinforcement and supervision	Needs repeated exercise corrections and encouragement to perform regular exercises
Equipment	Able to arrange equipment/home environment independently with information and instructions	Requires reinforcement/teaching regarding use of equipment or safety in home environment	Needs assistance to arrange home equipment
Transportation	Able to manage own needs, with or without disability transit, with instructions only	Needs assistance to set up disability transit or other transportation needs	Unable to manage transportation needs independently
Social work	Not required	Consult only	Lacks home support, lives alone, partner unwell/not able to assist
Nutritional consult	Not required	Consult only	Ongoing nutritional support needed
BMI (kg/m ²)	<29	29–35	>35
Cognition	No issues	No issues	Concerns raised/not independent with exercises or self-care
Comorbidities	None	Minimal	Significant
Home environment	Fully accessible	Home modifications easily completed	Not accessible—steps, bath/bedroom on different levels
Multiple joint involvement	Single joint concern	Single joint concern	Multiple joint ROM/strength issues (may include bilateral surgery)

out of 20 according to the method set out by Mendez, Ala, and Underwood (1992).¹⁷ The Clock Draw provides basic information about planning and organizational skills and is relatively free of influence from language, cultural, and ethnic factors.^{16,18}

Self-reported function

The Lower Extremity Functional Scale (LEFS) is a 20-item questionnaire¹⁹ that has been shown to be highly reliable, correlates with other constructs, and is an independent predictor of patient and physician assessment of change.²⁰ The LEFS has outperformed other questionnaires in distinguishing between pain and function in patients following hip or knee TJA.²⁰ Each item is rated on a five-point scale (0 = extreme difficulty or unable to perform activity, 4 = no difficulty); total scores range from 0 to 80, and lower scores represent greater difficulty. The minimal clinically important difference of the LEFS for this population has been found to be a change of at least 9 points.²¹

Performance measures of physical function and associated pain

Three lower-extremity performance measures were selected to evaluate function: the timed up-and-go (TUG), self-paced walk (SPW), and timed stair tests.

These tests, which measure performance on tasks that are important for activities of daily living, have been used widely in evaluating outcomes in individuals undergoing TJA^{22–25} and are commonly used for functional assessment of elderly people.^{26–29} Time was recorded to the nearest 0.01 s with a handheld stopwatch for all measures. Pain (visual analogue scale 0–10) was recorded before and after performance of the functional tasks.

For the TUG, participants were asked to rise from a standard armchair, walk at a safe and comfortable pace to a mark 3 m away, then return to a sitting position in the chair, using gait aids and chair armrests to assist with sit to stand as needed. The outcome measured was the time to complete the task. The same standardized procedures we have previously reported for performing the TUG were used.^{22,24,25} The TUG has been shown to be reliable, reproducible, and responsive to change and is widely used to assess and monitor pre- and postoperative change in physical function of people undergoing primary unilateral hip or knee TJA.^{22–25} The minimal detectable change at the 90% confidence level (MDC₉₀) for people after TJA is 2.49 s for the TUG.²³

For the timed stair test (ST), participants ascended and descended 8 stairs (step height 18.5 cm) in their usual

manner, at a safe and comfortable pace, using a gait aid and/or the handrail for stability as needed. The outcome measured was time to complete the task.²³ The ST has also been shown to be reliable, reproducible, and responsive to change (improvement or deterioration) in people undergoing primary unilateral hip or knee TJA.^{22–25} The MDC₉₀ for the ST for this population is a change of at least 5.49 s.²³

For the fast SPW, participants walked 2 lengths of a 20-metre indoor course in response to the instructions “walk quickly and safely without overexerting yourself.” Usual gait aids were allowed as needed. The outcome measured was time to complete the task; total time to complete the task was transformed to m/s.²³ The fast SPW test has been reported to be reliable, reproducible, and responsive to change (improvement or deterioration) in people undergoing primary unilateral hip or knee TJA.^{22–25} The MDC₉₀ for the fast SPW for this population is a change of at least 4.04 seconds.²³

Prehabilitation programme

Stream 1

People triaged to Stream 1 were those who were deemed to be functioning well and could be taught to manage a daily home exercise programme independently. They received general education about OA, energy conservation, joint protection, home safety, and TJA and information about community resources available to them. A physiotherapist and a physiotherapist assistant taught an exercise regimen and discussed the importance of continuing regular appropriate exercise. Those who were generally active received recommendations for a home programme and community resources available to maintain or increase their activity level before surgery.

