Does a Relationship Exist Between Lower Body Power and Balance Scores Among Older Adults?

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ABSTRACT

Context: Falls are the second-leading cause of unintentional injury and death worldwide.

Objective: To determine if a relationship exists between lower body power scores and center of pressure (CoP) and limits of stability (LoS) scores.

Methods: A one-shot case study design (n = 13) was selected for the investigation. All participants were assessed stability scores via computerized posturography to determine CoP and LoS balance scores. Participants stood on a perturbed surface with their eyes open and closed. An experimental stair ramp with a switch mat timing device was used to determine lower body power scores in watts.

Results: There was a strong correlation (r = 0.725, p = 0.005) between the posterior (LoS) plane and relative peak power. An intraclass R revealed a strong correlation among the three trials (R = 0.831) performed on the stair ramp.

Conclusion: Muscle power output and LoS scores have moderate to strong correlations with balance scores in older adults.

BACKGROUND AND OBJECTIVES

The US senior population is expected to double by 2050, as life expectancy improves with advances in medical care and pharmacology.[1] Along with extended longevity, however, functional issues can negatively influence quality of life for elderly people.

Falls are the leading cause of fatal and nonfatal injuries for older Americans.[2] One group of investigators discovered that medical costs associated with fatal and nonfatal falls totaled $19.2 billion in 2006, with injuries ranging from hip fractures to traumatic brain injuries.[2] Research now considers factors that may diminish a person's ability to perform activities of daily living (ADLs). ADLs are daily tasks a person must be able to perform such as locomotion and feeding. Multiple and complex variables are involved with predicting the circumstances under which older adults may fall, which increases the difficulty associated with developing a care plan.

Research demonstrates that balance and strength are important for fall prevention, but few studies have focused on the importance of muscle power output.[3] Power is defined as the measurement of force times distance over time compared with strength, which is a concept of maximal force production.[4] Leg power is a stronger predictor in self-reported ADL functionality in older women in relation to other measurements such as peak oxygen consumption, leg strength, chest press strength, and upper back power.[5] Similar results were noted in a study performed on nonagenarian adults that identified muscle power output as a factor in gait variability.[6] Investigators in a 2002 study noted that women with a history of falls were 24% less powerful than their peers who had not sustained falls.[7] Initial studies focusing on generational differences among men revealed an 8.3% decrease in maximal anaerobic power per decade.[8] A reduction in muscle power wattage in comparison to strength has been identified in people ages 65 to 89 years.[9] Evidence suggests that muscle power output may influence fall likelihood and should be considered in addition to strength training.[5,10] The ability to predict muscle power output should help to forecast functional decline in ADLs and loss of independence in elderly patients.[10]

Although muscle power output is an important factor in fall prevention, testing this variable in older adults has presented challenges. Many testing options, including the five-times-sit-to-stand test, stair walk tests, stand-up-and-go tests, and vertical jumping are available to assess muscle power output.[11] However, available tests may be dangerous, expensive, or inapplicable for the elderly population. One of the most effective tests for muscle power assessment is the Margaria-Kalamen test,[12] which was designed for athletic people who can escalate 12 steps with the highest possible velocity. Although the Margaria-Kalamen test can reliably assess leg muscle power output, performing the required task is risky for older participants. Signorile et al[13] created a valid alternative for older people that used a ramp rather than a staircase, and this test allowed for improved safety and reliability when working with elderly patients. Shim and Drum[4] made further changes to the ramp to simulate real-life stairs by adding steps, side rails, and a back rail on the top platform. Researchers noted that the modified lower body power output test with the stair ramp was a valid and reliable replacement for the Margaria-Kalamen test.[4]

Clinicians can use other assessment methods to evaluate fall risks in older people. Center of Pressure (CoP) testing, which involves body pressure via the soles of the feet concentrated in one location, is becoming popular with older adults. A potential benefit associated with multifactorial CoP testing is the ability to observe numerous variables to elucidate the relationship between muscle power and CoP measurements.

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There is a void in the literature regarding the relationship between lower body muscle power output and balance.

The purpose of this study was to observe if a relationship exists between lower leg muscle power output and CoP and Limits of Stability (LoS) measurements through use of a computerized posturography plate.

