Published in final edited form as:

Arch Phys Med Rehabil. 2018 May ; 99(5): 967–972. doi:10.1016/j.apmr.2017.12.030.

Pre-operative Risk Factors for Postoperative Falls in Persons with Hip or Knee Arthroplasty: A Longitudinal Study of Data from the Osteoarthritis Initiative

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Abstract

Objective—The primary purpose was to identify preoperative risk factors associated with post-hospitalization falls over an approximate 2-year postoperative period in patients undergoing hip and knee arthroplasty.

Design—The study utilized a longitudinal cohort design.

Setting—Participants were recruited from communities surrounding four urban university-based medical centers.

Participants—All participants underwent hip or knee arthroplasty over a 9-year study period and were followed yearly in the Osteoarthritis Initiative study.

Main Outcome Measure—The primary outcome measure was a self-reported history of falls over the two-year postoperative period. A fall was recorded when the participant reported landing on the floor or ground. Preoperative predictors of falls derived from prior evidence included preoperative fall history, depressive symptom severity, narcotic use, age, activity level and comorbidity. Multinomial regression analysis was applied to determine factors that predicted either a single fall or multiple falls during a two-year postoperative period.

Results—Preoperative predictors of multiple postoperative falls were a preoperative history of falling, depressive symptoms and hip versus knee arthroplasty. Patients with hip arthroplasty were more than twice as likely (Odds Ratio = 2.26, 95% CI = 1.21, 4.20) as patients with knee arthroplasty to have multiple self-reported falls in the first two postoperative years. No predictors were found for persons who reported falling only once postoperatively. Findings were generally supported in a sensitivity analysis.

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Conclusions—Clinicians involved with the pre-and postoperative care of persons undergoing hip or knee arthroplasty can use these findings to inform fall risk screening and intervention delivery to reduce fall risk in patients who are at risk for multiple falls following hip or knee arthroplasty.

Keywords

knee; hip; arthroplasty; falls

Falls among persons who are middle-aged and older are often highly consequential and costly, particularly among individuals aged 65 years and older. Pain is a risk factors for falls particularly among older persons with osteoarthritis of the hip or knee.¹ Costs for falls treatment approach \$30 billion annually in the United States and many of those treated have painful osteoarthritis.²

For persons with severe symptomatic osteoarthritis of the hips or knees, joint arthroplasty is common with more than 1 million procedures expected in the United States in 2015.³ Falls among persons with arthroplasty are common. Approximately a third of persons fall at least once in the year following hip (HA) or knee arthroplasty (KA).⁴⁻⁶ Falls may explain why patients undergoing KA are at higher risk of hip fracture in the year following surgery as compared to similarly aged persons without KA.⁷

Fall prevention interventions have been extensively studied and found to be effective.^{8;9} Fall incidence and associated injuries may be potentially reduced by identifying patients at increased risk and providing targeted intervention delivered by rehabilitation clinicians pre- or post-operatively to reduce fall risk and subsequent injury in these patients.

Longitudinal studies of risk factors of post-hospitalization falls in persons following hip or knee arthroplasty are generally lacking. Only one study was found that examined persons with both hip and knee arthroplasty⁶ but this study did not specifically study risk factors for persons who fall multiple times, arguably the sub-group at greatest risk for injury. Because multiple falls result in greater exposure to injury risk relative to single falls, risk factors for single versus multiple falls warrant additional investigation. One purpose was to identify risk factors for single and multiple self-reported falls up to two years following HA or KA. Because falls following HA are understudied relative to falls following KA, this study also determined whether there is a difference in fall risk for patients with HA versus those with KA.

METHODS

This was a retrospective analysis of data obtained as part of a prospective observational study of 4,796 persons assessed yearly over a nine-year period. Participants were recruited from four sites. The data source was the Osteoarthritis Initiative (OAI), a prospective National Institutes of Health and privately funded multicenter prospective 9-year longitudinal community-based study of persons with radiographic knee osteoarthritis (OA) or at high risk for knee OA.¹⁰ Knee OA risk was determined by the presence of overweight or obesity, prior knee injury or surgery, knee symptoms or family history of knee

replacement surgery. The study was approved by the Institutional Review Boards of the four sites and all patients provided informed consent.