Stream 2

Individuals triaged to Stream 2 were those deemed to require more supervision of their exercise programme than those triaged to Stream 1. They received the same general education as those in Stream 1 and attended between two and six group exercise sessions (1–2 sessions/wk for 2 or 3 weeks) with individual correction and modification as required. They were also given recommendations for continuing their exercise programme and information about community resources available.

Stream 3

Individuals triaged to Stream 3 were those with more comorbidities and more significant levels of disability. This group included those deemed to require greater supervision with respect to their exercise programme as well as additional discipline-specific interventions (including physical therapy, occupational therapy, nursing, social work, and nutrition). They received the same general education as those in the other streams and attended two or

three exercise sessions per week (individual or group, depending on identified need) over a period of 6–12 weeks.

Components of the exercise programme

The most severely disabled participants in Streams 2 and 3 worked with a physiotherapist who prescribed a personalized exercise programme based on individual needs. The goal was to reach a skill level with the exercises that would allow long-term independence and maximize functional level before surgery.

In general, the programmes were designed to improve the involved and contralateral lower-extremity joints. Active range of motion (ROM), active stretching, and exercises designed to improve strength of the supporting joint musculature were practised, along with passive mobilizations and/or passive stretches if indicated. An aerobic programme using a cycle ergometer was used if ROM and pain allowed. Balance, proprioception, gait practice, and gait-aid adjustment to ensure safety were also addressed as indicated. Activities that increased joint surface compression were avoided, and performance of exercises within a comfortable ROM was emphasized. All participants were encouraged to exercise independently at least once a day on their own, with a focus on the exercises that could be done independently at home.

All patients were also instructed to continue taking their usual medication prescribed for OA (analgesia and non-steroidal anti-inflammatory drugs). The mean duration of the prehabilitation programmes was 9 (SD 6) weeks.

Statistical analyses

We used descriptive statistics to summarize participant characteristics and self-reported function using the LEFS, performance measures of physical function, and associated pain level for the initial total cohort of participants. Kruskal–Wallis analysis of variance (ANOVA) on ranks and chi-square tests were used to assess differences in personal, clinical, and functional characteristics between the three streams for participants in the initial total cohort ($n = 650$). Mann–Whitney rank sum tests were used as post hoc tests.

As noted above, participants in Streams 2 and 3 who agreed to participate in supervised prehabilitation and be reassessed at the end of the programme formed the subset of patients whose results were analyzed to evaluate the effects of the programme. Mann–Whitney rank sum tests, chi-square tests, and independent t -tests were used to assess differences between patients in Streams 2 and 3 from the initial cohort and participants in this subset.

Wilcoxon signed rank tests, paired Student's t -tests, and 95% CIs were used to assess overall change in pain and function between baseline and post-intervention scores. We initially checked the data for normal distribution; when distribution was non-normal, the Wilcoxon signed rank test was preferred. Because of the small

Table 1 Differences in Selected Characteristics of the Initial Cohort of Participants Enrolled in the Pre-arthroplasty Outpatient Prehabilitation Programme According to Clinical Rating of Severity ($n = 650$)

