The Relationship of Plantar Flexor Strength to Functional Balance in Older Adults

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Abstract: The incidence of falls in older adults increases with a decline in lower extremity strength, functional balance, and multi-tasking while walking. This study examined the relationship between plantar flexor muscle strength and balance as it is used in everyday tasks. The participants were thirty-eight adults age 65 or older residing in an independent living community. Participants’ plantar flexor strength was measured using a Hand-Held Dynamometer followed by performance of the Timed Up-and-Go (TUG) test under three different conditions. The relationship between strength and TUG scores was explored. No significant relationship was found, therefore, plantar flexors were not found to be the most important muscle group in the lower extremities to reduce fall risk.

1. Introduction

In situations that older adults face daily, challenges beyond their functional abilities may increase their risk of falls. We chose to study the relationship between the functional ability to balance and plantar flexor muscle strength. It is hoped that knowledge gained will allow older adults to improve functional balance by training specific muscle groups, such as the plantar flexors. Research has shown that lower extremity strength correlates with functional balance.[1,2,3] However, specific studies regarding the relationship between functional balance and plantar flexor strength have not been studied extensively.[4] This study measured plantar flexor strength using a hand-held dynamometer (HHD) and challenged functional balance with the Timed “Up & Go” Test (TUG) under three different conditions to examine the relationship between plantar flexor strength and balance in independent, community-dwelling older adults.[4,5,6,7]

2. Experiment, Results, Discussions, Significance

Experiment
Testing began with measuring the strength of the plantar flexors of the ankle using a HHD. Seated participants were instructed to place both feet flat on the ground. The tester positioned the participant’s dominant foot at a 90º angle from their lower leg with the heel resting on the ground and the HHD was placed with the force plate at the ball of the foot. Participants were then instructed to push the foot down (plantar flex) with as much force as possible. The average of three trials was recorded. Following this, the TUG was performed to assess functional balance during mobility.[5,8,9,10] Subjects rose from a standard arm chair, walked 10 feet to a tape line on the floor, turned and walked back to the chair, and descended to the starting seated position. Timing began just before the subject rose from the chair and ceased upon return to the starting position. This test was repeated two additional times adding a functional or cognitive challenge. The functional challenge was carrying a plastic cup of water filled up to a 1 inch mark from the lip, and the cognitive challenge was counting backwards by threes from 85. The order of TUG tests was randomized.

Results
No significant relationship was found between plantar flexor strength and time taken to complete the TUG under each of three conditions. However, the time to complete the TUG test increased with addition of a physical or mental task.

Discussion and Significance
This study challenged attention by adding a functional and cognitive component to the TUG. Research has shown that any redirection of attention or cognition during a movement will alter the performance of that movement.[11]
This includes performing a motor task while walking, or backward counting.\cite{12,13,14,15} Increasing levels of difficulty in cognitive tasks result in decreased ability to adapt motor tasks.\cite{16}

Factors to consider in analyzing our results included reliability, muscles involved in the movement, testing procedures, and the population tested. Researcher inter-rater reliability for the TUG was +/-0.01 and intra-rater reliability for the HHD was +/-0.02. McCarthy et al found that although ankle plantar flexor, hip flexor, and knee extensor strength play essential roles in performing the sit-to-stand movement, most variance was unexplained, suggesting that variables other than muscle strength are involved.\cite{17} Factors in this study that may have impacted movements during the TUG include attention, visual distractions, or anxiety. Verbal cueing rather than standardized instruction was used in administering the tests. According to Nordin et al verbal cues were found to be an equally effective method of test administration.\cite{5} Also, note that the sample population used may have been more high functioning than our target population. In a study by Daubney et al, the average PF strength of their sample was 19.61Nm in subjects without falls.\cite{1} The average PF strength of our sample was 38Nm. This may be contributed to the HDD testing position. Our subjects were measured in a closed kinetic chain position to mimic standing on a solid surface. Daubney et al, measured subjects prone.

3. Conclusion

Although our study showed no significant relationship between plantar flexor strength and functional balance in older adults, it is still important to strengthen the lower extremity muscles as well as address balance and/or proprioceptive training to reduce fall risk. The addition of a mental or physical task during gait will increase the risk for falls, therefore needs to be addressed with this population in addition to general strengthening by integrating cognitive challenges with gait and balance training. Further research is needed to determine if there is a muscle of more importance to functional balance or another contributing factor that has not been identified.

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