A total of 17,457 persons were screened. More common exclusion criteria were magnetic resonance imaging height and weight limitations (n=2,328), age and sex-based recruitment thresholds (n=2,954) and dropouts prior to enrollment (n=4,381). No care was provided in the study. The OAI website provides more detailed information (<http://www.oai.ucsf.edu/>).

Selection of participants for the current study

Of the 4,796 participants in OAI, a total of 596 underwent either knee (KA) or hip arthroplasty (HA) for osteoarthritis over the nine-year study period. A total of 449 participants had an isolated knee (n = 303) or hip (n=146) arthroplasty. The other 147 subjects had multiple procedures with 95 undergoing bilateral KA, 24 had bilateral HA, 7 had bilateral KA and unilateral HA, 1 had bilateral HA and unilateral KA and 20 had unilateral HA and KA. For the analysis, persons were coded as having either HA or KA based on their earliest procedure. We also created an additional dichotomous variable indicating whether persons had an isolated arthroplasty procedure or multiple procedures over the study period.

Figure 1 illustrates the yearly time points for the first arthroplasty surgery for each participant in the study. The surgical data in OAI are time-varying. That is, the day from the OAI yearly follow-up visits to the day of surgery varies for each patient. The pre-operative data collection visit occurred a mean of 179 days (sd = 103) prior to the arthroplasty surgery of interest while the first and second postoperative visits occurred a mean of 197 days (sd = 100) and 556 days (sd = 107) following surgery, respectively.

Measurement of falls

Each participant visited a study site yearly, or a questionnaire was completed yearly. During each yearly study visit from baseline to year 4 and then at year 6 and year 8 visits, all participants were asked the following question: "During the past 12 months, have you fallen and landed on the floor or ground?" Responses were either yes or no. If yes, the participant was asked: "How many times have you fallen in the past 12 months?" Possible responses were one, two or three, four or five and six or more. The number of falls was categorized as either no falls, one fall per year or two or more falls per year. Self-report measures for falls over a 12-month period have strong validity based on systematic review evidence¹¹ with specificity ranging from 91% to 95% and sensitivity ranging from 80% to 89% when compared to prospective weekly reporting.

Predictors of fall risk

A recent systematic review was used to derive key predictors of fall risk for community dwelling older persons¹² and these were age, sex, self-reported opioid use during the prior month, physical activity as measured with the Physical Activity Scale for the Elderly (PASE), a validated self-reported scale of overall activity level with higher scores indicating greater activity¹³ extent of depressive symptoms as measured with the Center for Epidemiologic Studies Depression (CES-D) score, a validated 20-item self-report scale of

extent of depressive symptoms with scores from 0 to 60 and higher scores indicating greater symptoms.¹⁴ Comorbidity was measured with a validated modified Charlson comorbidity scale with higher scores indicating higher comorbidity.¹⁵ Walking aid use during indoor walking (yes or no) was recorded for each participant. Preoperative narcotic use was assessed by asking patients to bring all medications to annual site visits and was coded as “yes” if an opioid medication was being used. Opioid use has been shown to increase fall risk in persons with osteoarthritis.¹⁶ To account for all participants who had additional arthroplasty procedures over the study period a dichotomous variable was coded to indicate whether the participant had a single arthroplasty procedure or multiple arthroplasty procedures.

Data Analysis

Descriptive data for the entire sample is reported in Table 1. To identify pre-operative risk factors for postoperative falls, categorized as 0, 1 or 2 or more falls during the two-year postoperative period (as measured from the first two postoperative visits), a multinomial multivariable logistic regression model was generated. The time period of interest for the primary analysis was the first four years of data collection because all participants had one-year pre-operative and 2-year post-operative data over this time period. During this period, a total of 244 persons underwent either KA (n = 165) or HA (n = 79).

