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ORIGINAL RESEARCH

Factors Associated With Dynamic Balance in People With Knee Osteoarthritis

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Abstract

Objective: To identify potential neuromuscular factors associated with dynamic balance in individuals with knee osteoarthritis (OA).

Design: Cross-sectional observational study; backward stepwise multiple linear regression was used to identify factors associated with dynamic balance in 2 statistical models.

Setting: University clinical research laboratory.

Participants: Individuals aged ≥50 years (N=52) with osteoarthritic changes on radiograph participated.

Interventions: Not applicable.

Main Outcome Measures: Dynamic balance was assessed using the Community Balance and Mobility Scale (CB&M). Potentially modifiable neuromuscular factors associated with dynamic balance were measured, including the sum of concentric and eccentric lower-extremity muscle strength, 2 quadriceps-hamstrings muscle strength ratios, knee joint proprioception (joint position sense), anticipatory postural control velocity, and knee joint range of motion.

Results: The first model for explaining variance in CB&M scores consisted of eccentric lower-extremity muscle strength and knee joint range of motion as factors. The model containing these 2 variables explained 50% of the variance in CB&M scores. The second model adjusted for descriptive variables, including age, body mass index, and knee pain, contained only the neuromuscular variables eccentric lower-extremity muscle strength, and explained 68% of the variance in CB&M scores.

Conclusions: These results suggest that muscle strength and, to a lesser extent, knee joint range of motion are important factors associated with dynamic balance as measured by the CB&M and should be considered in dynamic balance interventions.

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Dynamic balance, or locomotor stability during movement,[1] is critical for independence, and balance deficits have been linked to the risk of falling.[2] Those with knee osteoarthritis (OA) demonstrate impairments in dynamic balancing ability, such as significantly lower scores than healthy older adults on the Community Balance and Mobility Scale (CB&M).[3] It is hypothesized that this reduced dynamic balancing ability may be attributed to neural and muscular deficits linked to impairments associated with the disease and beyond the neuromuscular changes normally experienced with healthy aging.[4,5]

Neuromuscular deficits seen in those with knee OA which may affect dynamic balance include increased muscle weakness, impaired proprioception, altered postural control, and reduced knee joint range of motion. Muscle weakness is a known risk factor for falls, and studies suggest a marked difference in lower-body strength between older fallers and nonfallers.[6] Numerous studies have highlighted deficits in concentric quadriceps[7-9] and hip muscle[10] strength in those with knee OA. Individuals with knee OA also produced 76% less eccentric quadriceps force than those without.[11] Further, previous studies have shown that knee and ankle strength values are correlated in people with knee OA, suggesting that ankle plantarflexor strength may also be reduced.[12,13] Those with knee OA also have greater difficulty with joint repositioning (proprioception) tests than healthy controls,[11,14] and poor proprioception has been associated with an increased risk of experiencing multiple falls.[15] Anticipatory postural control is also an important element of dynamic balance.[16] An appropriate anticipatory postural adjustment (APA)

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counteracts the destabilizing forces of voluntary movement and assists in movement initiation. Another impairment seen in individuals with knee OA includes reductions in knee joint range of motion,[17] which may drive individuals to adopt alternative, destabilizing strategies (eg, stooping instead of crouching) to complete daily tasks requiring dynamic balance. Further, knee range of motion has been shown to be associated with standing balance in those with knee OA (r=.41).[18] Taken together, these findings highlight the multiple neural and muscular deficits which may contribute to impaired dynamic balance and an increased falls risk in those with knee OA.

Although many neuromuscular factors appear to influence dynamic balance and the risk of falls, the specific factors associated with dynamic balance have not been reported in those with knee OA. In contrast, factors associated with static standing balance, including muscle weakness and knee pain,[19,20] have been identified. Although static balance deficits have been linked to falling, a large portion of falls occur during movement.[21] Therefore, the purpose of this exploratory study was to identify modifiable neuromuscular factors associated with dynamic balance in individuals with knee OA.

