Preoperative Predictors of Persistent Impairments During Stair Ascent and Descent After Total Knee Arthroplasty

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Background: Although total knee arthroplasty improves functional mobility in persons with end-stage knee osteoarthritis, many subjects have reported continued difficulty with stair ascent and descent after surgery. The purpose of the present study was to determine preoperative predictors of handrail use during stair ascent and descent following primary unilateral total knee arthroplasty.

Methods: One hundred and five adults who were scheduled for unilateral total knee arthroplasty participated in the study. Postoperative handrail use during stair ascent or descent was predicted on the basis of preoperative functional measures. Preoperative age, body mass index, knee strength, knee flexion active range of motion, Knee Outcome Survey scores, time to complete a stair-climbing task, and previous handrail use were entered as covariates into a binary logistic regression. Forward logistic regression was performed to determine which preoperative factors best predicted handrail use at three months and two years after surgery. Handrail use in a control group was also evaluated at baseline and at the time of the two-year follow-up.

Results: Prior to surgery, sixty-three of the 105 subjects required a handrail. Two years after surgery, sixty of the 105 subjects required a handrail. In the control group, nineteen of the sixty-four subjects required a handrail at baseline and ten of thirty-one required a handrail at the time of the two-year follow-up. At two years, the preoperative ability to ascend and descend stairs without a handrail was the best predictor of individuals who would not require a handrail after surgery, followed by younger age and greater quadriceps strength. Collectively, these variables correctly predicted the ability of ninety of 105 persons to negotiate stairs without a handrail at two years after surgery ($p < 0.001$).

Conclusions: Younger, stronger patients who do not use a handrail prior to unilateral total knee arthroplasty can expect the best outcomes in terms of ascending and descending stairs following surgery. This information may provide patients with more realistic expectations after surgery and allow them to make more appropriate discharge plans.

Level of Evidence: Prognostic Level I. See Instructions to Authors for a complete description of levels of evidence.

Total knee arthroplasty is the most common and most effective surgical intervention for the treatment of end-stage knee osteoarthritis¹. Persons who undergo total knee arthroplasty report an increase in functional ability in comparison with their preoperative condition². Nevertheless, some physical limitations continue after surgery³. As demonstrated by Walsh et al., individuals continue to report difficulty ascending and descending stairs when compared with an age-matched group of healthy individuals without knee pain or osteoarthritis⁴.

Following total knee arthroplasty, the ability to safely ascend and descend stairs (termed stair negotiation in the present report) is an exceptionally important concern. The majority of falls occur on stairs in a domestic setting⁵. These falls may result in major injuries or even death, and an estimated 10% of fall-related deaths occur on stairs⁶. Providing an adequate appraisal of a person's ability to safely negotiate stairs is essential to preventing serious injury in the home. Previous studies have evaluated the ability of individuals to ascend and descend stairs after total knee

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arthroplasty; however, those studies involved the use of self-report questionnaires that contained only one or two questions pertaining to an individual's stair-climbing ability and did not discriminate whether the patients required a handrail^{7,8}. Other studies have evaluated the time to complete a stair-climbing task regardless of the use of a handrail⁹. The use of a handrail, even with light touch, can alter the way in which an individual negotiates stairs¹⁰. While knee flexion range of motion, quadriceps strength, age, and self-reported confidence with stair negotiation are related to difficulty with stair-climbing, none of these measures have been used to predict the use of a handrail after total knee arthroplasty¹¹⁻¹³.

Persons who reside in multistory homes or who must use steps to enter the residence do not always have a handrail available. After total knee arthroplasty, patients who must use stairs that do not have a handrail may require the use of an assistive device or assistance from another individual to ascend or descend the stairs. The ability to predict which patients will require a handrail after surgery could improve the decision-making of clinicians and individuals about the need for postoperative assistance. Additionally, accurate prediction from clinically useful measures may provide information as to whether the installation of railings in a home would facilitate an individual's ability to function independently after surgery.

The purpose of the present study was to use preoperative functional measurements to predict whether individuals will require a handrail after surgery. We hypothesized that preoperative measures will differ between patients who require a handrail and those who do not and that these variables will predict whether a person will require a handrail at three months and two years after total knee arthroplasty.