Pre-operative predictor variables were age, sex, opioid use, PASE score, CESD score, comorbidity, history of falls in the year prior to the pre-op visit, receipt of either knee or hip arthroplasty, and receipt of an isolated arthroplasty or multiple arthroplasty procedures over the study period. Because only 5% of participants reported using a walking aid indoors at the preoperative visit, this variable was excluded from the main analyses. All two-way interactions were tested and only significant interactions at $p < 0.05$ were retained. The Pearson Chi Square goodness of fit test and the Nagelkerke pseudo R^2 tests were used to judge acceptability and explained variance.

To take full advantage of all available data, a sensitivity analysis was conducted using all available data (n = 596 patients) over the entire nine-year period for participants who had either one-year or two-year pre and postoperative fall data available (falls data were not collected in OAI during years 5, 7 and 9). For the sensitivity analysis, a total of n = 413 KA participants and n = 183 HA participants were studied. All analyses were completed using IBM SPSS, Version 24.

RESULTS

Characteristics of the entire sample and the sample stratified by HA or KA are reported in Table 1. For the entire sample, participants were, on average, 68.18 years of age at the preoperative visit, and 60.1% were female. Participants with HA were similar to those with KA for most characteristics with the exception of a slightly greater rate of opioid use prior to surgery and greater rates of multiple falls during the two-year postoperative period.

Pre-operative Predictors of postoperative falls

For the primary analysis, multinomial logistic regression analysis indicated that, relative to the no falls sample, persons reporting 1 fall had no identifiable risk factors for falls. Compared to the no falls group, persons falling two or more times were more likely to have higher depressive symptoms, have fallen at least once in the pre-operative year and have had HA versus KA. For each point increase in depressive symptoms, risk of falling 2 or more times increased by 8%, on average (95%CI = 1.02, 1.14). Persons reporting at least 1 fall preoperatively were, on average, almost four times more likely to fall two or more times postoperatively as compared to those with no preoperative falls (OR=3.89, 95% CI=1.79,8.44). Persons with HA (as compared to KA) were more than two times more likely (OR = 2.26 (1.21, 4.20) to fall two or more times during the postoperative period versus the referent no falls group (See Table 2). Whether a person used opioid medication, or had an isolated HA or KA or multiple joint replacements did not influence the prediction of fall risk.

For the sensitivity analysis, similar results were found with a few exceptions. First, females had a statistically significant risk of a single fall postoperatively as compared to males (OR = 2.25, 95%CI = 1.14, 4.41). Second, having at least 1 comorbidity preoperatively increased risk of 2 or more postoperative falls (OR = 1.95, 95%CI = 1.06, 3.58). Other findings were similar to the primary analysis (see Table 3).

No significant interactions among the predictors was found for either model. The Pearson Chi Square goodness of fit test was not significant ($p = 0.33$) for both the primary analysis and the sensitivity analysis ($p = 0.21$) indicating well-fitting models. The Nagelkerke R^2 estimate indicated 25% explained variance in the primary analysis and 26% explained variance in the sensitivity analysis.

DISCUSSION

This study is, to the authors' knowledge, the largest study of preoperative risk factors associated with postoperative falls following KA and HA. Prior work has been limited by small samples or a focus strictly on KA. Use of the OAI dataset allowed us to study almost 600 persons undergoing KA or HA, most of whom had multiple years of follow-up and yearly fall history data. Several novel findings were noted. First, risk factors for a single postoperative fall are different from risk factors for multiple falls. No other evidence was found to indicate that risk factors for single versus multiple falls in persons with HA and KA are different.^{4-6;17} Studies that have examined fall risk following KA or HA dichotomized postoperative fall data, coded as either fallers or non-fallers. This approach appeared to miss important differences in risk factor identification between persons who had a single postoperative fall and those that fell multiple times.

Depressive symptoms and a history of previous falls were independently associated with multiple postoperative falls. Associations between depressive symptoms and preoperative fall history^{4-6;17} have been reported. However, these prior studies did not account for the number of postoperative falls in the analyses. Preoperative fall history and higher depressive symptoms preferably associated with multiple postoperative falls and not with single falls,

an important distinction given that multiple falls increase risk of injury relative to a single fall because of the more frequent exposure to falling.