Characteristics	Stream 1* ($n = 381$)		Stream 2* ($n = 94$)		Stream 3* ($n = 175$)		Comparison between streams			
	Mean (SD)	No. (%) of participants	Mean (SD)	No. (%) of participants	Mean (SD)	No. (%) of participants	Overall test value and p -value†	Pairwise comparisons		
								1 vs. 2	1 vs. 3	2 vs. 3
Age, y	66.4 (10.2)	380	69.1 (10.7)	93	65.1 (11.6)	175	$H = 10.551$ $p = 0.011$ ‡	ns	ns	$p = 0.03$ ‡
Sex										
Female		205 (54)		70 (74)		121 (69)	$\chi^2 = 20.3$ $p < 0.001$ ‡	$p < 0.001$ ‡	$p = 0.003$ ‡	ns
Male		176 (46)		24 (26)		54 (31)				
BMI, kg/m ²	29.9 (5.2)	370	32.1 (6.3)	89	35.1 (7.7)	168	$H = 71.281$ $p < 0.001$ ‡	$p = 0.003$ ‡	$p < 0.001$ ‡	$p = 0.013$ ‡
Cognition—Clock Draw test, /20	16.6 (4.6)	373	17.4 (3.8)	85	16.9 (4.2)	163	$H = 0.114$ $p = 0.94$	ns	ns	ns
Affected joint										
Hip		93 (25)		25 (27)		44 (26)	$\chi^2 = 0.23$ $p = 0.90$	ns	ns	ns
Knee		287 (75)		69 (73)		127 (74)				
LEFS (/80)	35.2 (13.7)	381	26.7 (12.1)	93	25.6 (13.4)	175	$H = 68.08$ $p < 0.001$ ‡	$p < 0.001$ ‡	$p < 0.001$ ‡	ns
SPW, m/s	1.18 (0.32)	328	0.93 (0.31)	55	0.94 (0.41)	151	$H = 57.18$ $p < 0.001$ ‡	$p < 0.001$ *	$p < 0.001$ ‡	ns
ST, s	21.4 (15.2)	376	33.9 (25.1)	85	38.0 (28.9)	158	$H = 88.81$ $p < 0.001$ ‡	$p < 0.001$ ‡	$p < 0.001$ ‡	ns
TUG test, s	12.0 (7.0)	378	17.2 (11.8)	94	19.6 (15.3)	174	$H = 96.71$ $p < 0.001$ ‡	$p < 0.001$ *	$p < 0.001$ ‡	ns
Pre-performance tests pain, /10	2.4 (2.4)	380	3.2 (2.9)	93	3.3 (2.8)	174	$H = 12.93$ $p = 0.002$ ‡	ns	$p = 0.002$ ‡	ns
Post-performance tests pain, /10	3.3 (2.5)	379	4.8 (3.0)	92	4.4 (2.8)	173	$H = 28.77$ $p < 0.001$ ‡	$p < 0.001$ ‡	$p < 0.001$ ‡	ns

*Streams 1, 2, and 3 correspond to a need for minimal, moderate, and maximal intensity of surgical preparation and prehabilitation, respectively.

†Kruskal–Wallis ANOVA on ranks with post hoc Mann–Whitney rank sum tests, except for *Sex* and *Affected joint* variables, for which overall and pairwise chi-square tests were performed because variables are categorical.

‡Significant at $p < 0.05$.

ns = not significant; LEFS = Lower Extremity Functional Scale; SPW = self-paced walk test; ST = timed stair test; TUG = timed up-and-go.

number of participants, we also compared all paired Student's t -test results with Wilcoxon signed rank test results to assess the robustness of the initial results. We also examined the proportion of individuals whose change scores on the physical performance tests exceeded the identified MDC₉₀ values. Results were considered significant at $p < 0.05$. All statistical analyses were performed using SigmaStat software, version 3.5 for Windows (Systat Software, Inc., San Jose, CA).

RESULTS

Participants

Table 1 presents selected characteristics of the entire cohort of participants referred to the pre-arthroplasty

outpatient prehabilitation programme, according to their assigned preoperative streams.

Significant differences were found between streams for all participant characteristics ($p < 0.05$) except the Clock Draw test ($p = 0.94$) and the affected joint ($p = 0.90$). Participants in Stream 2 were older than those in Stream 3 ($p = 0.03$), and the proportion of women was higher in Streams 2 ($p < 0.001$) and 3 ($p = 0.003$) than in Stream 1. Participants in Stream 3 had a higher BMI than those in Streams 1 ($p < 0.001$) and 2 ($p = 0.013$), and participants in Stream 2 also had a higher BMI than those in Stream 1 ($p = 0.003$). Participants in Streams 2 and 3 had lower LEFS scores ($p < 0.001$), lower fast SPW speed ($p < 0.001$), and longer ST ($p < 0.001$) and TUG times

Table 2 Overall Change for the Dependent Variables Before and After the Prehabilitation Programme ($n = 28$)

