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

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ABSTRACT. ***Objective.*** To determine the effectiveness of a preoperative exercise/education program on functional recovery, health related quality of life (HRQOL), health service utilization, and costs following primary total knee arthroplasty (TKA).

Methods. One hundred thirty-one subjects were randomized to either the control (n = 66) or treatment (n = 65) group 6 weeks before TKA surgery. Patients in the treatment group underwent a 4-week exercise/education program before surgery. All subjects were assessed 6 weeks preoperatively (before the exercise/education intervention), immediately preoperatively (after the exercise/education intervention), and 3, 6 and 12 months after surgery utilizing the Western Ontario McMaster Osteoarthritis Index, the SF-36, and knee range of motion (ROM) and strength measures. Data on length of stay, numbers of community rehabilitation or homecare visits following discharge from the surgical hospital, and the costs associated with these services were also collected.

Results. Subjects were similar in demographic characteristics and all measurements at the baseline assessment. No differences were seen in knee measurements (ROM and strength), pain, function, or HRQOL between the 2 groups following the intervention program or at any postoperative measurement point. Patients in the treatment group used fewer postoperative rehabilitation services and stayed for a shorter time in hospital than the control group, but these differences did not attain statistical significance.

Conclusion. The exercise/education intervention did not alter functional recovery or HRQOL following TKA. Health service utilization was less in the treatment group, but our study was underpowered to attain statistical significance for these measures. (J Rheumatol 2004;31:1166–73)

Key Indexing Terms:
ARTHROPLASTY KNEE
HEALTH RELATED QUALITY OF LIFE HEALTH SERVICE UTILIZATION

With an aging population, the incidence of total knee arthroplasties (TKA) continues to increase. Although TKA has been reported frequently to improve quality of life for the patient, it is an expensive procedure[1-3]. It is essential that patients receive the most effective and efficient treatment at the lowest possible cost to the healthcare system.

No studies have described the extent to which a preoperative exercise/education program prior to TKA is effective in assisting postoperative recovery in a Canadian setting. Three studies with very small patient groups reported preoperative benefits of an exercise program, with 2 also examining the postoperative effects[4-6]. Neither Rodgers, *et al*[5] nor D'Lima, *et al*[6] found any postoperative benefits to a preoperative strengthening or conditioning program. However, neither of these studies examined health related quality of life (HRQOL) or health service utilization. Roach, *et al* examined how an education program affected length of stay (LOS) postoperatively, but their program did not include an exercise component[7]. It remains unclear how a preoperative program combining both education and exercise will affect postoperative recovery and health service utilization following primary TKA.

Aggressive postoperative physical therapy is effective in shortening hospital stay in postoperative hip and knee arthroplasty patients, and contributes significantly to the degree of postoperative knee flexion regained[8-10]. It has also been shown that arthritic patients can respond, within 4 to 6 weeks, to a controlled exercise program designed to increase quadriceps and hamstring strength and endurance[11,12]. Dexter reported compliance to perform exercises improved with instruction and support[13].

Preoperative patient education has also been shown to affect recovery, as illustrated by reports of lower pain levels

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and shorter LOS, when patients are given appropriate information and instruction preoperatively[14,15]. Still, it has been suggested that patients perceive they are given inadequate information preoperatively regarding either the procedure or the postoperative recovery period[16]. A preoperative program that spans 4 to 6 weeks allows patients sufficient time to assimilate information and to have their concerns answered regarding the upcoming surgery.

The proposed preoperative exercise/education treatment intervention was expected to have a short-term (within one year) influence on the quality of life of the treatment subjects. A faster return to adequate knee strength and range of motion (ROM) and reduced pain was anticipated to lead to a shorter rehabilitation period and a more rapid return to independence in activities of daily living (ADL) in the treatment group. As a result, the healthcare costs in all stages of postoperative care after discharge from the surgical hospital were anticipated to decline for those patients receiving the intervention, offsetting the additional expense of the preoperative intervention. We investigated whether receiving a preoperative exercise/education program prior to TKA surgery would result in (1) improved pre/postoperative knee ROM and strength; (2) reduced pain and increased HRQOL as measured by the Western Ontario McMaster Osteoarthritis Index (WOMAC) and the Medical Outcome Study Short Form-36 (SF-36); (3) reduced health service utilization (including LOS); and (4) reduced healthcare costs postoperatively compared to current clinical practice.

MATERIALS AND METHODS

This study was a randomized clinical trial with blinded assessment of outcomes by a physical therapist not involved with the intervention. Patients were randomized, in blocks of 20 patients, to one of 2 groups, treatment or control, following the enrolment visit. Randomization was performed using consecutively numbered opaque envelopes.

Patient selection. Subjects were recruited from the current waiting list of subjects awaiting TKA. Seven orthopedic surgeons practising at the University of Alberta Hospitals participated in this study. Subjects who met all the following criteria were accepted into the study: (1) had a diagnosis of noninflammatory arthritis, (2) were booked for a primary TKA, (3) were between 40 and 75 years of age, (4) were willing to undertake the intervention and attend followup visits, and (5) were able to understand and comprehend verbal and written English or have a translator.

