ABSTRACT

Background: Past literature has shown that balance and strength are important in preventing falls, but few studies have focused on developing strength and power in a lateral plane. The purpose of this study was to determine if a lateral pedal recumbent training device can improve balance scores among older adults in 4 weeks.

Methods: A 2-group experimental-control multivariate design (43 women, 13 men; age, 77.4 ± 3 years; weight, 78.91 ± 0.2 kg; height, 167.13 ± 0.8 cm; body mass index, 28.7 ± 0.5 kg/m) was selected for the study. Participants (n = 56) were divided into 2 groups and were pretested and posttested on a computerized posturography plate to determine center of pressure scores with eyes opened with stable surface (EOSS), with eyes closed with stable surface (ECSS), with eyes open with perturbed surface (EOPS), and with eyes closed with perturbed surface (ECPS). The experimental group used the lateral trainer for 15 minutes, 3 times per week, for 4 consecutive weeks; the control group maintained a sedentary lifestyle. A mixed-effects repeated measures multiple analysis of variance was used to determine significance.

Results: There were statistically significant differences over time for EOPS (p = 0.047) and ECPS (p = 0.047). Likewise, there were statistically significant differences for each univariate outcome with EOSS (p = 0.045), ECSS (p = 0.033), EOPS (p = 0.010), and ECPS (p = 0.026).

Conclusion: A recumbent lateral stability device can improve balance scores among older adults within 4 weeks of training.

INTRODUCTION

According to the United States Census Bureau, it is predicted that there will be approximately 78 million people 65 years of age or older by the year 2035, compared with the population of 76.7 million people under the age of 18.1 Assessing fall risk among the older population would likely help sustain their quality of life. All individuals over the age of 65 ought to be asked at least once a year by their health care provider if they have fallen, based upon a neutral opinion from health care providers associated with this article.

Falls are the number one cause of fatal and nonfatal injuries in adults ages 65 and older.2 The National Council on Aging3 reports that falls are the leading cause of trauma-related visits to the hospital in elderly adults. Patel and Ackermann4 reported that approximately 2.5 million falls among adults age 65 and older are treated in the emergency room. Of those treated in the emergency room, 87% of fractures are caused from falls. The estimated medical costs of fatal and nonfatal falls in adults age 65 and older was over $50 billion in the United States. From fatal falls alone, the medical expenditure was estimated to be $754 million.5 As the population ages, an increase in costs is expected for older adults, and these negative outcomes may diminish the quality of life in victims as well as create burdensome healthcare costs.6

Falling can result in a decrease of self-esteem and assurance and therefore in eventual withdrawal from communal activities and participation. Research has begun to consider factors that may diminish a person’s ability to perform activities of daily living after falling.7 Activities of daily living are described as tasks that an individual must perform on an everyday basis, such as movement or eating on their own. The ability to perform these tasks is greatly diminished once a fall has occurred. The risk factors for falling increase the likelihood for subsequent falls. Tinetti and Kumar8 showed that a person has a 78% chance of falling if 4 risk factors are present. Other risk factors listed include use of psychoactive medications, polypharmacy (taking too many medications that could contraindicate with others), poor visual acuity, vertigo, cognitive impairment, orthostasis (decreased blood pressure shortly after standing), and the female sex.9

Previous falls, balance impairments, muscle strength, and gait are the strongest risk factors for subsequent falls. Hess and Woollacott10 showed the importance of muscle strength and balance for preventing future falls in the elderly; however, few research studies have put precedence on the importance of muscular power output.