Another novel finding was that participants undergoing HA had over double the risk, on average, for multiple falls postoperatively as compared to participants with KA. Prior work⁶ on a sample of similar size to that used in the primary analysis did not find a difference in postoperative fall risk between HA and KA participants. One difference is that postoperative fall history was examined up to approximately 2 years following surgery whereas the study by Levinger and colleagues⁶ studied postoperative falls for only one year following surgery. Reasons for the differences in HA and KA risk between the current study and the study by Levinger and colleagues⁶ are speculative.

Because pain increases fall risk for medically treated patients,¹ a post-hoc multinomial regression was used to determine whether pain, measured pre-operatively with the WOMAC Pain scale,¹⁸ in combination with predictors used in the primary analysis was a significant predictor of postoperative falls for the 165 persons with KA (pain data were not available for HA cases). Pain did not predict fall status (data not shown) which was likely explained by the intervening surgery which is generally highly effective at relieving pain.¹⁹

Several known risk factors for falls in prior work were not found to be significant predictors in this study. Females, older persons, those with higher BMI, those with multiple arthroplasty procedures or persons taking opioids were not at an elevated risk for falls following HA or KA. However, an important caveat is that the sensitivity analysis suggested that females and those with at least one comorbidity may be at higher risk of falls. More study is needed to clarify this issue. Findings from the current study suggest that clinicians should focus on preoperative fall history, depressive symptom severity, and HA versus KA candidates to identify the most likely and important factors associated with increased fall risk.

A variety of strategies could be used to identify patients who may benefit from interventions designed to reduce fall risk. For example, targeting interventions of known efficacy including balance and targeted strength training in persons with lower extremity strength or balance impairments and a fall history has potential to reduce fall risk for a substantial number of persons who are at risk for multiple falls in the two years following surgery.^{8;9} Treatment of depressive symptoms, a modifiable risk factor is a likely target for pre-operative intervention to reduce subsequent fall risk. A total of 58% of persons with hip arthroplasty who reported at least one preoperative fall reported falling at least twice during the two postoperative years while 46% of persons with TKA who reported at least one preoperative fall had at least two falls. Benefits of interventions to reduce fall risk have been established in the literature and support the use of preoperative interventions for this high-risk subgroup of prior fallers.

Study Limitations

Because the OAI dataset relied on self-reports of falls over a 12-month period, less-than-optimal reliability of fall assessments could have affected the results. However, self-reports of 12-month fall history have been validated.¹¹ In addition, participants in the OAI are

generally relatively healthy with few comorbidities. The OAI may therefore not be representative of the US population as a whole. Additionally, the substantial majority of participants (90% of HAs and 95% of KAs) had degenerative osteoarthritis as the diagnostic indication for arthroplasty, and the remaining diagnoses were acute trauma, traumatic arthropathy and osteonecrosis. The findings may be different for patients with other diagnoses such as inflammatory arthropathy. For the primary analysis, there was a relatively small sample of 244 participants which likely reduced the power to assess additional variables. For example, the sensitivity analysis identified a greater number of predictor variables, most importantly female sex and the presence of comorbidity. Assuming an association of similar magnitude to that reported in the sensitivity analysis, this study would have likely found a similarly significant association between these variables and multiple postoperative falls if a larger sample was included in the primary analysis.

The timing of HA and KA surgeries relative to follow-up OAI visits varied, meaning that time from surgery to OAI follow-up visits was not controlled. Data interpretation from the first post-operative visit was not consistent because of the time varying nature of the data. For example, some patients may have recalled falls that occurred prior to surgery in the first postoperative visit because the visit occurred less than a year after surgery. In the authors' opinion, it was important to include data from the first postoperative visit because this visit captured the time period early in the post-hospitalization recovery period when pain and postoperative muscle weakness is greatest following surgery making falls more likely. This approach may have led to some over-reporting of postoperative falls. Additionally, the sensitivity analysis likely underestimated falls given that some patient had only a 1-year follow-up. Finally, multinomial regression was used with several covariates to control for potential confounding, but a limited subset of known risk factors for falls were included in the analysis. Because the variables assessed were not exhaustive (e.g. lower extremity strength and balance assessment was missing), unmeasured confounding may have influenced the findings.