Intervention. The education program consisted of instruction regarding (1) crutch walking on level ground and on stairs, (2) bed mobility and transfers, and (3) the postoperative ROM routine. The exercise program was designed to improve knee mobility and strength using simple exercises similar to those utilized in the postsurgical exercise routine. These consisted of simple strengthening exercises with progressive resistance added to patient tolerance (Appendix). A warmup and cool-down was also included to prevent injury and minimize swelling and therefore pain post-exercise. The subjects were asked to attend the treatment program 3 times per week for 4 weeks for a total of 12 treatment sessions.

Through liaison with the surgery booking clerk at the hospital, the research coordinator determined appropriate subjects' date of surgery. The subjects were then contacted and an appointment was scheduled for their initial assessment 6 weeks before surgery.

At the initial assessment, all subjects were assessed for pain, function, knee ROM, and strength using validated measures. After the initial appointment, subjects were randomized to either the treatment or control group. The control group continued with their regular activities until surgery. These subjects were not required to record their exercise level, nor were they forbidden to seek out treatment. This group was meant to reflect "usual care" and they were allowed to determine for themselves their preoperative exercise level. The treatment group was set up with appointments to attend an intervention program at a community physical therapy clinic convenient for them. Each clinic that agreed to participate in the study was provided with written instructions regarding the standardized exercise/education program as well as a logbook for each patient. The logbook was used for charting attendance and progression of resistance and repetitions of the exercises. The completed logbooks were returned to the investigators at the end of the 12 treatment sessions.

After completion of the 4-week treatment program, the subjects attended the Pre-Admission Clinic (PAC), where they underwent an assessment identical to the baseline assessment. The control group was also reassessed at PAC to determine if any changes had occurred in this group since the initial assessment.

After their surgery, all subjects followed the standard postoperative mobilization routine of the care-map implemented at this hospital. Data were extracted from the chart regarding surgical characteristics, postoperative complications, length of surgical hospital stay, and place of discharge.

Subjects were reassessed at 3, 6, and 12 months postsurgery by a physical therapist blinded to group allocation. Patients were also asked to report any complications requiring medical intervention since the previous assessment.

Outcome measures. Each assessment included administration of the WOMAC Index and the SF-36, and measurement of knee ROM and strength. In addition, health service utilization data were collected at the completion of the trial.

The WOMAC was used to obtain pain, stiffness, and function measures. The WOMAC is a disease-specific health questionnaire that takes 5 to 10 minutes to complete. A 5-point Likert scale was used for measuring patient responses, with scores derived by summing the items under each of the 3 divisions. Each subscale score was transformed to a range from zero to 100 points, a score of 100 indicating no pain or dysfunction, in the method described by Bombardier, *et al*[17]. The reliability, internal consistency, and validity have been tested in several clinical trials[18-21].

Active knee ROM was assessed with a goniometer with the patient in supine position. Enwemeka[22] and Gogia, *et al*[23] have described reliability and validity of goniometric measurement of the knee.

Quadriceps and hamstring strength were assessed using a held-held dynamometer. This device measures muscle strength in pounds of force generated. Hayes and Falconer have shown the reliability of this instrument[24]. Patients performed 3 maximal isometric contractions of each muscle group, with the average of these measurements used in the analysis. Quadriceps strength was measured in sitting position while hamstring strength was measured in prone, so that both assessments were against gravity. Positioning of the patient was according to that recommended by Daniels and Worthingham[25].

The SF-36 was used to determine overall health status. The SF-36 is a 36-item general health questionnaire that takes 10 to 15 minutes to complete. Eight dimensions are measured: emotional role function, physical role function, physical function, mental health, general health perceptions, social functioning, vitality, and bodily pain. In addition, summary scores for physical health (physical component scores, PCS) and mental health (mental component scores, MCS) are also calculated. Its validity and reliability have been extensively tested in several patient populations including joint arthroplasty populations[26-30].

Health service utilization data were obtained from regional health authorities' administrative databases, relating to service utilization during a one-year study period immediately following surgery. Institutional, outpatient therapy and homecare services relating directly to the intervention under study were included in the analysis. Institutional services were

related to transfers to a rehabilitation subacute care program within a continuing care facility, a rehabilitation hospital, or rural acute care hospitals. In addition, readmissions to acute care hospitals during the study period that were related to the TKA surgery were included. Physical and occupational therapy services pertaining to direct care or case management, in both homecare and outpatient therapy programs, were included. Personal and home support services, provided by the homecare program, were also recorded.

