

Fall Risk and Utilization of Balance Training for Adults With Symptomatic Knee Osteoarthritis: Secondary Analysis From a Randomized Clinical Trial

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ABSTRACT

Background and Purpose: Knee osteoarthritis (KOA) is a common disease that hinders activity participation in older adults. Associated symptoms and physiological changes can increase risk of falling in individuals with KOA. Balance training can decrease fall risks in older adults. Limited evidence exists regarding utilization of balance training in physical therapy (PT) for this population. This secondary data analysis investigated the proportion of participants at high risk for falling in the Physical Therapy vs. Internet-based Exercise Training for Patients with Osteoarthritis (PATH-IN) study and the frequency with which balance training was utilized as an intervention in PT.

Methods: PATH-IN study participants (N = 344) performed the Four-Stage Balance Test and the Timed Up and Go (TUG) test during baseline assessment. Participants were randomly

allocated to PT, an Internet-based exercise program, or a control group. Participants were classified as being at high risk for falling if they did not progress to the single-leg stance (SLS) during the Four-Stage Balance Test, were unable to maintain SLS for 5 seconds, or took longer than 13.5 seconds to complete the TUG test. The proportion of participants at high risk for falling was calculated for all participants and separately for those allocated to PT. In addition, PT notes were coded for balance training and the frequency of balance training utilization was calculated.

Results and Discussion: Upon enrollment, 35.5% (N = 122) of all participants and 36.2% (N = 50) of those allocated to PT were at high risk for falling. Of participants allocated to PT with documentation available for coding (N = 118), 35.5% (N = 42) were at high risk for falling. Balance training was

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provided to 62.7% (N = 74) during at least one PT session. Of those classified as being at high risk for falling, 33.3% (N = 14) did not receive balance training.

Conclusions: The finding of high fall risks in more than one-third of all participants with KOA is consistent with previous reports of a higher risk of falling in this population. Many PT participants did receive some balance training; however, one-third of participants at high risk for falling did not. Balance training for individuals with KOA at high risk for falling may be underutilized.

Key Words: balance training, fall risk, knee osteoarthritis, physical therapy

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INTRODUCTION

Knee osteoarthritis (KOA) is a degenerative joint disease that involves the breakdown of cartilage and bone within the knee joint, which can result in significant pain, swelling, and stiffness.¹ Damage to joint cartilage increases joint laxity, allowing excessive motion within the knee.² This deterioration in joint integrity can result in a cycle of pain, physical impairments, and disability in individuals with KOA.² The progressive deterioration within the joint capsule may be further exacerbated during the aging process or after injury to the knee joint.²

Knee osteoarthritis is a highly common joint disorder in the United States, with a prevalence of 37.4% of participants 60 years or older in a national survey.³ Risk factors associated with the incidence of KOA include age more than 50 years, female sex, obesity (body mass index [BMI] >30 kg/m²), and prior trauma to the knee.⁴ Because of the aging population and rising obesity rates in the United States, the prevalence of individuals affected by this disease is likely to continue to rise.⁵

Reduced muscular strength and loss of physical function are common impairments found in individuals with KOA.⁶ In addition, individuals with KOA frequently experience a loss of proprioception, potentially due to articular cartilage damage and impaired mechanoreceptors.⁷⁻⁹ These deficits contribute to decreased neuromuscular control, which can decrease an individual's ability to safely perform functional activities and increase risk for falling.⁶ Doré et al¹⁰ reported that participants with symptomatic KOA had a 39% higher odds of future falls. Tsonga et al⁶ reported a frequency of falls in older adults with KOA to be 63.2% over the course of 1 year. In addition, individuals who report a history of falls with a diagnosis of KOA are more likely to have a poorer health-related quality of life than individuals with a history of falls or KOA alone.¹¹ The rapidly aging population and increasing prevalence of arthritis will likely compound this public health problem.

Because of the increased risk for falling in this population, balance training and fall prevention programs may be important management strategies for individuals with symptomatic KOA. The Centers for Disease Control and Prevention¹² and

the American and British Geriatrics Societies Clinical Practice Guidelines¹³ describe balance exercises as effective and essential components in a fall prevention program. Several studies have demonstrated the additive benefit of balance training to standard exercise programs for individuals with KOA.^{8,14-16} Recently, Takacs et al¹⁶ reported decreased pain and fear of movement, as well as improved physical function, in individuals with KOA following a 10-week dynamic balance training program. Other trials have reported positive effects of balance training on outcomes including the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) total and subscale scores, physical function tests, global rating of change, and proprioceptive function in individuals with KOA.^{8,9,15-17} Furthermore, balance training interventions have decreased fear of movement and depression symptoms in this population.^{15,16} Despite the increased risk of falling in individuals with KOA and the benefit of balance training in older adults, information is lacking about utilization of this intervention as a component of physical therapy (PT) for this population.^{18,19}