Conclusions

This study provides new insights into the factors that likely lead to falls, potentially a highly consequential complication following KA and HA. A preoperative history of falls, greater depressive symptoms and HA versus KA are associated with elevated risk of multiple postoperative falls in patients undergoing lower extremity joint replacement. It is recommended that rehabilitation clinicians and orthopaedic surgeons take a detailed history of prior falls and educate the patient regarding risk factors that increase risk of multiple postoperative falls. A determination of likely causes of prior falls and additional intervention to address these suspected causes may be helpful. Patients should be counseled regarding these risk factors prior to surgery and interventions particularly directed toward reduction of depressive symptoms in those with higher than expected symptoms should be considered. Patients undergoing HA should be educated about the increased risk of falls as compared to persons undergoing KA.

Acknowledgments

The Osteoarthritis Initiative (OAI) is a public-private partnership comprised of five contracts (N01-AR-2-2258, N01-AR-2-2259, N01-AR-2-2260, N01-AR-2-2261, N01-AR-2-2262) funded by the National Institutes of Health, a branch of the Department of Health and Human Services, and conducted by the OAI Study Investigators. Private funding partners include Merck Research Laboratories; Novartis Pharmaceuticals Corporation, GlaxoSmithKline; and Pfizer, Inc. Private sector funding for the OAI is managed by the Foundation for the National Institutes of Health. This manuscript was prepared using an OAI public use data set and does not necessarily reflect the opinions or views of the OAI investigators, the NIH, or the private funding partners. The investigators of the current study is not members of the OAI investigative team.

Abbreviations

HA	hip arthroplasty
KA	knee arthroplasty
OAI	Osteoarthritis Initiative
OA	osteoarthritis
PASE	Physical Activity Scale for the Elderly
CES-D	Center for Epidemiologic Studies Depression

Reference List

1. Stubbs B, Binnekade T, Eggermont L, Sepehry AA, Patchay S, Schofield P. Pain and the risk for falls in community-dwelling older adults: systematic review and meta-analysis. *Arch Phys Med Rehabil.* 2014; 95(1):175–87. [PubMed: 24036161]
2. Barbour KE, Stevens JA, Helmick CG, Luo YH, Murphy LB, Hootman JM, et al. Falls and fall injuries among adults with arthritis--United States, 2012. *MMWR Morb Mortal Wkly Rep.* 2014; 63(17):379–83. [PubMed: 24785984]
3. Kurtz SM, Ong KL, Lau E, Bozic KJ. Impact of the economic downturn on total joint replacement demand in the United States: updated projections to 2021. *J Bone Joint Surg Am.* 2014; 96(8):624–30. [PubMed: 24740658]
4. Matsumoto H, Okuno M, Nakamura T, Yamamoto K, Hagino H. Fall incidence and risk factors in patients after total knee arthroplasty. *Arch Orthop Trauma Surg.* 2012; 132(4):555–63. [PubMed: 22089514]
5. Swinkels A, Newman JH, Allain TJ. A prospective observational study of falling before and after knee replacement surgery. *Age Ageing.* 2009; 38(2):175–81. [PubMed: 19029071]
6. Levinger P, Wee E, Margelis S, Menz HB, Bartlett JR, Bergman NR, et al. Pre-operative predictors of post-operative falls in people undergoing total hip and knee replacement surgery: a prospective study. *Arch Orthop Trauma Surg.* 2017; 137(8):1025–33. [PubMed: 28597247]
7. Prieto-Alhambra D, Javaid MK, Maskell J, Judge A, Nevitt M, Cooper C, et al. Changes in hip fracture rate before and after total knee replacement due to osteoarthritis: a population-based cohort study. *Ann Rheum Dis.* 2011; 70(1):134–8. [PubMed: 20980287]
8. Osho O, Owwoye O, Armijo-Olivo S. Adherence and Attrition in Fall Prevention Exercise Programs for Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis. *J Aging Phys Act.* 2017:1–41.
9. Sherrington C, Michaleff ZA, Fairhall N, Paul SS, Tiedemann A, Whitney J, et al. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. *Br J Sports Med.* 2016
10. Lester G. Clinical research in OA--the NIH Osteoarthritis Initiative. *J Musculoskelet Neuronal Interact.* 2008; 8(4):313–4. [PubMed: 19147953]