Health service costing was undertaken using standard unit-costs to value all services. Standard unit-costs were used to avoid the confounding effects of cost variation among programs and institutions. As Capital Health provided most services received by study patients, the standard unit-costs were based on Capital Health program costs. Unit-costs were expressed in 1997/98 Canadian dollars, and consequently adjustment for price changes over the study period was not necessary. Because the study period for all patients was only one year, discounting was not required to convert costs to present value.

The units of measurement of services and corresponding standard unit-costs varied across programs. Homecare services were measured in terms of hours of provider care, whereas outpatient therapy services were measured by visits to the program, and institutional care was measured in terms of days of stay. The per-diem cost of the rehabilitation subacute program was used as the standard for all institutional transfer cases, as nearly all of these admissions were for followup rehabilitation services. However, because all readmission cases were to acute care hospitals, the average per-diem cost of Capital Health acute care hospitals was used to value readmission cases.

As there were no differences in clinical outcomes between the 2 study groups, a cost-minimization analysis to determine the most economic intervention was performed[31]. The health service costs were based on the services described above and excluded the cost of the initial surgical stay, which was similar for both study groups. The cost of the preoperative exercise and education program provided to the treatment group was included.

Analysis. All analyses were performed on an "intent to treat" basis. Descriptive statistics (means, quartiles, standard deviations, ranges, and proportions) were generated for all variables included in the study. Standard bivariate tests (T tests and chi-square) were used to evaluate any potential systematic differences at baseline. Paired T tests were used to measure changes within groups between the initial and preoperative assessments following the intervention to determine the effect of the intervention on the measured outcomes prior to the TKA. Changes that occurred in continuous data over the entire study period were analyzed using a 2-way repeated measures analysis of variance (ANOVA) to measure differences between groups and over time. All statistical analyses were performed utilizing 2-tailed tests and a significance level of $\alpha = 0.05$. The Statistical Package for the Social Sciences, version 10.07, was used for analyses.

Sample size. Data from a previous study using similar candidates indicated that the functional evaluation of the WOMAC Index in this population had a standard deviation of approximately 18 points[32]. To detect a difference of 10 points in the functional evaluation of the WOMAC between groups, a sample size of 130 (65/group) subjects was required (power = 0.80; 2-tailed test with $\alpha = 0.05$). This 10-point difference was chosen a priori as a difference that could be clinically detectable by either patients or clinicians, considered a small effect size[33-35].

RESULTS

One hundred thirty-one subjects were enrolled and underwent the initial assessment, 66 control and 65 treatment. Subjects were similar in both groups in demographic characteristics (Table 1) as well as baseline measurements of all outcome measures (Table 2). Of the 7 surgeons contributing patients to the study, 4 were high-volume arthroplasty surgeons (defined as > 50 TKA/year) and 3 were low-volume surgeons. Patients from high and low-volume surgeons were evenly distributed between the 2 groups (Table 2) as were different implant types, fixation methods, and patellar resurfacing, removing any confounding effects of these variables.

Sixteen patients (6 control and 10 treatment) cancelled their surgeries. Cancellations occurred either as a result of concomitant medical conditions that precluded the subject undergoing surgery within the defined time period or because the patients changed their minds. Reasons for cancelling surgery did not differ between groups ($p = 1.00$). Further, these subjects were not different from subjects who underwent surgery in age, sex, diagnosis, number of comorbidities, or group allocation ($p > 0.05$). As no surgery occurred, this group of patients was not followed beyond the initial assessment.

Losses to followup. In addition to the 16 patients who cancelled surgery, 2 subjects from the treatment group died

Table 1. Demographic and surgical characteristics.

	Group		
	Treatment, n = 65	Control, n = 66	p
Demographics, mean (SD)			
Age, yrs	67 (7)	67 (6)	0.69*
Body mass index	32 (6)	31 (5)	0.40*
Female, n (%)	39 (60)	33 (50)	0.29†
Diagnosis of osteoarthritis, n (%)	63 (96)	64 (97)	0.51†
No comorbid condition, n (%)	28 (70)	22 (55)	0.36†
> 1 joint with osteoarthritis, n (%)	33 (51)	38 (58)	0.73†
Surgical variables, n (%)			
No. undergoing surgery	55 (85)	60 (91)	0.30†
High volume surgeon (> 50 TKA/yr)	43 (78)	48 (80)	0.82†
Posterior cruciate retaining prosthesis	47 (86)	51 (85)	0.57†
Patella resurfaced	28 (51)	32 (53)	0.85†
Cemented components	32 (58)	31 (53)	0.21†

* Independent T test. † Chi-square analysis.

Table 2. Baseline characteristics.