Muscular power output is the ability to exert maximal force at a fast rate in a short period of time, such as accelerating and jumping.7 Skelton, Kennedy, and Rutherford11 noted that women with a history of falls were 24% less
powerful than their peers who had not sustained falls by measuring their lower limb explosive power, isometric strength of the quadriceps and hamstrings, and isokinetic concentric strength of the lower limbs. Initial studies focusing on generational differences of men also have displayed a decrease of 8.3% in maximal anaerobic power per decade. A faster decrease in muscle power in comparison to strength has been identified in individuals between the ages of 65 and 89. The evidence suggests that low power output in patients may influence falls and should be considered in addition to strength training. Comparable results were noted in a study performed on nonelderly adults, identifying muscle power as a factor with gait variability. Findings from that study showed that muscle quality and quantity in the quadriceps influence how frail the elderly person is. If there are additional higher-density muscle fibers in the quadriceps, the elderly person performed significantly better in step time variability, gait performance, and velocity.

Modifying exercise programs to address improving lower body strength and power would vastly improve stability and functional movement. The study by Shim et al demonstrated a strong correlation between posterior limit of stability plane among 13 seniors over the age of 65 and relative peak power by using a 15-foot ramp to measure power output in seniors (n = 17) and observing that lower body power output does have a relationship with balance scores. Based on these findings, use of an exercise device that addresses both lower body strength and power development safely for older adults could reduce the risks of falling in older adults.

Recently, a seated bicycle called a SCIFIT Latitude Lateral Stability Trainer was developed by a fitness manufacturer that proposed pedaling in a lateral direction could possibly prevent falls by strengthening additional prime movers, such as the hip adductors and abductors, that a traditional recumbent exercise bike was not designed to do. Based on direct information from SCIFIT, there has been no clinical data collection to prove the manufacturer’s claims of improving balance in older adults by using this novel device (Figure 1). Therefore, the purpose of this study was to determine if a recumbent bicycle with pedals that allowed lateral movement would improve balance scores in older adults within a 4-week period.

METHODS

A 2-group pretest/posttest experimental/control design was selected for this 4-week study. All subjects (n = 56) 59 years of age or older were recruited from senior independent living centers from the vicinity (43 women, 13 men; age, 77.4 ± 3 years; weight, 78.91 ± 0.2 kg; height, 167.13 ± 0.8 cm; body mass index, 28.7 ± 0.5 kg/m). Subjects had to be over the age of 55 years, independent, and determined healthy by answering a health questionnaire. Seven subjects who were experiencing musculoskeletal pain or unable to perform the balance assessments or adhere to the 4-week training were excluded. Group assignments for experimental and control groups were based on location of the facility and nonrandomized. Informed consent was signed by all participants before the start of the study. The Institutional Review Board of the sponsoring university approved the investigation before the start date. One local senior residential site was designated as the experimental group, and the other independent senior center was designated as the control group.

The primary pieces of equipment the researchers used for this study were the SCIFIT Latitude Lateral Stability Trainer (Brunswick Corporation, Rosemont, IL) and a BalanceCheck computerized posturography plate (Bertec Corporation, Columbus, OH). The experimental group used the SCIFIT Latitude Lateral Stability Trainer 3 times per week for a minimum of 15 minutes for 4 consecutive weeks. Safety and user directions were given to the participants before each session as well explaining the training curriculum. The experimental participants were instructed to perform light calisthenics such as walking quickly for approximately 5 to 10 minutes to increase blood flow and pressure, heart rate, and body temperature gradually before using the SCIFIT Latitude Lateral Stability Trainer. The experimental group followed the directions on the exercise machine’s display to completion during each training session, which lasted 15 minutes. Instead of pedaling back and forth in the anterior/posterior plane, each pedal allowed motion in a horizontal plane, requiring effort to maintain the lateral movement of each pedal. Each exercise session performed was noncompetitive in nature among the experimental group participants. A Borg intensity chart numbered from 1 to 10 was used to determine the pedaling intensity during the exercise session, with 1 representing an
Does a Recumbent Lateral Stability Trainer Improve Balance Scores Among Older Adults Within 4 Weeks?