Materials and Methods

Subjects

One hundred and five consecutive subjects who underwent primary unilateral total knee arthroplasty performed by three different surgeons participated in the study (Table I), along with a control group of sixty-four persons without a history of knee pain or osteoarthritis. Prior to surgery, all patients in the total knee arthroplasty group had evidence of end-stage knee osteoarthritis in at least two compartments (Kellgren-Lawrence score¹⁴, ≥ 3). Subjects were excluded if they presented with notable pain in the contralateral limb (maximum pain, ≥ 4 of 10 during daily activities); had a diagnosis of arthritis involving any other lower extremity joint; or had cardiovascular or neurological impairments, including peripheral neuropathies. To reduce the chance that the type of implant would influence stair-climbing ability, all of the total knee prostheses were posterior cruciate ligament-sacrificing condylar implants with patellar resurfacing¹⁵. All subjects in the total knee arthroplasty group completed functional evaluations at three different time points: prior to surgery (at a mean [and standard deviation] of 11 ± 8 days prior to surgery), three months after surgery, and two years after surgery. All patients underwent measurement of height and weight, active knee range of motion, and bilateral quadriceps strength. They completed the Knee Outcome Survey (KOS), and their stair-climbing ability was assessed. All of the subjects in the total knee arthroplasty group participated in aggressive postoperative physical therapy at the same therapy clinic. The therapy regimen consisted of progressive strengthening exercises; manual therapy to improve range of motion; therapeutic exercises to improve endurance, flexibility, and strength; electrical stimulation to improve quadriceps strength; functional retraining; and

TABLE I Baseline Variables

Variable*	Total Knee Arthroplasty Group			Control Group		
	Mean and Standard Deviation	Median	Range	Mean and Standard Deviation	Median	Range
Age (yr)	65.77 $\pm$ 8.94	65.5	50 to 84	63.06 $\pm$ 8.45	63	50 to 82
Height (m)	1.71 $\pm$ 0.10	1.72	1.47 to 1.88	1.71 $\pm$ 0.10	1.7	1.47 to 1.91
Weight (kg)	90.74 $\pm$ 17.6	90.47	47.62 to 162.81	78.4 $\pm$ 15.0	78.12	44.67 to 113.83
BMI (kg/m ²)	30.9 $\pm$ 5.2	30.18	21.79 to 53.78	26.79 $\pm$ 4.2	26.29	18.61 to 38.37
KOS-ADLS score (%)	50.38 $\pm$ 16.66	50	8.57 to 88.6	98.04 $\pm$ 3.8	100	85.7 to 100
Quadriceps strength (N/BMI)						
Operative side	19.28 $\pm$ 7.30	19.3	3.40 to 40.86			
Nonoperative side	23.50 $\pm$ 8.75	23.24	1.83 to 51.40	28.95 $\pm$ 9.47	28.74	5.55 to 56.7
Active knee range of motion (deg)						
Extension	4 $\pm$ 5	3	-4 to 25	-1 $\pm$ 3	-1	-10 to 6
Flexion	119 $\pm$ 14	122	64 to 142	138 $\pm$ 7	138	121 to 155

*BMI = body mass index, and KOS-ADLS = Knee Outcome Survey Activities of Daily Living Scale.

TABLE II Predictors of Handrail Use at Three Months *

Model	Variables in Model	Percentage Correctly Predicted			Odds Ratio (Nagelkerke R ² Value)	Significance of Model (P Value)	Significance of Model if Variable Removed (P Value)
		Handrail	No Handrail	Overall			
Step 1	Age	42%	80%	65%	0.123	0.002	Age, 0.003
Step 2	Age, preoperative handrail use	47%	87%	71%	0.177	0.001	Age, 0.003; preoperative handrail use, 0.022

*At three months, the best predictor of handrail use was age (Step 1). The addition of preoperative handrail use significantly improved the predictive ability of the model (Step 2).

modalities to reduce pain and inflammation. Subjects in the control group participated in a baseline evaluation and a two-year follow-up evaluation. All of the subjects reviewed and signed an informed consent form that was approved by the Human Subjects Review Board prior to participating in any portion of the study. The subjects were participants in a larger clinical trial registered in a public registry (NCT00224913).