Variable	Treatment, n = 65 Mean (SD)	Control, n = 66 Mean (SD)	p*
WOMAC pain	49 (15)	49 (20)	0.91
WOMAC stiffness	45 (16)	45 (19)	0.83
WOMAC function	50 (17)	49 (19)	0.80
Knee ROM (degrees)	105 (14)	105 (21)	0.87
Quadriceps strength (lbs of force)	22 (12)	24 (11)	0.54
Hamstring strength (lbs of force)	16 (7)	16 (7)	0.96
SF-physical function	28 (15)	29 (15)	0.71
SF-role physical	16 (27)	18 (30)	0.79
SF-bodily pain	38 (16)	37 (16)	0.93
SF-general health	70 (16)	71 (18)	0.86
SF-mental health	73 (16)	75 (17)	0.57
SF-vitality	46 (22)	52 (20)	0.11
SF-social function	65 (27)	67 (26)	0.70
SF-role emotional	60 (44)	67 (40)	0.33
SF-PCS	29 (7)	29 (6)	0.87
SF-MCS	51 (11)	54 (13)	0.22

* Independent T test.

between the initial postoperative period and the 3-month assessment, one due to acute cardiac problems postoperatively and one unrelated to surgery. In addition, 4 other patients (2 from each group) withdrew from the study. All withdrawals occurred between the initial and preoperative appointment. The health services data of these subjects have been analyzed in the allocated group as per the intention to treat strategy. Eighteen patients missed one of their postoperative visits, with similar numbers from both groups: 9 missed the 3-month (2 treatment, 7 control) and 9 missed the 6-month appointment (7 treatment, 2 control). No patient remaining in the study missed the one-year assessment.

Because all active participants completed 80% of their followup assessments, and to increase use of all available data, values were imputed for missing 3 and 6-month postoperative data using the "cold decking" strategy described by Curran, *et al*[36]. This involves imputing a constant value from an external study. We used data from a study that measured knee ROM, pain, function, and HRQOL using identical outcome measures at the same postoperative time points in a similar population[32]. The slider-board group's mean values for each of the outcomes were utilized, as this group represented the standard of care at the institution during the study time-frame. As the previous study did not assess strength of the knee, no imputing was done for knee strength. A sensitivity analysis was undertaken comparing imputed versus nonimputed results to ensure that outcomes were not changed. Results were similar using either data set so imputed results have been reported to utilize more of the available data.

Adherence to assigned intervention. All but one subject completed the 12 treatment sessions prior to surgery, based upon review of the logbooks. This patient was offered an earlier surgery date after finishing only 9 sessions. Her data were analyzed in the assigned group as per intention to treat. No control patient attended a formal exercise program, although some patients reported that they performed a home exercise program using exercises learned from prior physical therapy treatments.

Clinical outcomes. Subjects commenced the study with similar baseline scores in all outcome measures (Table 2). After the intervention, at the preoperative visit, most baseline measurements were similar to initial measurements, with no differences over time or between groups (Tables 3-5). The treatment group showed a nearly significant difference in quadriceps strength measured using a paired T test ($p = 0.06$), while the control group showed no change in quadriceps strength ($p = 0.62$). This finding would suggest that the control group was doing less intense exercise preoperatively than the treatment group.

Postoperatively, significant differences were seen in all measurements over time ($p < 0.05$), with the exception of the general health dimension of the SF-36, which was unchanged over the study time period in both groups. Aside from the dimension of vitality of the SF-36 questionnaire, no differences were seen between groups ($p > 0.05$) as measured by a 2-way ANOVA with repeated measures (Tables 3-5). The control group had higher scores than the treatment group in vitality over the entire study period ($p = 0.04$), including baseline assessment (Table 5). No significant interaction occurred between time and group in any clinical measure, indicating that the 2 groups followed a similar pattern of recovery throughout the study period.

Health service utilization and costing. Despite LOS in the surgical hospital being directed by the care-map guidelines, the treatment group stayed one day less than the control group in the surgical hospital, a nonsignificant difference (Table 6). More patients in the control group (n = 31) were

Table 3. WOMAC Osteoarthritis Index scores measured over time.

	Pain		Stiffness		Function	
p value (group)†	0.39		0.83		0.80	
p value (time)†	0.00		0.00		0.00	
P value (group*, time)†	0.40		0.55		0.83	
	Treatment	Control	Treatment	Control	Treatment	Control
	Mean (SD)		Mean (SD)		Mean (SD)	
No.	51	58	51	58	51	58
Initial assessment	50 (16)	50 (19)	46 (16)	44 (22)	51 (18)	50 (17)
Immediate preoperative	48 (13)	49 (17)	45 (19)	44 (18)	50 (14)	51 (17)
3-Month postoperative	74 (18)	73 (14)	62 (17)	61 (18)	73 (17)	73 (15)
6-Month postoperative	80 (15)	75 (15)	82 (13)	80 (16)	78 (15)	74 (15)
1-Year postoperative	82 (13)	80 (16)	67 (18)	71 (21)	77 (14)	77 (16)

† Two-way repeated measures ANOVA.

Table 4. Knee ROM and strength scores measured over time.