Results: Data were collected and analyzed with SPSS Version 26 (IBM Corp, Armonk, NY). The descriptive statistics for the pretest and posttest from both groups can be found in Table 1. When comparing Group 1 numbers with Group 2, noticeable differences are seen regarding the static balance scores during the 4 weeks of training. Postural sway (CoP) scores have decreased over time in the experimental group. However, significance is not recognized until empirical data are revealed in Table 2. Table 2 illustrates the mixed-effect, repeated-measures multiple analysis of variance results for the linear combination of EOS, ECSS, EOPS, and ECPS. There were no significant main treatment effects for either group (p = 0.221) observed in Table 2 or Figure 3 for EOS. However, Figures 4 and 5 show there were statistically significant differences over time for EOPS (p = 0.047) and ECPS (p = 0.047). Likewise, there were statistically significant differences (Figure 6) for each univariate outcome with EOS (p = 0.045), ECSS (p = 0.033), EOPS (p = 0.010), and ECPS (p = 0.026). Statistical power (ie, the ability to detect a true difference when one is present) was achieved (> 0.98) for both univariate and multivariate measures. It is generally accepted that the power of a study will be > 0.80, indicating an 80% greater chance of rejecting the null hypothesis. The multivariate outcome for the group × time interaction accounted for 15.2% more variance than time alone (28.1%) for the experimental group (Group 2).

Discussion: This current investigation demonstrated among elderly adults that an exercise protocol consisting of pedaling in the lateral plane on a SCIFIT Latitude Lateral Stability Trainer can improve CoP scores within 4 weeks compared with the control group. In their investigation of over 700 studies of

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Table 1. Descriptive statistics for pretest/posttest by treatment groups

<table>
<thead>
<tr>
<th>Tests</th>
<th>Pretest Mean</th>
<th>Pretest SD</th>
<th>Posttest Mean</th>
<th>Posttest SD</th>
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<tr>
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<td></td>
<td>Group 2</td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
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<tr>
<td></td>
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<td>ECSS 88.0</td>
<td>5.6</td>
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<tr>
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<td>EOPS 87.1</td>
<td>5.5</td>
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<tr>
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<tr>
<td>Posttest</td>
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<td>EOS 90.1</td>
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<td>11.3</td>
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EOS = eyes closed stable surface; ECSS, eyes closed stable surface; EOPS = eyes open perturbed surface; ECPS = eyes open perturbed surface; EOS = eyes closed perturbed surface.
various exercise modalities on older adults, Thompson et al\textsuperscript{15} demonstrated that a varied exercise intensity 2 to 3 times per week could improve muscle force after several weeks of training. When observing body sway in the elderly, increases occur when an individual does not have postural control due to decreased muscle mass and strength.\textsuperscript{16} Individuals who have large body sway displacements increase demands for large postural corrections to maintain their balance. Low's\textsuperscript{16} investigation showed that proper corrective exercise training can decrease postural sway by improving muscular strength and power of the lower extremities. The current investigation promoted not only muscular strength but also power production based on varying the bicycle pedaling intensities that required the participant to pedal with a higher velocity for a short period of time. Rouffet and Hautier's\textsuperscript{17} study on cyclists demonstrated improvements in peak EMG amplitude in 6 major muscles (gluteus maximus, vastus lateralis, rectus femoris, biceps femoris long head, gastrocnemius medialis, and soleus) while cycling under 15 different submaximal and maximal conditions for 30-second intervals. Their study demonstrated peak EMG
values with muscle activation under maximal pedaling. This resulted in improved neural responses from the 6 selected prime movers of the lower limbs. Moreover, activating muscles used for stability through the lateral movements and producing greater energy output bursts for a short period of time may translate to improved balance. Even though this study did not measure lower body power production or EMG neural activity, the exercise protocol provided to the experimental group should have encouraged developing lower body power production, resulting in activation of additional adductors and abductor prime movers. The study protocol allowed each participant to quickly increase intensity by pedaling faster for a shorter time near the end of the exercise session. The researchers also speculated that the bidirectional lateral motion activated different neuromuscular firing patterns that standard upright or recumbent bicycles do not promote. This bicycle training protocol, involving a short burst of intensity, could have promoted and enhanced increased power production in the lateral plane, creating additional benefits of motor unit recruitment and lower body power production. Shim’s investigation demonstrated the importance of developing or maintaining lower body power as a major contributor toward improving stability among the elderly.