DESIGN AND METHODS

Qualified volunteers (n = 13) who were readily available from an independent senior citizen center in Sioux City, IA, were selected for this study. Participants were age 60 years and older. All participants lived independently, completed a general health questionnaire, provided informed consent, did not have vertigo or other diagnoses that could interfere with balance, and did not take medication that can cause dizziness. Those who had medical contraindications or missed their appointment times were excluded from the study. The project was approved by Briar Cliff University's institutional review board (Sioux City, IA) before the participants were recruited.

Muscle power output and balance testing took place at the senior center on the same day. The experimental stair ramp was placed on level, nonslip flooring. Before the testing, participants performed a specific neuromuscular warm-up by practicing on the ramp for several minutes. After the warm-up was complete, each participant was given directions to line up 3 meters away from the power ramp. Each participant ascended the ramp as quickly as possible. Lafayette Instruments (Lafayette, IN) switch mats were interfaced to an official timing device that was accurate to 0.001 second. Each switch mat was placed at the first and third ramp steps to start and stop the timing device once foot pressure was detected. Times were recorded to the nearest 0.01 second. Coaching was initiated to remind participants to step on each sensor to ensure accuracy. Each participant completed the test 3 times; a 2- to 3-minute rest period was provided between each trial to restore adenosine triphosphate and allow full recovery. Participants were not allowed to use handrails to help them ascend the ramp.

After lower leg muscle power output was completed, the balance tests were conducted in a private room. A computerized posturography plate (BalanceCheck System, Bertec Inc, Columbus, OH) was used to determine balance scores, which also calculated body mass index. Stability can be assessed by measuring changes in CoP scores on a force plate or posturography plate. Each participant was given five tests: Static stability with eyes open, static stability with eyes closed, perturbed stability with eyes open, perturbed stability with eyes closed, and LoS in four different planes. LoS is the distance to which a person can lean without losing balance. People with decreased levels of LoS are at higher risk for falls attributed to lack of cognitive readiness to make adjustments to their base of support. Participants were asked to stand on the plate for ten seconds for each test while the computer measured postural sway. They were coached to relax while standing on the plate and minimize unnecessary movements, including gestures, turning, or talking.

Participants stood on a foam labile pad with their eyes open during perturbed stability testing. They were coached to stand as still as possible and reduce unnecessary gestures, talking, or turning. After the eyes-open test, each participant performed the same protocol on the perturbed surface with their eyes closed.

The LoS test performed with the BalanceCheck was next. Participants remained on the perturbed surface with their feet centered in the middle of the force plate. The researcher reminded participants to reduce all unnecessary gestures, talking, and turning. Once testing began, the participant was asked to lean as far forward, backward, left, and right as possible with their eyes fully open without losing balance to measure maximal range in the frontal and sagittal planes. Data were collected and evaluated with SPSS Version 22 (IBM Corp, Armonk, NY). A Pearson product moment correlation was used to view the relationship between lower body muscle power output from the ramp and CoP and LoS scores. An intraclass correlation was used to measure reliability of measurements from the power ramp.

RESULTS

LoS testing revealed a strong correlation ($r = 0.725$, $p = 0.005$) between posterior plane scores and relative peak power as shown in Figure 1. LoS posterior scores also moderately correlated ($r = 0.680$, $p = 0.011$) with relative average power (Figure 2). LoS anterior scores correlated with both LoS left ($r = 0.746$, $p = 0.003$) and LoS right ($r = 0.759$, $p = 0.003$) scores as shown in Figures 3 and 4, respectively. No significant correlations were found between power output measurements and CoP. An intraclass correlation between trials ran on the power ramp revealed a strong correlation ($r = 0.831$).

DISCUSSION

In 2012, investigators demonstrated that lower body muscle power output is a proximal determinant of falls and functional limitations in adults age 60 years and older.[14] The World Health Organization defined a fall as "inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other subjects."[15] The ability to predict falls and improve functionality in this growing population will help to sustain quality of life and improve the economic impact associated with care of this population. Between 2012 and 2050, the US population of those age 65 years and older is projected to increase from 43.1 million to 83.7 million.[1] On the basis of the number of people living beyond age 65, and without any positive interventions in place, longevity itself will place a large burden on tax dollars and medical care if injury rates attributable to falls continue on the current trajectory.