	ROM		Quadriceps Strength*		Hamstring Strength*	
p value (group)†	0.98		0.89		0.52	
p value (time)†	0.00		0.00		0.00	
p value (group*, time)†	0.13		0.24		0.78	
	Treatment	Control	Treatment	Control	Treatment	Control
	Mean (SD)		Mean (SD)		Mean (SD)	
No.	51	58	42	49	42	49
Initial assessment	107 (14)	105 (21)	22 (8)	24 (11)	16 (6)	17 (7)
Immediate preoperative	109 (12)	105 (18)	26 (11)	25 (10)	18 (9)	20 (16)
3-Month postoperative	93 (16)	93 (15)	27 (10)	27 (8)	18 (7)	18 (6)
6-Month postoperative	95 (14)	96 (17)	29 (9)	28 (9)	19 (6)	20 (7)
1-Year postoperative	99 (16)	103 (16)	30 (10)	29 (8)	21 (8)	21 (6)

ROM: knee flexion + extension (i.e., total range of sagittal knee motion), measured in degrees. * Measured in pounds of force. † Two-way repeated measures ANOVA.

Table 5. SF-36 scores measured over time.

	Physical Functioning		Role Physical		Bodily Pain		General Health		Mental Health		Vitality		Social Function		Role Emotional		PCS		MCS	
P value, group†	0.45		0.46		0.75		0.40		0.31		0.04		0.63		0.29		0.64		0.18	
P value, time†	0.00		0.00		0.00		0.23		0.00		0.00		0.00		0.00		0.00		0.04	
P value, group*, time†	0.07		0.10		0.26		0.63		0.51		0.70		0.38		0.47		0.29		0.65	
	Treat	Con	Treat	Con	Treat	Con	Treat	Con	Treat	Con	Treat	Con	Treat	Con	Treat	Con	Treat	Con	Treat	Con
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)	
No.	51	58	51	58	51	58	51	58	51	58	51	58	51	58	51	58	51	58	51	58
Initial	27 (15)	29 (15)	16 (26)	19 (32)	38 (17)	38 (16)	71 (16)	72 (17)	72 (18)	75 (18)	45 (23)	53 (19)	63 (28)	68 (25)	54 (45)	69 (42)	29 (6)	29 (6)	51 (13)	55 (10)
Preop	32 (18)	31 (18)	23 (33)	16 (28)	40 (15)	39 (14)	73 (18)	77 (20)	73 (16)	78 (18)	49 (21)	54 (18)	66 (28)	69 (23)	66 (42)	74 (39)	30 (6)	30 (6)	53 (10)	56 (11)
3-Mth Postop	43 (20)	49 (22)	26 (35)	28 (37)	55 (21)	56 (18)	75 (15)	75 (15)	78 (17)	79 (16)	57 (19)	60 (18)	70 (21)	75 (24)	70 (42)	73 (39)	35 (9)	35 (8)	54 (10)	55 (11)
6-Mth Postop	52 (18)	48 (24)	34 (35)	42 (40)	59 (20)	57 (17)	74 (14)	75 (18)	80 (13)	80 (18)	59 (18)	63 (19)	80 (21)	76 (24)	68 (39)	79 (38)	37 (8)	37 (10)	55 (10)	56 (11)
1-Yr Postop	53 (22)	58 (25)	44 (38)	56 (42)	69 (22)	70 (22)	73 (16)	76 (18)	81 (15)	85 (12)	57 (20)	65 (19)	84 (22)	85 (0)	69 (38)	87 (26)	38 (8)	41(10)	56(9)	58 (7)

† Two-way repeated measures ANOVA. Treat: Treatment, Con: Control. PCS: physical component score. MCS: mental component score.

transferred for subacute rehabilitation compared to the treatment group (n = 23), but this did not reach statistical significance (p = 0.35). Once admitted for subacute rehabilitation, subjects in both groups stayed for comparable lengths of time (Table 6). Eleven patients were readmitted over the one-year period, 6 patients from the control group and 5 from the treatment group (p = 1.00). Readmissions from both groups stayed a similar length of time (Table 6). When LOS in different settings was combined, overall LOS was less in the treatment group, but did not attain statistical significance (Table 6).

Of patients who received physical therapy in the community (either through homecare or clinic-based), no significant difference was seen between the 2 groups (Table 7). Although the total cost for postsurgical hospital rehabilitation was less for the treatment group, this difference did not attain statistical significance (p = 0.32). When the cost of the treatment intervention was added to the postoperative costs, the cost difference between the groups was further reduced (Table 7).

Complications. Eighty-four (73%) of 115 subjects who underwent surgery had no complications during their hospital stay, with similar proportions of patients coming from both treatment groups (p = 0.83). Two patients in each group had pulmonary emboli (p = 1.00), while 9 patients (3 treatment, 6 control) had deep vein thromboses (DVT; p = 0.49), despite routine DVT prophylaxes being administered. Five superficial infections were reported (2 treatment, 3 control), resolving with either oral or intravenous antibiotics (p = 1.00). The remainder of the complications reported were general medical complications similarly dispersed across both groups (i.e., urinary tract infections, postoperative angina).