Knee Range of Motion

Active knee range of motion was measured with the subject in the supine position. The investigator asked the subject to maximally flex the knee. This was done by actively flexing the hip and sliding the heel toward the buttocks. The proximal arm of a standard long-armed goniometer was aligned parallel to the long axis of the femur and was directed toward the greater trochanter. The distal arm was aligned with the lateral malleolus of the ankle. The axis of the goniometer was aligned over the lateral epicondyle of the femur. Values were recorded with respect to full extension of the knee being 0°. Measurements were made three times, and the average value was considered to be the knee flexion range of motion. Measurement of knee flexion range of motion has been

shown to be a highly reliable measure in individuals with knee osteoarthritis¹⁶.

Quadriceps Strength

Quadriceps strength was measured isometrically with the subject seated in a KinCom Dynamometer (Chattanooga Group, Hixson, Tennessee). With the hips flexed to approximately 90° and the knees flexed to 75°, the subject was instructed to kick as hard as possible. The subject was given verbal and visual encouragement during the test. The peak volitional force from three trials was averaged to determine quadriceps strength. Quadriceps strength (in newtons) was normalized to body mass index (BMI) and was represented as N/BMI. From this value, we derived the quadriceps index, which is the ratio of the strength of the involved limb to the strength of the uninvolved limb¹⁷. The strength of the involved limb is divided by the strength of the uninvolved limb and multiplied by 100. A value of 100 represents equal strength in both legs. Quadriceps strength in the control group is presented as the average of the values for both limbs, whereas quadriceps strength in the total knee arthroplasty group is expressed separately for the operatively treated and contralateral limbs.

TABLE III Predictors of Handrail Use at Two Years *

Model	Variables in Model	Percentage Correctly Predicted			Odds Ratio (Nagelkerke R ² Value)	Significance of Model (P Value)	Significance of Model if Variable Removed (P Value)
		Handrail	No Handrail	Overall			
Step 1	Preoperative handrail use	58%	76%	68%	0.152	<0.001	Preoperative handrail use, <0.001
Step 2	Preoperative handrail use, age	58%	81%	71%	0.263	<0.001	Preoperative handrail use, 0.001; age, 0.002
Step 3	Preoperative handrail use, age, quadriceps index	58%	86%	74%	0.316	<0.001	Preoperative handrail use, 0.001; age, 0.001; quadriceps index, 0.024

*The best predictor of handrail use at two years was preoperative handrail use (Step 1). The addition of age and quadriceps index significantly improved the predictive ability of the model.

Knee Outcome Survey

For the present study, we utilized the Activities of Daily Living Scale of the Knee Outcome Survey (KOS-ADLS), which is a self-administered questionnaire that contains fourteen questions about the individual's ability to perform typical daily tasks¹⁸. Subjects rank their ability to perform the task with use of a 6-point Likert scale, with 0 representing an inability to complete the task and 5 representing an ability to complete the task without difficulty. The scores for the fourteen questions are added, and the result is divided by the highest possible score. The result is multiplied by 100 to give a percentage score, with 100 being the highest score. This test has been shown to be a valid and reliable measure of a person's self-perceived physical ability^{18,19}.

Stair-Climbing Task

The subject began at the bottom of a flight of twelve steps that were 18 cm high and 28 cm deep. On the investigator's verbal command, the subject ascended, turned around, and descended the steps as quickly as possible while using a safe technique. The subject completed two trials, and the average time to complete the task was recorded. Prior to the task, the subject was instructed to use the handrail only if needed. The use of a handrail as well as the gait pattern (step-to-step or step-over-step) during ascent and descent were recorded. This test previously has been used to reliably measure functional

performance in subjects who have undergone total knee arthroplasty^{13,20}. The same set of stairs was used for assessments at all time points and for both subject groups.

Statistical Analysis

To determine which preoperative measures predict whether a subject will require a handrail after surgery, a binary logistic regression was performed. For each subject, the preoperative age, body mass index, quadriceps index, knee flexion range of motion, KOS-ADLS score, time to complete the stair-climbing task (continuous variables), and use of a handrail preoperatively were entered as the covariates into a forward stepwise regression model. The dichotomous outcome variable was handrail use, and the subject was classified as either "handrail" or "no handrail" depending on whether he or she used the handrail during stair ascent or descent. Independent sample t tests were performed to determine differences between handrail groups. In addition to the variables described above, we compared height, weight, quadriceps force (normalized to body mass index), and knee extension range of motion with use of the independent t test. Fisher exact tests were used to calculate the probability of differences between the handrail groups in terms of sex, preoperative handrail use, and preoperative gait pattern during stair ascent and descent. Independent t tests were used to compare baseline variables between the control and total knee arthroplasty