11. Ganz DA, Higashi T, Rubenstein LZ. Monitoring falls in cohort studies of community-dwelling older people: effect of the recall interval. *J Am Geriatr Soc.* 2005; 53(12):2190–4. [PubMed: 16398908]
12. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La VC, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology.* 2010; 21(5):658–68. [PubMed: 20585256]
13. Washburn RA, McAuley E, Katula J, Mihalko SL, Boileau RA. The physical activity scale for the elderly (PASE): evidence for validity. *J Clin Epidemiol.* 1999; 52(7):643–51. [PubMed: 10391658]
14. Radloff LS. The CES-D scale: a self report depression scale for research in the general population. *Appl Psychol Meas.* 1977; 1:385–401.
15. Katz JN, Chang LC, Sangha O, Fossel AH, Bates DW. Can comorbidity be measured by questionnaire rather than medical record review? *Med Care.* 1996; 34(1):73–84. [PubMed: 8551813]
16. Rolita L, Spegman A, Tang X, Cronstein BN. Greater number of narcotic analgesic prescriptions for osteoarthritis is associated with falls and fractures in elderly adults. *J Am Geriatr Soc.* 2013; 61(3):335–40. [PubMed: 23452054]
17. Levinger P, Menz HB, Wee E, Feller JA, Bartlett JR, Bergman NR. Physiological risk factors for falls in people with knee osteoarthritis before and early after knee replacement surgery. *Knee Surg Sports Traumatol Arthrosc.* 2011; 19(7):1082–9. [PubMed: 21107530]
18. Bellamy N. The WOMAC Knee and Hip Osteoarthritis Indices: development, validation, globalization and influence on the development of the AUSCAN Hand Osteoarthritis Indices. *Clin Exp Rheumatol.* 2005; 23(5 Suppl 39):S148–S153. [PubMed: 16273799]
19. Lingard EA, Katz JN, Wright EA, Sledge CB. Predicting the outcome of total knee arthroplasty. *J Bone Joint Surg Am.* 2004; 86-A(10):2179–86. [PubMed: 15466726]

Figure 1.

The figure illustrates the number of participants who underwent either knee or hip arthroplasty over the 9-year study period.

Preoperative characteristics and postoperative fall rates for the primary analysis and sensitivity analysis sample and stratified by knee and hip arthroplasty[#]

Table 1

	Primary Analysis Sample n (%) or mean (sd), (N = 244)	Sensitivity Analysis Sample n (%) or mean (sd), (N = 596)	KA Cases n (%) or mean (sd) (N = 413)	HA Cases n (%) or mean (sd) (N = 183)
Age	66.7 (8.7)	68.18 (8.73)	68.24 (8.42)	67.94 (9.07)
missing	0	0		
Female sex	145 (59.4)	358 (60.1)	250 (60.5)	108 (59.0)
missing	0	0		
Body Mass Index [*]	29.96 (4.64)	29.87 (4.72)	29.89 (4.72)	28.72 (4.33)
missing	0	30	20	10
African American race	36 (14.8)	75 (12.6)	52 (12.6)	23 (12.6)
missing	1	1	1	0
Comorbidity Index				
0	161 (66.0)	379 (67.9)	263 (68.0)	116 (67.8)
>=1	73 (29.9)	179 (32.1)	124 (32.0)	55 (32.2)
missing	10	38	26	12
PASE score	131.49 (81.31)	131.26 (79.29)	129.92 (72.09)	132.85 (90.57)
missing	17	50	32	18
CES-D score	6.6 (5.9)	7.05 (6.54)	7.15 (6.71)	7.14 (6.20)
missing	18	39	23	16
Pre-operative history of falls (yes)	77 (31.6)	148 (34.7)	101 (33.56)	47 (37.60)
missing	14	33	21	12
Opioid use (yes)	36 (14.8)	61 (14.4)	38 (12.22)	26 (20.15)
missing	8	19	11	8
Two-year Post-operative Falls				
0	124 (53.2)	284 (57.8)	206 (60.8)	78 (51.3)
1	41 (17.6)	93 (19.0)	63 (18.6)	30 (19.7)
2 or more	68 (29.2)	114 (23.2)	70 (20.6)	44 (29.0)
missing	11	36	24	12