Eleven readmissions occurred in the initial postoperative year for treatment of post-TKA complications that included 3 manipulations for poor ROM (2 control, one treatment), or treatment for unspecified joint or medical problems. Only one patient in the treatment group developed a deep infection requiring exchange arthroplasty.

Table 6. Health service utilization following discharge from acute care hospital.

Variable	Treatment, Mean (SD)	n	Control, Mean (SD)	n	p*
Acute care LOS	6.7 (2.2)	55	7.3 (2.5)	60	0.14
Transfer LOS	7.7 (2.0)	23	7.7 (2.8)	31	0.66
Readmission LOS	3.4 (0.55)	5	3.8 (2.0)	6	0.95
Total LOS	10.2 (4.5)	55	11.7 (5.2)	60	0.10

* Independent T test. LOS: length of stay, in days.

Table 7. Health service costs (all 1997/98 $CDN) following discharge from acute care hospital.

Variable	Treatment, Mean (SD)	Control, Mean (SD)	p*
Institutional costs**	878 (1233)	1090 (1316)	0.38
Homecare costs	127 (177)	117 (159)	0.76
Community rehabilitation costs	125 (226)	159 (251)	0.45
Total costs†	1369 (1274)	1366 (1415)	0.99

* Independent T test. † Costs for the treatment group also reflect the cost of the exercise/education program ($240 CDN). ** Institutional costs include both transfer and readmission costs.

DISCUSSION

This study is the first to describe the effectiveness of a preoperative exercise/education program on the postoperative recovery of a TKA population in a Canadian setting. Previous trials that examined the effect of preoperative exercise on recovery after TKA reported that no meaningful postoperative effects were seen[5,6]. Those studies had very small groups, and did not examine function or HRQOL. Our study utilized a larger patient group and examined multiple indicators of recovery after TKA, including function and HRQOL in addition to knee ROM and strength.

We found no significant changes in patients' functional recovery or HRQOL following the intervention program during the one-year study interval. Any differences that occurred in the early postoperative period may have been missed, as our initial postoperative assessment did not occur until 3 months after surgery. Our study was powered to detect a 10-point difference between groups in the WOMAC Osteoarthritis Index dimension scores. At no time point did the 2 groups ever have a 10-point difference in any dimension of the index, suggesting that our program did not significantly affect functional recovery. Aside from the dimension of vitality, the groups were also similar in their SF-36 scores at each measurement time, suggesting there was also no difference in HRQOL as a result of the preoperative intervention. The control group had higher scores in the dimension of Vitality than the treatment group at all intervals, including the baseline assessment, suggesting a systematic difference may have existed between groups that was unrelated to the intervention.

Strength and ROM of the knee were also unaffected by the intervention program. Although subjects in the treatment group were able to demonstrate an almost significant increase in quadriceps strength following the exercise intervention, no postoperative benefits were realized as a result of the improvement in strength. Indeed, the groups were very similar in clinical measures at each assessment point.

Although this program included a reasonably rigorous exercise component for endstage arthritis, it was only 4 weeks in duration and did not have a significant aerobic conditioning component. However, increasing the duration of the program would also increase the costs of such intervention. The preoperative exercise program used in the

study and programs utilized in previous studies appear to have limited, if any, postoperative benefit for this patient group based upon reported findings[5,6].

One strength of our study is that we examined not only functional recovery in the first year after TKA, but also investigated the effects of the intervention on health service utilization during the same time period. Using only a preoperative education program, Roach, *et al*[7] reported LOS was nonsignificantly reduced. We attempted to reduce postoperative recovery time, and thus health service utilization, by preparing the patient for their surgery through both exercise and education.

Health service utilization between these 2 patient groups did not differ significantly over the one-year followup period, although there was a trend toward reduced LOS in the treatment group compared to the control group. A clinical pathway predicated LOS in the surgical hospital, with discharge criteria related to functional independence rather than knee ROM. Patients are discharged home or transferred for further rehabilitation at 5 to 7 days postoperatively, dependent upon independence in ADL. Knee ROM is not a consideration for remaining in hospital, as all patients are referred for further physical therapy upon discharge.

Patients in the treatment group stayed roughly one less day in hospital than the control group, a nonsignificant difference. Further, more patients were discharged home in the treatment group compared to the control group. On the whole, the control group stayed in hospital almost 2 days longer than the treatment group when overall LOS (including transfer LOS and readmission LOS) was considered.

Although our study had adequate power for the clinical variables, it was underpowered to detect differences in the health services or costing measures. A 2-day difference in overall LOS has important clinical implications for health service utilization and costs, but group sizes of 100 would have been required to attain statistical significance with the group differences reported in this study. Assessment of health service utilization should be the primary outcome in future work, as this study has shown that functional recovery and HRQOL are unaffected by a preoperative exercise intervention. Further, future studies that examine the effect of preoperative interventions should focus on reducing LOS by preparing the patient for discharge based upon attainment of functional goals, rather than having time of discharge predetermined by care-map guidelines.