About one-third of adults age 65 years and older will sustain a fall within a single year.[16] Among these falls, 800,000 will result in hospitalization with an injury.[17] Falls are likely to result in fractures or other injuries for older adults.[17] Accounting for inflation, fatal and nonfatal fall-associated medical costs are projected to reach $637.5 million and $31.3 billion, respectively, in 2015.[18] When researching primary care in the UK, investigators noted in a longitudinal cohort study that death risk at 1 year and 3 years was increased for recurrent elderly people who fall.[16] Among people ages 75 and older, people who fall are 4 to 5 times more

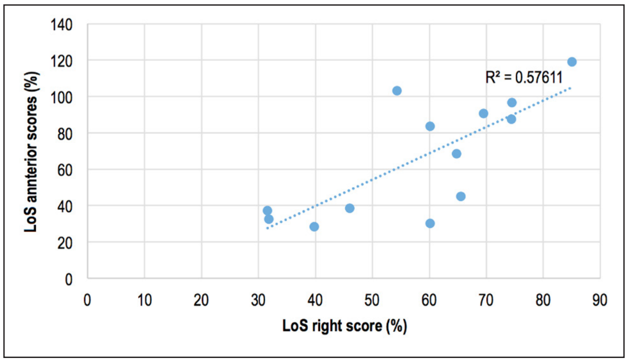

Figure 1. Correlation between relative peak power and LoS posterior scores.
LoS = limits of stability

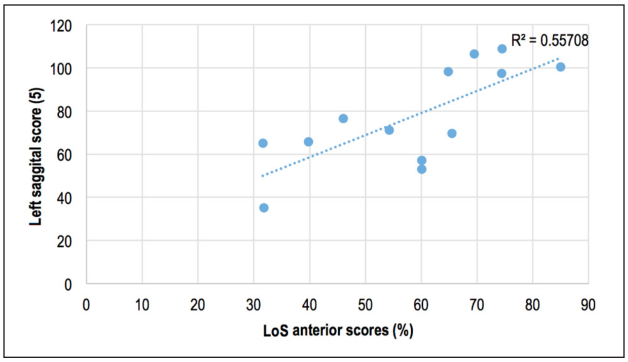

Figure 2. Correlation between relative average power and LoS posterior scores.
LoS = limits of stability

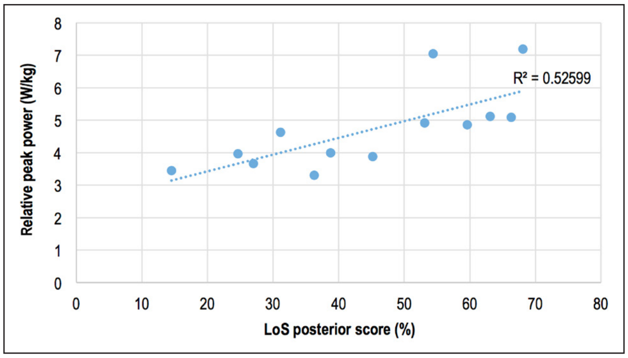

Figure 3. Correlation between LoS anterior scores and LoS left scores.
LoS = limits of stability

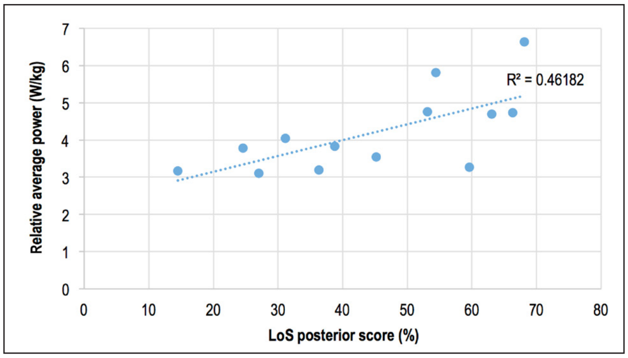

Figure 4. Correlation between LoS anterior scores and LoS right scores.
LoS = limits of stability.

likely to be placed in a long-term care facility for the rest of their lives than those who do not.[16]