Dependent variables	Mean (SD) score		Mean (SD) improvement after prehabilitation	95% CI	Comparison between time points*
	At enrolment	After prehabilitation			
LEFS, /80	26.7 (12.1)	34.3 (16.1)	7.6 (15.2)	1.7–13.5	$t = 2.66, p = 0.013§$
SPW, m/s†	0.92 (0.35)	1.09 (0.33)	0.17 (0.25)	0.07–0.26	$t = 2.73, p = 0.011§$
Stair test, s	34.0 (21.1)	30.4 (31.2)	3.8 (14.6)	—	$Z = -2.86, p = 0.004§$
TUG test, s	16.6 (8.8)	12.4 (5.5)	4.2 (5.6)	2.0–6.4	$t = 4.17, p < 0.001§$
Pre-performance tests pain, /10†	3.6 (2.8)	2.9 (2.8)	0.6 (2.4)	–0.36 to 1.6	$t = 1.28, p = 0.211$
Post-performance tests pain, /10†	4.5 (2.8)	3.7 (3.1)	0.8 (2.2)	–0.04 to 1.7	$t = 1.98, p = 0.059$

*Paired Student's t -test for all dependent variables except for the stair test, for which a Wilcoxon signed rank test was performed because of non-normal distribution.

† $n = 27$.

§Significant at $p < 0.05$.

LEFS = Lower Extremity Functional Scale; SPW = self-paced walk test; TUG = timed up-and-go.

($p < 0.001$) than participants in Stream 1 (all $p < 0.001$). These findings show that the triaging physiotherapists were able to use the tool successfully. On pre-programme performance tests of pain, participants in Stream 3 reported more pain than those in Stream 1 ($p = 0.002$). Pain scores recorded immediately following the performance tests also showed that participants in Streams 2 ($p < 0.001$) and 3 ($p < 0.001$) had more pain than those in Stream 1.

The subset of 28 participants who attended supervised prehabilitation on an ongoing basis were reassessed at the end of the programme to evaluate the effects of the prehabilitation intervention on those with the greatest disability. To test for systematic differences between those who were able to attend the programme and those who were not, we compared the physical and functional characteristics of those in the subset of active prehabilitation programme participants ($n = 28$) with the larger group of potential candidates. We found no significant differences between patients in Streams 2 and 3 and the sub-group of participants on any of the dependent variables or on any personal or clinical characteristic ($p > 0.05$).

The active prehabilitation participant group (11 in Stream 2, 17 in Stream 3) had a mean age of 66.5 (SD 10.4) years. The majority were women ($n = 16$, 57%); mean BMI was very high at 32.9 (7.6) kg/m², and the knee joint was most frequently affected. The mean Clock Draw test score was 16.4 (5.8), below the normal threshold of 17/20 that indicates slightly impaired cognition.¹⁷

Effects of the supervised prehabilitation programme

Table 2 presents overall change for all dependent variables before and after the supervised prehabilitation programme. Participants tended to show improvement on all dependent variables. We found a significant improvement from before to after prehabilitation on the LEFS (mean change 7.6; 95% CI, 1.7–13.5). The change in

self-reported function reached statistical significance and, more importantly, was just below the minimal clinically important change of 9 points. On the actual performance measures, we found significant mean improvement on the fast SPW (0.17 [SD 0.25] m/s; $p = 0.011$), the ST (–3.8 [SD 14.6] s; $p = 0.004$), and the TUG (–4.2 (5.6) s; $p < 0.001$). The number of participants who exceeded the MDC₉₀ on the fast SPW was 21/28 (75%); on the ST, 18/27 (67%); and on the TUG, 19/28 (68%).²³

DISCUSSION

Patients with hip or knee OA awaiting TJA between January 2006 and December 2008 attended a clinic for prehabilitation assessment and treatment and were triaged into streams based on their need for minimal, moderate, or maximal intensity of prehabilitation and surgical preparation. The triage guidelines were established a priori by consensus among administrators, health professionals (physiotherapists, nurses, and occupational therapists), and the research team, with feedback from the referring orthopaedic surgeons, as guidelines for triaging and not as explicit inclusion/exclusion criteria. Each potential participant was reviewed by a physiotherapist who decided, based on clinical examination and individual circumstances (distance from hospital, etc.), what programme best suited his or her needs. Interestingly, the most important criterion used by physiotherapists to distinguish Stream 2 (moderately disabled) from Stream 3 (severely disabled) people with OA appears to have been BMI, which has been shown to be associated with the development and progression of OA.³⁰ The prehabilitation intervention of education and exercise was clinically developed and personally tailored to address patients' specific needs. Patients were enrolled in a specific prehabilitation regimen according to their stream allocation. For those triaged into Streams 2 and 3 who were found to have the greatest disability, the prehabilitation exer-

