Archives of Physical Medicine and Rehabilitation
journal homepage: www.archives-pmr.org
Archives of Physical Medicine and Rehabilitation 2014;95:253-61

ORIGINAL ARTICLE

Age-Related Hip Proprioception Declines: Effects on Postural Sway and Dynamic Balance

Jason R. Wingert, PhD, MPT,[a] Catherine Welder, BSN,[b] Patrick Foo, PhD[c]

From the [a]Department of Health and Wellness, University of North Carolina Asheville, Asheville, NC; [b]Massachusetts General Hospital Institute of Health Professions, Boston, MA; and [c]Department of Psychology, University of North Carolina Asheville, Asheville, NC.

Abstract

Objective: To evaluate the effects of age on hip proprioception, and determine whether age-related hip proprioception declines disrupt balance.

Design: Survey of proprioception and balance differences between 3 age groups.

Setting: University balance laboratory.

Participants: Volunteer sample of independent community-dwelling adults (N=102) without sensory or other neurologic impairments in 3 age groups: younger (mean age, 24.6y; range, 19−37y), mid-aged (mean age, 53.3y; range, 40−64y), and older adults (mean age, 76.3y; range, 65−94y).

Interventions: Not applicable.

Main Outcome Measures: Hip joint position sense (JPS) and kinesthesia were measured using a custom-built device. JPS error was determined by the magnitude of matching errors during vision and no-vision conditions. Kinesthesia was evaluated by the ability to detect passive limb rotation without vision. Postural sway was assessed during static stance and measured using root mean square of center of pressure (COP) displacement and velocity of COP displacement. Clinical balance and fear of falling were assessed with the mini-Balance Evaluation Systems Test (mini-BESTest) and Activities-specific Balance Confidence Scale, respectively.

Results: Both older and mid-aged adults had significantly increased JPS error compared with younger adults ($P<.05$). Kinesthesia accuracy was significantly decreased in older adults compared with mid-aged and younger adults ($P\leq.01$). Both measures of proprioception error correlated with age ($P\leq.001$). There were no relationships between hip proprioception error and postural sway during static stance. However, older adults with lower proprioceptive error had significantly higher mini-BESTest scores of dynamic balance abilities ($P=.005$).

Conclusions: These results provide evidence of significant hip proprioception declines with age. Although these declines are not related to increases in postural sway, participants with hip proprioception declines demonstrated disrupted dynamic balance, as indicated by decreased mini-BESTest scores.

Archives of Physical Medicine and Rehabilitation 2014;95:253-61

Upright postural stability relies on vision, vestibular sense, and proprioception, and the acuity of each sense likely decreases with age (for review, see Sturnieks et al[1]). Proprioception is the sense of both body segment position (joint position sense [JPS]) and movement (kinesthesia).[2] Previous studies have shown age-related declines in proprioception (for review, see Goble et al[3]) at the knee,[4-7] ankle,[8-11] and the upper extremity,[12,13] yet few studies have evaluated hip proprioception across the lifespan. Additionally, most research on hip proprioception in older adults has involved participants with either total hip replacement or hip fracture, and neither significantly decreased proprioceptive acuity.[14,15] To date, Pickard et al[16] have conducted the only known study assessing the effects of aging on hip proprioception. Their study showed no such declines but only included older adults who were highly physically active, averaging 10 hours of physical activity per week.[16] Whether hip proprioception declines in older adults with more typical activity levels has not been reported.

Several researchers have linked lower extremity proprioception and balance. Increased JPS error of the great toe is associated with

Presented in part to the American Physical Therapy Association, February 10, 2012, Chicago, IL.

Supported by the North Carolina Center for Health and Wellness through funding from the Blue Cross Blue Shield Foundation.

No commercial party having a direct financial interest in the results of the research supporting this article has conferred or will confer a benefit on the authors or on any organization with which the authors are associated.

0003-9993/14/$36 - see front matter © 2014 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2013.08.012

increased sway, decreased performance on clinical balance measures, and an increased history of falls.[17,18] Similar increases in sway have been associated with age-related declines in knee and ankle JPS.[19] Decreased hip proprioception may similarly affect postural stability and contribute to increased fall risk in older adults.

Direction of sway also appears to be an important factor in fall morbidity and mortality. In older adults, wrist fractures have been associated with anterior-posterior (AP) falls, whereas hip fractures have been associated with medial-lateral (ML) falls.[20,21] Furthermore, numerous studies[22-24] linked increased ML sway to future falls. Since motor control strategies at the hip are primarily responsible for controlling ML sway,[22,25] decreased hip proprioception may be related to excessive ML sway and falls, especially in the lateral direction. However, the precise role of hip proprioception in postural control and fall risk remains unclear.