TABLE IV Preoperative Characteristics According to Group

Variable*	Handrail Use at Three Months			Handrail Use at Two Years		
	No Handrail	Handrail	P Value	No Handrail	Handrail	P Value
Age† (yr)	62.6 ± 8.4	67.7 ± 8.9	0.005†	62.4 ± 7.6	68.4 ± 9.1	0.001†
Height† (m)	1.7 ± 10.1	1.72 ± 0.1	0.753	1.7 ± 0.1	1.7 ± 0.1	0.263
Weight† (kg)	88.6 ± 15.2	91.6 ± 18.7	0.404	92.9 ± 20.4	89.1 ± 15.1	0.269
BMI† (kg/m ²)	30.2 ± 4.1	31.1 ± 5.8	0.434	31.0 ± 5.3	30.8 ± 5.2	0.845
Stair-climbing task† (s)	25.0 ± 10.6	28.3 ± 12.5	0.175	25.6 ± 9.0	28.2 ± 10.2	0.267
KOS-ADLS score† (%)	52.0 ± 17.3	49.3 ± 16.4	0.448	49.6 ± 17.3	50.1 ± 16.3	0.673
Quadriceps index† (%)	87.5 ± 36.1	85.5 ± 28.1	0.797	93.2 ± 33.7	80.0 ± 27.1	0.029†
Quadriceps strength† (N/BMI)						
Operative side	18.7 ± 8.0	19.7 ± 8.0	0.54	21.3 ± 7.7	17.7 ± 7.7	0.022†
Nonoperative side	23.2 ± 9.8	23.7 ± 8.2	0.766	24.7 ± 9.6	22.6 ± 8.0	0.233
Range of motion† (deg)						
Extension	4.1 ± 5.1	3.9 ± 4.5	0.885	4.0 ± 4.0	4.2 ± 4.1	0.91
Flexion	118.7 ± 14.8	118.1 ± 13.7	0.821	118.0 ± 15.0	118.9 ± 13.1	0.745
Male:female ratio (%)	53:47	58:42	0.381	59:41	53:47	0.333
Preop. handrail use (yes/no) (%)	47/53	72/28	0.012†	54/46	76/24	0.002†
Pattern (step-over/step-to) (%)	82/18	73/27	0.245	76/24	76/24	0.581

*BMI = body mass index; KOS-ADLS = Knee Outcome Survey Activities of Daily Living Scale. †The values are given as the mean and the standard deviation. ‡Similar to the logistic regression, preoperative age, handrail use, and quadriceps index were significantly different between the handrail groups.

groups. No regression analysis was performed for the control group.

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Results

Prior to surgery, sixty-three of the 105 individuals in the total knee arthroplasty group required a handrail for either stair ascent or descent. Following surgery, the majority of subjects continued to require the use of a handrail during the stair-climbing task. Three months after total knee arthroplasty, sixty-five of the 105 patients required a handrail. Two years after total knee arthroplasty, sixty of the 105 individuals required a handrail. Of the sixty-five patients who required a handrail at three months, forty-five (69%) were the same individuals who had required a handrail preoperatively. Of the sixty patients who required a handrail at two years, forty-six (77%) were the same individuals who had required a handrail prior to surgery. At baseline, nineteen of the sixty-four subjects in the control group required a handrail. Thirty-one control subjects returned for the two-year follow-up and, of these, ten required a handrail at that time point. No differences were seen between the total knee arthroplasty group and the control group in terms of age or height, but the control group was significantly stronger and had higher KOS-ADLS scores, a lower body mass index, and a lower body mass ($p < 0.0001$)

(Table I). Approximately 50% (thirty-three) of the sixty-four control subjects were lost at the time of follow-up because of failure to return for evaluation or insufficient time since the baseline evaluation.

Collectively, preoperative values correctly identified as many as 87% of the individuals who did not require a handrail after surgery (Tables II and III). Three months after surgery, subject age and preoperative handrail use were significantly predictive of handrail use after surgery (Table II). Subject age was found to be the best predictor at the three-month time point, with an odds ratio of 1.077 and with older age predicting the use of the handrail. Two years after surgery, subject age, preoperative handrail use, and the quadriceps index were collectively predictive of handrail use (Table III). Preoperative handrail use was the most significant predictor of handrail use after surgery. Age was also a strong predictor, with younger patients being less likely to require a handrail at two years after surgery (odds ratio, 1.089).