cise programme took place in supervised individual sessions. Stream 2 participants attended sessions twice a week for 3 weeks; those in Stream 3 attended 2–3 times per week for a longer period (6–12 weeks). Patients in Streams 2 and 3 had significantly greater levels of disability (self-reported and performance measures) than those in Stream 1, but we found no differences between Streams 2 and 3 in terms of self-reported function, functional performance, or pain level. Surprisingly, participants in Stream 2 were significantly older than participants in Stream 3. In accordance with the suggested triage guidelines, BMI was significantly higher for Stream 3 than for Streams 1 and 2. More research is needed to fully assess the reliability and validity of this new triage tool, but our results provide preliminary evidence that the tool may be useful to distinguish Stream 1 from Streams 2 and 3, but not to differentiate between Stream 2 and Stream 3.

The severely compromised participants in Streams 2 and 3 formed the sub-group of patients whose results were analyzed to evaluate the effects of the supervised prehabilitation programme. The programme resulted in significant improvement in physical function: self-reported function and physical performance measures all showed statistically significant improvement. For self-reported function, the LEFS score showed an increase of 7.6 points (95% CI, 1.7–13.5), approaching the threshold considered to reflect clinically important change.²¹ A larger sample might improve precision of the estimates, which was low, as indicated by the wide confidence interval. All other performance measures showed both statistically and clinically detectable improvement: 67% to 75% of individuals exceeded MDC₉₀ values for the various instruments.²³ With respect to pain, there was a small trend toward a reduction in pain scores taken both before and immediately after the physical performance tests, although this trend was not statistically significant. The prehabilitation programme improved patient function without increasing pain—an important finding and a positive outcome, since the most debilitated patients increased their level of function without a concomitant increase in symptoms.

Long wait times for surgery have deleterious effects on health status: both pain and function have been shown to deteriorate in patients waiting for TJA.³ Although a research protocol with a control group, which our study lacked, would have allowed a more definitive conclusion, our results suggest that the prehabilitation programme not only altered this decline but helped participants to improve their level of function. As several studies have reported, preoperative physical function is a major determinant of postoperative physical function.^{4–7} Therefore, minimizing deterioration in function and worsening of pain for people awaiting TJA is important to maximize their rehabilitation potential.

A unique feature of our study is that the prehabilitation programme focused not just on people with severe

OA but on participants with severe OA who also presented with a severely compromised functional status. Prehabilitation was tailored to address patients' specific needs based on stream allocation. To our knowledge, this is the first study demonstrating that prehabilitation targeting patients with the most severe symptoms and disabilities waiting for TJA may be effective. One possible explanation for the positive results is that our intervention was individualized in both content and duration, so that participants in Stream 3 received treatment over a longer period than those in Stream 2 (combined mean 9.6 wk programme follow-up). The majority of published studies on the effects of a prehabilitation intervention used prehabilitation programmes of shorter duration, and these studies often show no or little effect of prehabilitation.^{9,10,15,31–33} Only one study in the literature incorporated a prehabilitation programme longer than the one presented here. Nuñez and colleagues (2006) used a 3-month prehabilitation programme for patients awaiting knee TJA; using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) as the primary outcome measure, they found that participants in the prehabilitation programme showed a significant improvement in self-reported function compared to a control group receiving usual pharmacological care.¹²

The fact that our prehabilitation programme was personally tailored to address patients' specific needs could also explain its relative efficacy compared to programmes used in other studies.^{9,10,15} As in previous studies reporting positive effects of prehabilitation interventions,^{12,13} the fact that our programme was delivered in supervised group education sessions may also have positively influenced outcomes. Group or class sessions will inherently add a social-support component, since participants interact with one another on multiple occasions. Ethgen and colleagues³⁴ have reported that social support is associated with mental and physical aspects of health-related quality of life in people with lower-limb OA and concluded that therapeutic intervention for this population may need to incorporate a social-support component.