Our outcome measures did not record patients' expectations after surgery or their satisfaction with either the process or the outcome, both of which may have been altered by the education/exercise intervention. Patient expectations and satisfaction should, perhaps, be more closely examined to determine if a preoperative education program is better preparation for surgery and the subsequent postoperative recovery phase. Further research regarding the effect of preoperative education on patients' expectations and satisfaction is warranted, based upon the evidence that patients report that they feel unprepared and lack information preoperatively[14-16].

The program model used in this study was chosen because there was very little information in the literature regarding the effectiveness of a preoperative exercise/education intervention. Structured exercise in a monitored environment ensured patient compliance and adherence to the program. Because we have now shown that a structured exercise program of 4 weeks' duration provided no postoperative benefits for patients between 40 and 75 years of age, future preoperative program structures can examine different methods of educating and preparing patients with less resource-intensive and more cost-effective approaches. These programs could be implemented in a video or pamphlet format at a significantly lower cost than the exercise/education program that was done onsite over a 4-week period. These other program formats would also manage high patient volumes better than the structured exercise program. Education with focus on early mobilization and discharge planning would be a reasonable goal of the intervention program. In future studies, health service utilization should be used as a primary outcome to determine if a preoperative education program is able to offer significant financial/service utilization advantages.

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Appendix: Exercise Program

A. Warmup: (1) Apply a hot pack to the involved knee for 15 to 20 minutes, with the knee placed in a comfortable resting position. (2) Then the patient must do low resistance (to patient's comfort) stationary cycling. Start at five minutes of cycling and progress to ten minutes by week 2.

B. Exercise instructions: (1) Each patient must do a minimum of 3 sets of 10 repetitions of each exercise in Week 1. Progress the patient to 3 sets of 15 repetitions by treatment day 7 (start of week 3) at the latest. If the patient is progressing rapidly, he/she may do more than the minimum number of repetitions if physically able and comfortable doing so. (2) You are encouraged to increase the resistance of these exercises to provide the patient the maximum gain from the exercise period, as long as this increase does not exacerbate the patient's condition. Resistance can be increased by adding weight at the level of the ankle for all quadriceps exercises. (3) The active exercise period is restricted to the minimum number of all required exercises or 30 minutes if the patient is able to do more than the minimum required. (4) Do not include any different exercises — do only those listed below.

C. Exercise program: (a) Static quadriceps contraction.

(b) Straight leg raise (SLR) to an approximate angle of 45°. (c) Short arc quadriceps contraction. (d) Isotonic quadriceps contraction in sitting from 90° to zero degrees. (e) Hamstring contraction in sitting using tubing for resistance. D. Cool-down: Apply an ice pack to the involved knee for 15 to 20 minutes, with the knee in a comfortable position.