The aims of this secondary data analysis were (1) to determine the proportion of participants in the Physical Therapy vs. Internet-based Exercise Training for Patients with Knee Osteoarthritis (PATH-IN) study at high risk for falling, and (2) the frequency with which balance training was included in the PT intervention relative to fall risks. In addition, this analysis summarizes the interventions utilized for balance training by the physical therapists. Assessment of current PT practice patterns for individuals with KOA at risk for falling may help physical therapists recognize the potential to integrate balance training into a comprehensive plan of care for individuals with KOA and potentially reduce risk for falling in this population.

METHODS

Participants

This secondary data analysis included participants from a randomized control trial of adults with symptomatic KOA.²⁰ Participants (N = 350) had a prior diagnosis of KOA and current symptoms (pain, aching, or stiffness on most days of the week) in at least one knee. Participants were excluded from the PATH-IN trial if they had a fall history deemed by a physical therapist investigator to impose risk for injury with participation in an independent home exercise program. Participants were randomly allocated to PT, an Internet-based exercise program, and a control group in a 2:2:1 ratio. The sample for this study included all participants who had data to assess fall risks, as described later, prior to randomization (N = 344). Physical therapy intervention analysis included participants allocated to PT with complete documentation of the interventions provided during sessions, also described later (N = 118). The PATH-IN research trial was approved by the institutional review boards of the University of North Carolina at Chapel Hill and Duke University Medical Center.

Measures and Fall Risk Determination

All participants who consented to participate in the PATH-IN trial provided demographic and personal information via self-report (age, college education, sex, race, marital status, BMI, and duration of joint pain). In addition, prior to randomization, they completed a battery of self-report questionnaires and physical function tests conducted by trained examiners. Self-report questionnaires included the WOMAC, a widely used health status questionnaire that assesses pain, stiffness, and physical function in individuals with KOA.²¹ Total WOMAC scores (0-96) were determined by the summation of scores for the Pain (0-20), Stiffness (0-8), and Physical Function (0-68) subscales.²¹ Higher WOMAC total scores indicate worse pain, stiffness, and physical function limitations.²¹ Physical function measures included the Four-Stage Balance Test²² and the TUG test.²³ The trained examiners were blinded to group assignment of participants.

An evidence-based classification of high fall risks was based on previously established cutoff scores for the single leg stance (SLS) and the TUG test. The SLS was the final component of the Four-Stage Balance Test, which assesses static balance in 4 progressively challenging positions held for a maximum of 10 seconds each.²² Vellas et al²⁴ reported that an inability to perform SLS for 5 seconds is predictive for injurious falls in older adults. The TUG test is a useful outcome measure to assess functional mobility and dynamic balance.²³ Shumway-Cook et al²⁵ reported that taking longer than 13.5 seconds to complete the TUG test can accurately predict falls in community-dwelling older adults. This cutoff for the TUG test was confirmed by Zasadzka et al²⁶ as an indicator for falls in older adults with lower extremity osteoarthritis. Therefore, participants were classified as being at high risk for falling if they did not progress to the SLS during the Four-Stage Balance Test, were unable to maintain SLS for 5 seconds, or took longer than 13.5 seconds to complete the TUG test. All other participants were classified as being at low risk for falling.

PT Intervention

Prior to participant enrollment, PATH-IN study investigators met with the physical therapists who would deliver PT to participants to provide orientation to the project, as well as training in the PT intervention and use of the study database. The physical therapists received a handout summarizing evidence-based interventions^{18, 19} to guide the content of the PT sessions (see the Appendix) and were instructed to use clinical judgment to tailor PT sessions to the needs of each participant. During the first PT session, the physical therapists completed a standardized, electronic evaluation form, along with documentation of any treatment provided during that visit. The electronic evaluation form included prepopulated data from the baseline assessments completed prior to randomization. Prepopulated data included participants' TUG score, as well as semi-tandem, tandem, and SLS times. The evaluation form indicated that a TUG score of 13.5 seconds or

more may predict risk for falling. During follow-up visits, physical therapists documented specific exercises and other interventions provided during sessions. Participants received up to eight 1-hour sessions based on the physical therapist's assessment of the need for skilled therapy and the participant's willingness to attend sessions.

After all PT sessions were completed, a chart review was completed to identify use of balance training. Progress notes in the study database were manually reviewed by the study authors, and each visit was coded as including balance training or not. If an exercise listed was unfamiliar, the physical therapist who provided the intervention was contacted for further description and purpose of the exercise to allow for proper coding. Interventions were coded as balance training if they included narrowing the base of support, movement of the center of mass, reaching with an upper or lower extremity to the limit of stability, or overcoming external perturbations. Interventions that focused on improving strength, flexibility, or aerobic capacity were not coded as balance training. A list was compiled of interventions coded as balance training (Table 1).