Limitations of our study include the use of an observational study design and the fact that the preliminary results presented here are from a pragmatic study without a control group. Therefore, caution is warranted in drawing conclusions. However, there is no indication of a selection bias, as there were no significant differences in age, gender, BMI, pain, or function between the more severely compromised participants in Streams 2 and 3 who attended the prehabilitation programme and those who did not.

The overall trend of improvement in all dependent variables measuring function demonstrates the efficacy of the prehabilitation programme, as all functional improvements were statistically significant and approached or exceeded minimal clinically important change. Despite the small sample size and the non-normal distribution of

some variables, parametric and non-parametric analyses yielded the same conclusions (data not shown). The outcomes measured included the LEFS self-report questionnaire, which has been found to be more responsive to change in self-reported function than the WOMAC function scale.²⁰ We also used actual physical performances measures, which are necessary when evaluating this population because they provide more distinct impressions of pain and function that complement information from self-report measures.³⁵

It is important to note that because of our limited sample, the precision of some estimates was low (i.e., confidence intervals were large). We did not measure potential co-interventions; therefore, it is possible, though unlikely, that the effects measured could be due to confounding medication use or to other concomitant interventions. However, the treating orthopaedic surgeon's decision to send patients to the outpatient prehabilitation clinic for assessment was made because TJA surgery had been booked, meaning that all other conservative options had been exhausted. Thus, it is unlikely that a new therapeutic option would have been initiated during patients' pre-surgery wait and their follow-up in the prehabilitation programme.

CONCLUSION

This study evaluated a programme of care in which patients with hip or knee OA awaiting TJA attended a clinic for prehabilitation assessment and treatment. Patients were triaged into one of three streams of care based on their need for minimal, moderate, or maximal intensity of prehabilitation and surgical preparation. The more severely compromised participants attended a supervised programme of education and individualized exercise that resulted in improved physical function. The findings show that prehabilitation improves physical function even in the most severely compromised patients awaiting TJA.

KEY MESSAGES

What is already known on this topic

OA is a degenerative disease for which there is currently no known cure; treatment is therefore aimed at alleviating symptoms and maintaining physical function. When conservative strategies can no longer alleviate pain and allow a reasonable level of function, total joint arthroplasty (TJA) is the treatment of choice. Unfortunately, there are long wait lists for TJA, and it has been clearly established both that function declines during the wait for surgery and that postoperative functional recovery depends largely on preoperative functional status.

What this study adds

While physiotherapists were able to identify patients with minimal versus severe disability secondary to OA, they were not able to readily subdivide moderate from severe disability. In our sample, people with severe OA

who were more compromised in their physical function were younger and had higher BMI. Even in the most severely compromised patients, a short course of prehabilitation education and individualized exercise improved physical function while awaiting TJA. The implications of these findings are that prehabilitation should be offered, particularly to the most severely compromised patients awaiting TJA, as it may minimize functional deterioration and increases in pain during the wait for surgery as well as improving postoperative recovery.