Methods

Participants

Individuals with osteoarthritic changes on radiograph (Kellgren and Lawrence [K&L][22] grade 1 or higher) were recruited from the local community using print advertisements and a laboratory database of previous participants. Individuals underwent radiographic screening to confirm the presence and grade of knee OA. Participants were excluded if they had articular cartilage degradation in the lateral tibiofemoral compartment greater than the medial, if they had an inflammatory arthritic condition, if they had pain originating predominantly from the patellofemoral joint, if they had a history of knee or hip replacement surgery, if they had a history of recent arthroscopic surgery or corticosteroid use (within 6mo), or if they were unable to ambulate without a gait aid. Participants were also excluded if they had a neurologic or musculoskeletal condition that affected their balance or movement (ie, Parkinson disease, multiple sclerosis). All participants provided informed consent before testing, and the study was approved by the university clinical research ethics board.

Sample size was calculated based on previous research where regression was used to predict standing balance.[20] Using an expected R^2=.55, α=.05, and statistical power of 80%, a sample size of 50 participants was required.[23]

List of abbreviations:

AIC	Akaike information criterion
APA	anticipatory postural adjustment
BMI	body mass index
CB&M	Community Balance and Mobility Scale
COP	center of pressure
K&L	Kellgren and Lawrence
LES	lower-extremity strength
OA	osteoarthritis
VIF	variance inflation factor

Testing procedures

Participants attended a single testing session at the university. Baseline descriptive characteristics, including age, height, body mass, knee pain (pain over the previous week using an 11-point numerical rating scale, where 0 is no pain and 10 is maximum pain), and fear of pain (using the Brief Fear of Movement Scale[24]), were collected. Potential neuromuscular factors associated with dynamic balance, including muscle strength, joint proprioception, anticipatory postural control, and knee joint range of motion, were also measured. Dynamic balance was evaluated using the CB&M. Measures are subsequently described. The order of testing was standardized and consistent across all participants.

Community Balance and Mobility Scale

The CB&M was developed to assess community-level functional deficits in dynamic balance and mobility,[25] including advanced activities (eg, rapid direction changes, dual tasking). The CB&M is sensitive to change[26] and does not suffer from ceiling effects commonly seen when using other tools (eg, Berg Balance Scale).[26,27] The CB&M is a valid and reliable tool for assessing dynamic balance and mobility in individuals with knee OA.[3]

The CB&M is comprised of 13 tasks, including bending, turning, walking, and stair descent. Tasks are rated on a scale of 0 (unable to perform) to 5 (proficient), with the exception of stair descent, where participants can earn a maximum of 6 points for completing the task while carrying a load. Unilateral tasks (eg, hopping on 1 leg) are performed and scored separately on both sides. Lower scores are given if participants are unable to meet time requirements or use discontinuous movements. Tasks such as walking and looking (over an 8-m distance) are timed, with slower times resulting in the loss of points on the task. The maximum score is 96, with a minimum score of 0.

Muscle strength

Concentric and eccentric muscle strength (torque) of the knee extensors, flexors, and ankle plantarflexors were measured using an isokinetic dynamometer.[a] For strength testing of the knee extensor and flexor muscles, participants were seated with hip and knee joints flexed to 90°. For strength testing of the ankle plantarflexor muscles, the seat was reclined 35° from the vertical, and the lower leg was positioned parallel to the floor with the foot secured on the footplate. Isokinetic eccentric and concentric strength were measured in 3 trials of maximal effort at 90°/s, as has been previously measured in those with knee OA.[28] Three warm-up trials at 50% perceived maximal intensity were completed. Maximum torque production relative to body weight (Nm/kg) from the 3 trials for each muscle group was recorded. Four composite measures were calculated, as described in table 1.[28-34]

Joint proprioception

Knee joint proprioception was measured using a knee joint repositioning task, previously used in those with knee OA to assess joint proprioception.[11] Participants were seated on the same isokinetic dynamometer used for strength testing and were blindfolded for the task. The participants' limb was passively positioned and held for 10 seconds in 1 of 3 target positions (15°, 30°, and 60° of knee flexion). Participants' knees were then