REFERENCES

1. Heck DA, Robinson RL, Partridge CM, Lubitz RM, Freund DA. Patient outcomes after knee replacement. Clin Orthop Rel Res 1998;356:93-110.
2. Norman-Taylor FH, Palmer CR, Villar RN. Quality-of-life improvement compared after hip and knee replacement. J Bone Joint Surg Br 1996;78:74-7.
3. Jones CA, Voaklander DC, Johnston DW, Suarez-Almazor ME. Health related quality of life outcomes after total hip and knee arthroplasties in a community based population. J Rheumatol 2000;27:1745-52.
4. Winter SV, Burch D, Weidenhielm L, Mattsson E, Brostrom L, Wersall-Robertsson E. Effects of preoperative water exercise on total knee replacement patients. J Aquatic Phys Ther 2000;8:12-7.
5. Rodgers JA, Garvin KL, Walker CW, Morford D, Urban J, Bedard J. Preoperative physical therapy in primary total knee arthroplasty. J Arthroplasty 1998;13:414-21.
6. D'Lima DD, Colwell CW, Morris BA, Hardwick ME, Kozin F. The effect of preoperative exercise on total knee replacement outcomes. Clin Orthop Rel Res 1996;326:174-82.
7. Roach JA, Tremblay LM, Bowers DL. A preoperative assessment and education program: implementation and outcomes. Patient Educ Couns 1995;25:83-8.
8. Hughes K, Kuffner L, Dean B. Effect of weekend physical therapy treatment on postoperative length of stay following total hip and total knee arthroplasty. Phys Can 1993;45:245-9.
9. Moller G, Jonsson E. Hospital care versus home care for rehabilitation after hip rehabilitation. Int J Technol Assess Healthcare 1992;8:93-101.
10. Shoji H, Solomonow M, Yoshino S, D'Ambrosia R, Dabezies E. Factors affecting postoperative flexion in total knee arthroplasty. Orthopedics 1990;13:643-9.
11. Kovar PA, Allegrante JP, MacKenzie CR, Peterson MG, Gutin B, Charlson ME. Supervised fitness walking in patients with osteoarthritis of the knee. A randomized, controlled trial. Ann Intern Med 1992;116:529-34.
12. Marks R. The effect of isometric quadriceps strength training in mid-range for osteoarthritis of the knee. Arthritis Rheum 1993;6:52-6.
13. Dexter PA. Joint exercises in elderly persons with symptomatic osteoarthritis of the hip or knee. Performance patterns, medical support patterns, and the relationship between exercising and medical care. Arthritis Rheum 1992;5:36-41.
14. Schwartz-Barcott D, Fortin J, Kim H. Client-nurse interaction: testing for its impact in preoperative instruction. Int J Nurs Studies 1994;31:23-35.
15. Wong J, Wong S, Nolde T, Yabsley R. Effects of an experimental program on post-hospital adjustment of early discharged patients. Int J Nurs Studies 1990;27:7-20.
16. Santavirta N, Lilliquist G, Sarvimaki A, Honkanen V, Konttinen Y, Santavirta S. Teaching of patients undergoing total hip replacement surgery. Int J Nurs Studies 1994;31:135-42.
17. Bombardier C, Melfi CA, Paul J, et al. Comparison of a generic and a disease-specific measure of pain and physical function after knee replacement surgery. Med Care 1995;33 Suppl:AS131-44.
18. Barr S, Bellamy N, Buchanan WW, et al. A comparative study of signal versus aggregate methods of outcome measurement based on the WOMAC Osteoarthritis Index. J Rheumatol 1994;21:2106-12.
19. Stucki G, Sangha O, Stucki S, et al. Comparison of the WOMAC (Western Ontario and McMaster Universities) osteoarthritis index and a self-report format of the self-administered Lequesne-Algofunctional index in patients with knee and hip osteoarthritis. Osteoarthritis Cartilage 1998;6:79-86.
20. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 1988;15:1833-40.
21. Bellamy N. Critical review of clinical assessment techniques for rheumatoid arthritis trials: new developments. Scand J Rheumatol 1989;80 Suppl:3-16.
22. Enwemeka CS. Radiographic verification of knee goniometry. J Aquatic Phys Ther 1986;18:47-9.
23. Gogia PP, Braatz JH, Rose SJ, Norton BJ. Reliability and validity of goniometric measurements at the knee. Phys Ther 1987;49:465-9.
24. Hayes KW, Falconer J. Reliability of hand-held dynamometry and its relationship with manual muscle testing in patients with osteoarthritis of the knee. J Orthop Sports Phys Ther 1992;16:145-9.
25. Daniels L, Worthingham C. Muscle testing: techniques of manual examination. 3rd ed. Philadelphia: Saunders; 1972:57-61.
26. Hawker G, Melfi C, Paul J, Green R, Bombardier C. Comparison of a generic (SF-36) and a disease specific (WOMAC) (Western Ontario and McMaster Universities Osteoarthritis Index) instrument in the measurement of outcomes after knee replacement surgery. J Rheumatol 1995;22:1193-6.
27. Hayes V, Morris J, Wolfe C, Morgan M. The SF-36 health survey questionnaire: is it suitable for use with older adults? Age Ageing 1995;24:120-5.
28. Stucki G, Liang MH, Phillips C, Katz JN. The Short Form-36 is preferable to the SIP as a generic health status measure in patients undergoing elective total hip arthroplasty. Arthritis Rheum 1995;8:174-81.
29. Parker SG, Peet SM, Jagger C, Farhan M, Castleden CM. Measuring health status in older patients. The SF-36 in practice. Age Ageing 1998;27:13-8.
30. Lyons RA, Fielder H, Littlepage BN. Measuring health status with the SF-36: the need for regional norms. J Pub Health Med 1995;17:46-50.
31. Drummond MF, O'Brien B, Stoddart G, Torrence G. Basic types of economic evaluation in methods for the evaluation of health care programmes. 2nd ed. Oxford: Oxford University Press; 1997.
32. Beaupre LA, Davies DM, Jones CA, Cinats JG. Exercise combined with continuous passive motion or slider board therapy compared with exercise only: a randomized controlled trial of patients following total knee arthroplasty. Phys Ther 2001;81:1029-37.
33. Lydick E, Epstein RS. Interpretation of quality of life changes. Qual Life Res 1993;2:221-6.
34. Cohen J. Statistical power analysis for the behavioral sciences. New York: Academic Press; 1977:8.
35. Osoba D, Rodrigues G, Myles J, Zee B, Pater J. Interpreting the significance of change in health-related quality of life scores. J Clin Oncol 1998;16:136-44.
36. Curran DL, Fayers P, Molenberghs G, Machin D. Analysis of incomplete quality of life data in clinical trials. In: Staquet MJ, Hays RD, Fayers PM, editors. Quality of life assessment in clinical trials: methods and practice. Oxford: Oxford University Press; 1998:250-80.