REFERENCES

1. The Arthritis Alliance of Canada. The impact of arthritis in Canada: today and over the next 30 years. Toronto: The Alliance; 2011 [updated 2011 Oct 27; cited 2012 Nov 2]. Available from: <http://www.arthritisalliance.ca>.
2. Moran CG, Horton TC. Total knee replacement: the joint of the decade. *BMJ*. 2000;320(7238):820. <http://dx.doi.org/10.1136/bmj.320.7238.820>. Medline:10731156
3. Desmeules F, Dionne CE, Belzile E, et al. The burden of wait for knee replacement surgery: effects on pain, function and health-related quality of life at the time of surgery. *Rheumatology (Oxford)*. 2010;49(5):945–54. <http://dx.doi.org/10.1093/rheumatology/kep469>. Medline:20144931
4. Fortin PR, Clarke AE, Joseph L, et al. Outcomes of total hip and knee replacement: preoperative functional status predicts outcomes at six months after surgery. *Arthritis Rheum*. 1999;42(8):1722–8. [http://dx.doi.org/10.1002/1529-0131\(199908\)42:8<1722::AID-ANR22>3.0.CO;2-R](http://dx.doi.org/10.1002/1529-0131(199908)42:8<1722::AID-ANR22>3.0.CO;2-R). Medline:10446873
5. Fortin PR, Penrod JR, Clarke AE, et al. Timing of total joint replacement affects clinical outcomes among patients with osteoarthritis of the hip or knee. *Arthritis Rheum*. 2002;46(12):3327–30. <http://dx.doi.org/10.1002/art.10631>. Medline:12483739
6. Lavernia C, D'Apuzzo M, Rossi MD, et al. Is postoperative function after hip or knee arthroplasty influenced by preoperative functional levels? *J Arthroplasty*. 2009;24(7):1033–43. <http://dx.doi.org/10.1016/j.arth.2008.09.010>. Medline:18963759
7. Kennedy DM, Stratford PW, Riddle DL, et al. Assessing recovery and establishing prognosis following total knee arthroplasty. *Phys Ther*. 2008;88(1):22–32. <http://dx.doi.org/10.2522/ptj.20070051>. Medline:17986495
8. Postl BD. Final report of the federal advisor on wait times [Internet]. Ottawa: Health Canada; 2006. [updated 2006 Jun 1; cited 2012 Nov 2]. Available from: http://www.hc-sc.gc.ca/hcs-sss/alt_formats/hpb-dgps/pdf/pubs/2006-wait-attente/index-eng.pdf.
9. Beaupre LA, Lier D, Davies DM, et al. The effect of a preoperative exercise and education program on functional recovery, health related quality of life, and health service utilization following primary total knee arthroplasty. *J Rheumatol*. 2004;31(6):1166–73. Medline:15170931
10. Gstoettner M, Raschner C, Dirnberger E, et al. Preoperative proprioceptive training in patients with total knee arthroplasty. *Knee*. 2011;18(4):265–70. Medline:20801047
11. McDonald S, Hetrick S, Green S. Pre-operative education for hip or knee replacement. *Cochrane Database Syst Rev*. 2004;(1):CD003526. Medline:14974019
12. Nuñez M, Nuñez E, Segur JM, et al. The effect of an educational program to improve health-related quality of life in patients with osteoarthritis on waiting list for total knee replacement: a randomized study. *Osteoarthritis Cartilage*. 2006;14(3):279–85. <http://dx.doi.org/10.1016/j.joca.2005.10.002>. Medline:16309929
13. Rooks DS, Huang J, Bierbaum BE, et al. Effect of preoperative exercise on measures of functional status in men and women undergoing total hip and knee arthroplasty. *Arthritis Rheum*. 2006;55(5):700–8. <http://dx.doi.org/10.1002/art.22223>. Medline:17013852