Abbreviations: PASE = Physical Activity Scale for the Elderly, CES-D = Center for Epidemiologic Studies Depression, KA = knee arthroplasty, HA = hip arthroplasty

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* Body mass index is calculated as the weight in kilograms divided by height in meters squared

For comorbidity, PASE, CES-D, fall history, opioid use, and postoperative falls, data were not collected in years 5 and 7 of OAI so data in these years were not coded as missing.

Table 2

Multinomial regression model for predicting postoperative fall risk from pre-operative variables. The sample size for this analysis was n = 244 patients. No falls is the reference category.

	Beta	Odd Ratio (95% CI)
1 Fall[#]		
Age	−0.005	1.00 (0.95, 1.04)
Female sex	0.56	1.74 (0.77, 3.97)
PASE score	0	1.0 (0.99, 1.01)
Depressive Symptoms	−0.003	0.99 (0.92, 1.08)
Comorbidity	0.26	1.29 (0.57, 2.95)
Narcotic use	−1.62	0.20 (0.02, 1.70)
Prior falls	−0.22	0.80 (0.30, 2.16)
Hip versus knee	0.40	1.49 (0.65, 3.43)
Isolated replacement	−0.11	0.90 (0.39, 2.10)
2 or More Falls[#]		
Age	0.004	1.00 (0.96, 1.05)
Female sex	−0.39	0.68 (0.33, 1.41)
PASE score	0.004	1.00 (0.99, 1.01)
Depressive Symptoms	0.08	1.08 (1.02, 1.14) [*]
Comorbidity	0.54	1.72 (0.81, 3.62)
Narcotic use	0.22	1.24 (0.48, 3.21)
Prior falls	1.37	3.89 (1.79, 8.44) ⁺
Hip versus knee	0.91	2.47 (1.20, 5.10) [*]
Isolated replacement	0.34	1.41 (0.66, 3.00)

[#] Persons with 1 fall and persons with 2 or more falls were compared to the group of participants who reported no falls in the prior year.

^{*} p < 0.05,

⁺ p = 0.001

Table 3

Sensitivity analysis multinomial regression model for predicting postoperative fall risk from pre-operative variables. The sample size for this analysis was n = 596 patients. No falls is the reference category.

	Beta	Odd Ratio (95% CI)
1 Fall[#]		
Age	0.005	1.00 (0.97, 1.05)
Female sex	0.81	2.25 (1.14, 4.41) *
PASE score	0	1.0 (0.99, 1.01)
Depressive Symptoms	−0.02	0.98 (0.92, 1.04)
Comorbidity	0.08	1.08 (0.55, 2.14)
Narcotic use	.14	1.15 (0.43, 3.08)
Prior falls	−0.41	0.66 (0.31, 1.45)
Hip versus knee	0.43	1.53 (0.79, 3.00)
Isolated replacement	−0.36	0.70 (0.33, 1.48)
2 or More Falls[#]		
Age	−0.001	1.00 (0.97, 1.04)
Female sex	0.004	1.00 (0.55, 1.85)
PASE score	0.002	1.00 (0.99, 1.01)
Depressive Symptoms	0.04	1.04 (1.00, 1.08) *
Comorbidity	0.67	1.95 (1.06, 3.58) *
Narcotic use	0.19	1.20 (0.54, 2.70)
Prior falls	1.78	5.92 (3.23, 10.83) ⁺
Hip versus knee	0.81	2.25 (1.21, 4.20) *
Isolated replacement	0.52	1.68 (0.90, 3.14)

[#] Persons with 1 fall and persons with 2 or more falls were compared to the group of participants who reported no falls in the prior year.

* p < 0.05,

⁺ p = 0.001