Preoperative body mass index, knee flexion range of motion, KOS-ADLS score, and time needed to complete the stair-climbing task did not significantly contribute to the prediction of handrail use after total knee arthroplasty. The independent *t* tests and the Fisher exact test revealed no significant differences between the handrail groups with respect to preoperative body mass index, knee flexion range of motion, KOS-ADLS score, stair-climbing time, sex, height, weight, knee extension range of motion, or gait pattern at either the three-month or the two-year time point (Table IV). Significant differences were seen in terms of age and preoperative handrail use at three months ($p = 0.005$ and $p = 0.012$, respectively). At

TABLE V Postoperative Characteristics According to Group*

Variable†	Handrail Use at Three Months			Handrail Use at Two Years		
	No Handrail	Handrail	P Value	No Handrail	Handrail	P Value
Age (yr)	62.6 ± 8.4	67.7 ± 8.9	0.005‡	64.4 ± 7.6	70.4 ± 9.1	0.001‡
Weight (kg)	87.8 ± 14.8	91.0 ± 19.0	0.389	87.8 ± 14.8	91.9 ± 18.3	0.408
Body mass index (kg/m ²)	30.0 ± 4.0	30.9 ± 6.0	0.426	30.0 ± 4.0	31.8 ± 6.3	0.985
Stair-climbing task (s)	13.0 ± 4.0	14.6 ± 5.3	0.112	11.7 ± 2.6	13.4 ± 5.1	0.042‡
KOS-ADLS (%)	79.8 ± 11.0	79.3 ± 11.3	0.825	84.9 ± 12.9	85.2 ± 12.1	0.93
Quadriceps index (%)	75.3 ± 23.9	76.1 ± 22.2	0.875	100.5 ± 31.1	98.7 ± 32.0	0.241
Quadriceps strength (N/BMI)						
Operative side	17.1 ± 6.3	16.7 ± 6.9	0.77	22.4 ± 9.1	17.8 ± 6.6	0.003‡
Nonoperative side	23.7 ± 8.7	22.8 ± 8.8	0.588	22.5 ± 9.8	19.2 ± 7.9	0.06
Range of motion (deg)						
Extension	1.9 ± 2.8	2.0 ± 2.5	0.847	-0.7 ± 3.1	0.6 ± 2.5	0.024‡
Flexion	116.7 ± 10.5	116.4 ± 11.5	0.914	121.4 ± 11.7	119.7 ± 10.8	0.449

*The values are given as the mean and the standard deviation. †BMI = body mass index; KOS-ADLS = Knee Outcome Survey Activities of Daily Living Scale. ‡At three months, a significant difference was found between groups with regard to age. At two years, significant differences were found between groups with regard to age, stair-climbing time, quadriceps strength on the involved side, and knee extension range of motion.

two years, age, preoperative handrail use, quadriceps index, and normalized quadriceps strength of the operatively treated limb were significantly different between the groups ($p = 0.001$, $p = 0.002$, $p = 0.029$, and $p = 0.022$, respectively).

Postoperative differences were also seen with the independent *t* tests and the Fisher exact test. Persons who required a handrail at three months were significantly older than those who did not require a handrail ($p = 0.005$). At two years, persons who required a handrail were also significantly older ($p = 0.001$), took significantly greater time to complete the stair-climbing task ($p = 0.042$), had weaker quadriceps on the operatively treated side ($p = 0.003$), and had less active knee extension range of motion ($p = 0.024$) when compared with the group that did not require a handrail (Table V). Differences in strength approached significant levels on the nonoperative side, with the group that used a handrail having less quadriceps strength ($p = 0.06$). No differences were found at three months or two years between individuals who never used a handrail and those who did not use one prior to surgery but required one after surgery. However, among the persons who required a handrail initially but did not at two years after surgery ($n = 21$), there was a significant difference in age. The mean age (and standard deviation) in this group was 62 ± 8 years, whereas the mean age of persons who continued to require a handrail was 67 ± 9 years ($p = 0.028$).