The primary purpose of this study was to quantitatively assess hip JPS and kinesthesia across the lifespan. Secondarily, this study aimed to determine whether decreased hip proprioception contributes to age-related postural instability and fall risk. We hypothesized that the magnitude of hip JPS and kinesthesia error would correlate with age, so that proprioception error would be greatest in older adults, and also increased in mid-aged adults compared with younger adults. Here proprioception was measured in the transverse plane using a protocol that has previously detected proprioception deficits, and linked those deficits to increased postural sway, in a patient population.[26,27] We also hypothesized that age-related decreases in proprioception would correlate with changes in static stance postural sway and clinical measures of dynamic balance. More specifically, we hypothesized that older adults with higher proprioceptive error would demonstrate increased sway in stance and diminished performance on clinical balance tests.

Methods

Participants

The analyzed sample consisted of 102 participants in 3 age groups: 34 younger adults (22 women; mean age, 24.6y; age range, 19−37y), 34 mid-aged adults (23 women; mean age, 53.3y; age range, 40−64y), and 34 older adults (24 women; mean age, 76.3y; age range, 65−94y). Younger adults were recruited from the university community. Mid-aged and older adults were recruited from the university community, a local lifelong learning institute, and 2 apartment complexes inhabited predominantly by older adults. Recruitment was via advertisements and word of mouth. In total, 122 community-dwelling adults volunteered for this study. However, 20 volunteers were not tested as a result of not meeting inclusion criteria because they were unable to independently ambulate, scored ≤25 on the Mini-Mental State Examination, had conditions affecting somatosensation (eg, diabetes mellitus, stroke, peripheral neuropathy, or other neurologic diseases), or used medications affecting cognition, balance, or sensory perception. This study was approved by the Human Studies Committee at the University of North Carolina Asheville; all participants signed an informed consent before data collection.

Participants self-reported the number of falls experienced in the 12 months before the study; falls were defined as an event resulting in unintentionally coming to rest on the ground or lower level, with or without injury.[28] Participants also reported the number of minutes per week spent in endurance, strength, and balance training exercise. Researchers used the self-reported activity values to determine whether each participant regularly engaged in (1) physical activity according to the American College of Sports Medicine guidelines[29] (≥150min/wk of moderate-intensity cardiorespiratory activity and resistance, flexibility, and neuromotor exercise 2−3 times/wk); and (2) balance exercise on a weekly basis (eg, yoga or tai chi). A modified Edinburgh Handedness Inventory[26,30] determined limb dominance; the dominant leg was assumed to be ipsilateral.[26]

Participants then completed the following testing in a randomized order: proprioception testing (JPS and kinesthesia), the mini-Balance Evaluation Systems Test (mini-BESTest), Activities-specific Balance Confidence (ABC) Scale, and postural sway measurement during normal stance and feet together, in both eyes open and closed conditions.

List of abbreviations:

ABC	Activities-specific Balance Confidence (Scale)
AP	anterior-posterior
CI	confidence interval
COP_D	center of pressure displacement
COP_V	velocity of center of pressure displacement
FDR	false discovery rate
JPS	joint position sense
mini-BESTest	mini-Balance Evaluation Systems Test
ML	medial-lateral
RMS	root mean square

Proprioception

The proprioception assessment methods have been previously described.[26] A custom-built device allowed for rotation around the axis of a semi-goniometer to measure JPS and kinesthesia in the transverse plane at the hip joint while the participant was sitting with the knee extended (fig 1). Order of leg (side) testing was randomly determined.

JPS was assessed by measuring the accuracy of actively pointing a marked line on the second toe to target angles along the semi-goniometer during 2 conditions. In the vision condition, participants viewed both their foot and the target angle; in the no-vision condition, an opaque curtain obscured the foot, requiring participants to rely on JPS to complete the task. Ten vision condition target trials were followed by 10 no-vision target trials. Target angles were clearly visible to the participant and were at 5° intervals, comfortably within their range of motion. The order of target angles was randomly determined, and all participants received the same target angles in the same order. The tester both pointed to and named the target angle aloud to the participant, and subsequently recorded the orientation angle of the marked toe to the nearest degree. In order to account for proprioceptive contribution to the task, the difference between error in the no-vision condition and error in the vision condition was calculated for each target. The root mean square (RMS) of the no-vision–vision JPS error difference for each target was calculated for analysis.

The same device was used to measure kinesthesia; however, participants' eyes were closed for all trials. The experimenter used a rod on the rear of the device to rotate the participant's limb