Table 1. Interventions Coded as Balance Training Activities

Balance Activities
Standing with feet together
Lateral weight shifting
Anterior and posterior weight shifting
Semi-tandem stance
Tandem stance
Marching in place
Unilateral stance
Lateral walking
Backward walking
Standing on a compliant surface (foam, trampoline, BOSU ball)
Closed-chain exercises on compliant surface (mini-squats, heel raises)
Cone step overs (forward or lateral)
Step up onto compliant surface
Figure-of-eight walking
Grape vine walking
Walking with head movements
Tandem walking
Wii balance games
Rocker board/slant board/wobble board activities
Throwing/catching/reaching for objects on compliant surface
Throwing/catching/reaching for objects with smaller base of support (semi-tandem, tandem, single-leg stance [SLS]) ^a
Agility ladder exercises
SLS ^a with contralateral lower extremity reaches in multiple directions
^a Also referred to as unilateral stance.

Data Analysis

Data analysis included (1) the frequency and percentage of PATH-IN participants at high risk for falling at baseline (total sample and for PT group separately) and (2) the frequency and percentage of participants in the PT group for whom balance training was utilized during at least one visit relative to fall risks. Descriptive statistics were computed for total sample and for PT group separately, overall and by risk for falling status. Means and standard deviations were calculated for continuous variables and percentages for categorical variables. Statistical significance between groups was not determined because this work was intended to be a descriptive analysis of a subpopulation of the full trial, and the study was not powered for testing these statistical hypotheses.

RESULTS

The mean age of participants who completed assessments for fall risks (N = 344) was 65.2 years (SD = 11.2). The average WOMAC total score was 32.1 (SD = 17.8). Individuals who were identified as being at high risk for falling (N = 122) tended to be older, less likely to have a college degree, and more likely to be female, to be of nonwhite race, to not be working, to not be married, to have a higher BMI, and to have a higher WOMAC total score (Table 2).

Upon enrollment, 35.5% (N = 122) of 344 participants in the PATH-IN trial, including those allocated to PT, were classified as being at high risk for falling. Of the subpopulation of participants in the PT group, 36.2% (N = 50) of the 138 participants were classified as being at high risk for falling.

Table 2. Participant Characteristics of Total Sample Who Completed Fall Assessment Measures, Overall and by Fall Risk Status^a

Characteristic	Total Sample (N = 344)	Low Fall Risk (N = 222)	High Fall Risk ^b (N = 122)
Age at baseline, y	65.2 (11.2)	63.6 (11.1)	68.1 (10.8)
College education, %	59.3	71.2	37.7
Female sex, %	71.8	67.6	79.5
Nonwhite race, %	26.2	23.4	31.4
Working, %	40.7	45.9	31.1
Married, %	61.9	69.4	48.4
Body mass index, kg/m ²	31.4 (8.0)	29.5 (6.6)	34.8 (9.1)
Pain duration, y	13.2 (11.7)	13.1 (12.4)	13.3 (10.4)
Western Ontario and McMaster Universities Osteoarthritis Index total score, units	32.1 (17.8)	27.8 (16.1)	40 (18.1)

^aValues are mean (standard deviation) unless indicated otherwise.
^bHigh fall risk is single-leg stance less than 5 seconds or Timed Up and Go test 13.5 seconds or more; low fall risk includes all others.

Of the 118 participants included in the PT group that had complete documentation of interventions provided to enable coding for balance training, 64.4% (N = 76) were at low risk for falling and 35.5% (N = 42) were at high risk for falling (Table 3). Regardless of fall risks, 62.7% (N = 74) received balance training during at least one visit. Twenty-eight of the 42 PT group participants classified as being at high risk for falling received balance training during at least one visit (66.7%). Exactly one-third of the participants who were classified as being at high risk for falling in the PT group did not receive balance training.

DISCUSSION

The findings from this secondary data analysis convey that a majority of participants at high risk for falling who participated in PT did receive balance training during at least one session (66.7%). Regardless of fall risks, use of some type of balance training in PT was relatively common (62.7%). Balance training in this study included a wide variety of activities, which illustrate an opportunity to adapt the intervention to match the specific impairments of an individual. Clinical practice guidelines for older adults recommend balance training to reduce fall risks^{12,13}, but one-third of participants in the PT group identified as being at high risk for falling did not receive specific balance training.