Discussion

Difficulty ascending and descending stairs is a persistent functional limitation that does not resolve after surgery. Fifty-seven percent (sixty) of the 105 individuals in the total knee arthroplasty group still required the use of a handrail at two years after surgery, virtually the same percentage as before surgery and nearly twice as many as in the age-matched control group. This is consistent with previous work demonstrating that persons continue to have difficulty with stair negotiation, even many years after total knee arthroplasty²¹.

While significant differences existed between individuals who did and those who did not require a handrail at three months and two years, the difference in quadriceps strength was the most important clinical finding. The quadriceps on the involved side was significantly weaker at three months and two years, and near-significant differences existed on the uninvolved side at two years. Of particular interest is the fact that the quadriceps strength of the involved limb showed a clinically meaningful increase between three months and two years in the group that did not require a handrail. Contrarily, the group that required the handrail showed minimum improvement over the same interval. Differences in the postoperative strength of the operatively treated limb at two years suggest that quadriceps strength never fully recovers after total knee arthroplasty in persons who require a handrail. Quadriceps weakness has been implicated in reduced functional ability twelve months after surgery and is highly related to an individual's ability to perform activities of daily living^{3,17,20}. Patients who do not demonstrate clinically meaningful improvements in strength should be identified and managed for their deficits.

Otherwise, the majority of recovery is complete at two years, and it is likely that this group of individuals will permanently require a handrail²². Given the large number of persons who required a handrail after surgery and the fact that falls on stairs account for the majority of fall-related injuries, recommending the installation of handrails should become the standard practice of surgeons and clinicians.

The fact that quadriceps strength on the nonoperative side was almost significantly different between the two groups at two years is also important. This quadriceps weakness may be indicative of disease progression in the contralateral limb^{23,24}. Disease progression in the contralateral limb may play a role in the ability to negotiate stairs without a handrail. Functional ability three years after total knee arthroplasty is most related to pain in the contralateral limb²⁵. While our results are for two years after total knee arthroplasty, the trend in our data showed that persons with quadriceps weakness at two years in the contralateral limb may experience difficulty with stair negotiation.

By itself, the finding of increased age being related to handrail use is not novel. Hamel and Cavanagh found that the majority of community-dwelling very elderly persons required a handrail during stair ascent or descent¹². In their study, sixteen of thirty-two individuals required a handrail during ascent and twenty-one required a handrail during descent. However, the average age of subjects in the present study was sixty-six years, whereas the average age of subjects in that study was eighty-three years, with the youngest participant being seventy-seven years old. This underscores our finding that factors beyond just advanced age predispose individuals to handrail use. The individuals in the present study had undergone major orthopaedic surgery, and older persons may have delayed healing time or an increased time for recovery of muscle function^{26,27}. It is also important to note that persons who were able to overcome relying on a handrail after surgery were significantly younger than those who still required the handrail. Musculoskeletal disease imposes additional burdens and impairments that predispose older individuals in the total knee arthroplasty group to poorer functional ability during stair-climbing.

Many factors determine the optimum time to undergo total knee arthroplasty. Typically, when symptoms progress to a point at which activities of daily living are substantially affected, total knee arthroplasty is performed. Age and preoperative handrail use are variables that cannot be directly affected through therapeutic interventions such as exercise or physical therapy, and aggressive preoperative strengthening programs in the presence of pain related to knee osteoarthritis are not always feasible. Performing a total knee arthroplasty earlier in the course of the disease therefore may be beneficial to an individual's postoperative stair-climbing ability, particularly because preoperative quadriceps strength has been shown to influence postoperative functional outcomes¹³.

The present study had a few limitations. Although we utilized a range of clinical variables to predict handrail use after surgery, other nonclinical variables also may contribute

to the need for a handrail. Additionally, the subject selection for the present study was from a narrow geographic window and comprised a relatively homogenous sample of patients, all of whom were operatively managed by one of three physicians. While we have examined the use of a handrail, we did not quantify the pressure or force used during stair ascent and descent. Quantification and differentiation of particular handrail use is challenging and would require either an instrumented handrail or a variety of descriptive categories. Although we had lost 50% of the control subjects at the time of follow-up, we believe that the results of the present study are valid and reflect the continuing need for a handrail fol-

lowing total knee arthroplasty in a high proportion of patients. ■

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