Much current and past research has examined the effects of strength on fall prevention. In 2005, Hess and Woollacott[3] reviewed the effects of high-intensity strength training on functional measures of balance. Their study revealed that high-intensity strength training can effectively strengthen lower extremity muscles in balance-impaired older adults, resulting in major improvements in stability and functional movement. Pretest-posttest results from this study showed significant changes in quadricep, hamstring, tibialis anterior, and gastrocnemius strength ($p \leq 0.001$). The only correlation between functional balance scores and strength was between gastrocnemius one-repetition-maximum strength change and Berg Balance Scale scores ($r = -0.683$). Chandak et al,[19] who studied correlations between isometric muscle strength and balance performance in elderly women, assessed isometric strength of hip flexors, extensors, abductors, and adductors. Knee flexors and extensors and ankle plantar and dorsiflexors were tested as well. Participants' knee extensor findings correlated more strongly with balance than other measured musculatures. This study demonstrated that participants with good knee extensor strength had higher stability scores. These findings explain the authors' focus beyond lower body strength. On the basis of our results, the primary investigators would have concluded similar results as seen in Hess and Woollacott's[3] and Chandak et al's[19] studies if the measured variables were replicated. In 2012, investigators observed strength measurements using the chair-stand test and stability index measurements.[20] This study showed a negative moderate correlation between strength and stability index scores ($r = -0.576$, $p < 0.01$). On the basis of past research, this study's investigators had expected to find a negative relationship between CoP scores and lower body wattage.[20] However, our significant results do not reveal a negative correlation attributable to variables such as LoS scores, which improved in the posterior plane as power output increased in all participants.

Intraclass correlation testing demonstrated that the stair ramp power test is a reliable assessment of lower power in older adults ($r = 0.831$). Shim and Drum[4] produced similar results when using the ramp with younger adults ($r = 0.995$). Their study also revealed that the ramp test was an adequate replacement for the Margaria-Kalamen test ($r = 0.861$). Signorile et al[13] developed the ramp by decreasing the angle to a ratio of 1:12 rise/run to increase accessibility for more elderly people and simulate standard access ramps. In 1989, investigators contended that the ramp method removed the skill component of stair running, further increasing muscle power output observed in testing.[21] This viewpoint may help to ease the fears of elderly patients who participate in power assessments. Safety rails and steps were added by Shim and Drum[4] and were very useful when testing older adults. Of 13 participants, only two required rails on the top platform to help them reduce speed upon completion, and only one participant needed support while ascending the ramp.[4] This trial was meaningful because it gave clinicians the opportunity to assist participants and show them the safety features of the ramp. When working with the elderly population, use of top rails to assist with speed reduction is rarely seen, however.

When observing correlations between LoS scores and lower body muscle power ramp outputs, our results reveal strong to moderate correlations between LoS posterior and relative peak power and relative average power. A high correlation between these variables may be attributable to testing of posterior chain muscles with the stair ramp test, which also could be involved with balance. Relative peak power and relative average scores produced much higher correlations ($r = 0.725$ and $r = 0.680$, respectively), indicating that power may be a better predictor than strength toward improving balance than seen in previous studies.[19,20] Power scores with LoS posterior scores produced higher correlations than previous studies.[19,20,22] LoS anterior scores correlated highly with both LoS right ($r = 0.759$, $p = 0.003$) and LoS left ($r = 0.746$, $p = 0.003$) scores. Although investigators did not look at posture as a factor in this study, posture shifts in the anterior plane may be responsible for this correlation. Rolled shoulders, a flexed thoracic spine, and a forward head more anteriorly may have contributed to the higher correlations of movement in the left and right plane movements. Study limitations included the time of day the assessments were held; study sample size; and competing activities that were not originally scheduled at the senior center on the testing day, which reduced our sample size.

CONCLUSION

Muscle power output and LoS scores moderately to strongly correlate with balance scores in older adults. Further studies involving these variables such as receiver operating characteristic analysis for specificity and sensitivity should be considered for power ramp use to determine the ability to detect fall risk. Specific power training for older adults also should be studied. Our near-future goal is to use muscle power ramp test findings to identify at-risk adults and lower their likelihood for falls. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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