14. Walls RJ, McHugh G, O'Gorman DJ, et al. Effects of preoperative neuromuscular electrical stimulation on quadriceps strength and functional recovery in total knee arthroplasty: a pilot study. *BMC Musculoskelet Disord.* 2010;11(1):119. <http://dx.doi.org/10.1186/1471-2474-11-119>. Medline:20540807
15. Topp R, Swank AM, Quesada PM, et al. The effect of prehabilitation exercise on strength and functioning after total knee arthroplasty. *PM&R.* 2009;1(8):729–35. <http://dx.doi.org/10.1016/j.pmrj.2009.06.003>. Medline:19695525
16. Paganini-Hill A, Clark LJ, Henderson VW, et al. Clock drawing: analysis in a retirement community. *J Am Geriatr Soc.* 2001;49(7):941–7. <http://dx.doi.org/10.1046/j.1532-5415.2001.49185.x>. Medline:11527486
17. Mendez MF, Ala T, Underwood KL. Development of scoring criteria for the clock drawing task in Alzheimer's disease. *J Am Geriatr Soc.* 1992;40(11):1095–9. Medline:1401692
18. Dohrenwend A, Kusz H, Eckleberry J, et al. Evaluating cognitive impairment in the primary care setting. *Clin Geriatr.* 2003;11:21–9.
19. Binkley JM, Stratford PW, Lott SA, et al; North American Orthopaedic Rehabilitation Research Network. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. *Phys Ther.* 1999;79(4):371–83. Medline:10201543
20. Stratford PW, Kennedy DM, Hanna SE. Condition-specific Western Ontario McMaster Osteoarthritis Index was not superior to region-specific Lower Extremity Functional Scale at detecting change. *J Clin Epidemiol.* 2004;57(10):1025–32. <http://dx.doi.org/10.1016/j.jclinepi.2004.03.008>. Medline:15528053
21. Binkley JM, Stratford PW, Lott SA, et al; North American Orthopaedic Rehabilitation Research Network. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. *Phys Ther.* 1999;79(4):371–83. Medline:10201543
22. Kennedy D, Stratford PW, Pagura SM, et al. Comparison of gender and group differences in self-report and physical performance measures in total hip and knee arthroplasty candidates. *J Arthroplasty.* 2002;17(1):70–7. <http://dx.doi.org/10.1054/arth.2002.29324>. Medline:11805928
23. Kennedy DM, Stratford PW, Wessel J, et al. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2005;6(1):3. <http://dx.doi.org/10.1186/1471-2474-6-3>. Medline:15679884
24. Walsh M, Kennedy D, Stratford P, et al. Perioperative functional performance of women and men following total knee arthroplasty. *Physiother Can.* 2001;53:92–100.
25. Walsh M, Woodhouse LJ, Thomas SG, et al. Physical impairments and functional limitations: a comparison of individuals 1 year after total knee arthroplasty with control subjects. *Phys Ther.* 1998;78(3):248–58. Medline:9520970
26. Bassey EJ, Fentem PH, MacDonald IC, et al. Self-paced walking as a method for exercise testing in elderly and young men. *Clin Sci Mol Med Suppl.* 1976;51(6):609–12. Medline:1070426
27. Cunningham DA, Rechnitzer PA, Pearce ME, et al. Determinants of self-selected walking pace across ages 19 to 66. *J Gerontol.* 1982;37(5):560–4. Medline:7096927
28. Fiatarone MA, Evans WJ. The etiology and reversibility of muscle dysfunction in the aged. *J Gerontol.* 1993;48(Spec No):77–83. Medline:8409245
29. Langlois JA, Keyl PM, Guralnik JM, et al. Characteristics of older pedestrians who have difficulty crossing the street. *Am J Public Health.* 1997;87(3):393–7. <http://dx.doi.org/10.2105/AJPH.87.3.393>. Medline:9096539
30. Bijlsma JW, Berenbaum F, Lafeber FP. Osteoarthritis: an update with relevance for clinical practice. *Lancet.* 2011;377(9783):2115–26. [http://dx.doi.org/10.1016/S0140-6736\(11\)60243-2](http://dx.doi.org/10.1016/S0140-6736(11)60243-2). Medline:21684382
31. Roach JA, Tremblay LM, Bowers DL. A preoperative assessment and education program: implementation and outcomes. *Patient Educ Couns.* 1995;25(1):83–8. [http://dx.doi.org/10.1016/0738-3991\(94\)00671-8](http://dx.doi.org/10.1016/0738-3991(94)00671-8). Medline:7603937
32. Thomas KM, Sethares KA. An investigation of the effects of pre-operative interdisciplinary patient education on understanding post-operative expectations following a total joint arthroplasty. *Orthop Nurs.* 2008;27(6):374–81. <http://dx.doi.org/10.1097/01.NOR.0000342428.74830.67>. Medline:19057367
33. Shrier I, Zukor D, Boivin J-F, et al. The feasibility of a randomized trial using a progressive exercise program in patients with severe hip osteoarthritis. *J Musculoskeletal Pain.* 2008;16(4):309–17. <http://dx.doi.org/10.1080/10582450802479883>
34. Ethgen O, Vanparyijs P, Delhalle S, et al. Social support and health-related quality of life in hip and knee osteoarthritis. *Qual Life Res.* 2004;13(2):321–30. <http://dx.doi.org/10.1023/B:QURE.0000018492.40262.d1>. Medline:15085904
35. Stratford PW, Kennedy DM. Performance measures were necessary to obtain a complete picture of osteoarthritic patients. *J Clin Epidemiol.* 2006;59(2):160–7. <http://dx.doi.org/10.1016/j.jclinepi.2005.07.012>. Medline:16426951