The control group was not physically or visually supervised during their 4-week period besides the pretesting and posttesting dates for balance assessments. Table 1 shows that there were mean increases to postural sway in the control group compared with the experimental group.
The investigators did hypothesize that stability improvements would not exist within this particular group based on nonparticipation of any physical activity. Past studies support these findings from the inactive control group because they did not exhibit any other balance improvements, including the perturbed surface testing. The significant improvement with the experimental group was likely due to improved lateral stability due to the SCIFIT Latitude Lateral Stability Trainer design and from participation in the exercise protocol. Proproprioception mechanoreceptors would be the main rationale of these balance improvements, probably based on the lateral rotation of the SCIFIT Latitude Lateral Stability Trainer pedaling increasing the ability to pay attention to changes of direction while visually cued to watch the screen.

Although most studies have focused on combining various modes of mobility and exercise programs for the elderly, the results were not as successful. Foldvari et al used combined exercise modalities with a self-reported functional status, and the only strong correlation was one that combined the self-reported functioning status with leg power. The current study focused on the connection between lower leg muscle power output and COP using the SCIFIT Latitude Lateral Stability Trainer to improve balance stability scores in elderly women. Yearly physical examinations and educating older adults on how they can prevent future or subsequent falls are important to the rising population of aging adults. By focusing on strengthening the lower leg muscles (increasing the muscle power output), this will significantly prevent future or subsequent falls as reported in Table 1.

CONCLUSION
The purpose of this study was to determine if the use of a SCIFIT Latitude Lateral Stability Trainer could improve balance scores in elderly adults within 4 weeks of an exercise protocol compared with an inactive control group. Balance exercise training can help improve postural sway by making the sway area smaller, decreasing the need for corrections. The experimental group had significant changes using the SCIFIT Latitude Lateral Stability Trainer over 4 weeks with “Perturbed Surface – Eyes Open and Eyes Closed” assessments. Proprioception mechanoreceptors would be the main rationale of improvements, probably based on the lateral rotation of the SCIFIT Latitude Lateral Stability Trainer’s pedaling increasing the ability to pay attention to changes of direction while visually cued to watch the screen. Limitations of this investigation included the time of day of the training sessions, specific type of curriculum proposed for this investigation, sample size of the study, and gender inequity of participants.

Future Research
It would be recommended for future studies to increase the sample size and combine multiple modalities of lateral stability exercises in the upright body position compared with being in a recumbent position. Also, measuring lower body power output as an additional dependent variable would determine that this variable was a major factor toward balance score improvement.

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

Authors’ Contributions
Andrew Shim, EdD, is the Program Director for Kinesiology & Exercise Science at College of Saint Mary, Omaha, NE. He proposed and developed the study, performed the data collection, and wrote 45% of the final manuscript. Samantha Prichard, MHS, is a Physician Assistant Studies student at Stephens College in Columbia, MO. She wrote 20% of the final manuscript and assisted with the editing. David Newman, PhD, is the Statistician and Associate Professor for the Christine E Lynn College of Nursing at Florida Atlantic University, Boca Raton, FL. He performed the data analysis and assisted with 15% of the final manuscript. Ms. Carly Lara is a KES major at College of Saint Mary, Omaha, NE. She assisted with the proposal, on-site data collection, and 5% of the final manuscript. Mike Waller, PhD, is an Associate Professor in Health & Physical Education at Arkansas Tech University. He assisted with the proposal and wrote 10% of the final manuscript. Maureen Hoppe, EdD, OTR/L, is an Assistant Professor for the Occupational Therapy Department at College of Saint Mary. She performed the editing, proofing, and wrote 5% of the final manuscript. All authors have given final approval to the manuscript.

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Abbreviations
CoP = center of pressure; EOGS = eyes open stable surface; ECSS = eyes closed stable surface; EOPS = eyes open perturbed surface; ECPS = eyes closed perturbed surface.

References