The proportion of participants allocated to the PT group at high risk for falling (36.2%) was consistent with the proportion of all PATH-IN participants at high risk for falling (35.5%). Prior studies of fall risks among adults with KOA have reported a range of 48% to 63.2%.^{6,27} The occurrence of high fall risks reported in this study may be lower because participants were excluded from the PATH-IN trial if deemed by a physical therapist investigator to impose risk for injury with participation in an independent home exercise program based on a history of falls.²⁰ However, even with this restriction, a little over one-third of participants were at high risk for falling. This study confirms that a high proportion of individuals with KOA are at an increased risk for falling, which warrants follow-up to decrease this risk and associated consequences.

Some limitations to the results of this study exist. This study assessed PT practice pattern during a clinical trial; therefore, these practice patterns may not reflect typical

Table 3. Frequency and Percentage to Whom Balance Training Was Provided for Participants Allocated to the Physical Therapy Intervention

Intervention	Physical Therapy Participants (N = 118)	Low Fall Risk (N = 76)	High Fall Risk ^a (N = 42)
Received balance training	74 (62.7%)	46 (60.5%)	28 (66.7%)
Did not receive balance training	44 (37.3%)	30 (39.5%)	14 (33.3%)

^aHigh risk for falling is single-leg stance less than 5 seconds or Timed Up and Go test 13.5 seconds or more; low fall risk includes all others.

clinical practice. Consistent with guidelines for conservative management of KOA,^{18, 19} guidance for PT interventions placed greater emphasis on strength and aerobic exercise than balance training, which may have biased the interventions selected by the physical therapists. However, the physical therapists were instructed to use their clinical judgment and tailor interventions to individual needs and deficits. Another limitation is the potential for error in coding of balance training. Some interventions may improve more than 1 impairment, such as strength and balance; however, interventions were coded as balance training only if they met the aforementioned criteria. Therefore, interventions that could improve balance may not have been counted if they were incorporated into an exercise that did not meet the criteria or were perceived to target another impairment. This study utilized a limited number of physical therapists and PT clinics, limiting the generalizability of the findings. As previously mentioned, participants were excluded from the PATH-IN trial if they had a history of falls deemed by a study investigator to impose risk for potential injury with participation in an independent home exercise program. Therefore, the occurrence of fall risks reported in this study may not be fully representative of the population with KOA.

Despite multiple studies demonstrating benefit from balance training in this population,^{8, 9, 14-17} actual implementation in clinical settings remains unclear. A larger-scale study is indicated to more broadly assess and understand PT intervention selection for individuals with KOA at risk for falling.

CONCLUSION

Consistent with previous findings, a substantial proportion of individuals with KOA in this trial were at an increased risk for falling. The majority of participants allocated to PT received balance training during at least one visit. However, one-third of participants at high risk for falling in the PT group did not perform specific balance training during any PT session. Balance training may be underutilized for those with KOA at risk for falling. Since balance training can reduce fall risks in community-dwelling older adults, further research is warranted on its effectiveness to reduce fall risks among individuals with OA, as well as best strategies for implementation.

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APPENDIX

PATH-IN Guidance for Physical Therapy Visits²⁰

1. Programs, both in the clinic and at home, should be comprehensive and functional, focusing on core and lower body functions, but can be tailored to meet the functional abilities, needs, and deficits of each participant.
2. Each visit should emphasize therapeutic exercise and include muscle strengthening, stretching/flexibility/range of motion, and aerobic exercise.
3. Education on activity pacing, joint protection, and pain management.
4. A home program should be recommended during the first visit and should be progressed over the course of treatment.
5. Home programs should emphasize the following:
 - a. Strengthening exercises
 - i.i. Recommend performing strengthening exercises 2 to 3 times per week;
 - i.ii. Include functional exercises, such as gait or stair training and neuromuscular education.
 - b. Stretching/flexibility/range of motion exercises
 - i.i. Recommend performing range-of-motion exercises daily.
 - c. Aerobic exercises
 - i.i. Promote “lifestyle” physical activity;
 - i.ii. Encourage moderate-intensity exercise;
 - i.iii. Episodes of activity should last at least 10 minutes, if the participant is able;
 - i.iv. Episodes should be spread out throughout the week with a long-term goal of working up to a total of 150 minutes of activity per week; and
 - i.v. Aerobic exercise can be weight-bearing, reduced weight-bearing, or non-weight-bearing.
6. Modalities for pain management can be included during the clinic visit and as part of the home program. Modalities should be used conservatively, taking no more than 25% of the time of each clinic visit.
7. If appropriate, manual therapy can be provided during the clinic visit.
8. Shoes should be assessed during the first visit, and shoe recommendations should be provided, if appropriate.
9. If limb length inequality or frontal plane knee malalignment is suspected, treatment with shoe lifts or shoe wedges, respectively, should be attempted.