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Effects of Short-Term Resistance Training on Functional Performance, Cognition, Static Postural Control and Gait in Older Adults: A Pilot Study

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Abstract

Previous studies have examined the efficacy of long-term resistance training for improving health status of older adults. However, long-term programs often encounter adherence issues. Short-term resistance training programs have more clinical utility but their effectiveness to improve cognition, functional performance, postural control and gait in older adults is unknown. Our purpose was to determine the impact of a short-term resistance training program for older adults on cognition, function, postural control and gait. Nine older adults (mean age, 73.4 years) completed four weeks of resistance training consisting of a 30-45 min. session of lower and upper extremity exercises. Functional performance assessments included five times sit-to-stand, 6- minute walk, and hand grip strength. Cognition assessments included Working Memory and Stroop tests. Postural control assessments were standing trials with eyes open/close on a firm/foam surface. Gait was assessed in single- and dual-task conditions. Paired samples t-tests showed that older adults improved postural control when proprioceptive information was not reliable (standing on foam). Also, temporal gait variability reduced under single-task condition but no changes were observed for dual-task condition except for increased step-time variability. There was minimal effect on functional performance and cognition. The effect sizes were moderate to strong only for postural control on foam surface and single-task condition gait variability. Changes in strength due to resistance training could increase the physiologic reserve capacity without necessarily showing improvements in function, cognition, postural control and gait. Overall, short-term resistance training for older adults might show immediate benefits for postural control under more challenging conditions and to reduce gait variability.

Keywords: Posture; Strength training; Gait variability; 6 Minute walk; Geriatrics; Balance

Introduction

Aging reduces muscle strength, impairs cognitive function, slows walking speed and increases the risk of falling by reducing postural control[1–3]. Sarcopenia or loss of muscle mass is often associated with aging and increased frailty levels in older adults[4]. Numerous studies have investigated the effectiveness of different kinds of interventions to counteract the effects of aging. These interventions include balance training, Tai Chi[5-7], yoga[8,9] and resistance training[10,11]. In particular, studies have investigated the efficacy of long-term resistance training involving 2 or more months of intervention to improve muscle strength, gait, balance, and fall risk in older adults[10,11].

Previous studies have shown mixed evidence on the benefits of long-term resistance training for older adults in improving gait, balance and cognition. While gait speed, considered an important clinical outcome measure to determine the health status of a person [15], has been shown to improve with long-term resistance training [12], there is contrasting evidence providing lack of improvement in gait performance [14]. Similarly, there is mixed evidence showing both the benefits [26,27,29] and lack of benefits [14,28] for improving balance due to long-term resistance training. While gait and balance/postural control can be assessed in multiple ways, incorporating a more comprehensive instrumented and objective analysis can help strengthen clinical assessment and effect of intervention. For example, increase in gait variability measured using instrumented techniques has been associated with increased risk of falls in persons with Parkinson's disease [16], decreased functional performance and increased fall-risk and fear of falling in older adults [17,18]. Similarly, computerized posturography is widely used in clinics and is a valuable objective assessment technique to measure postural control with several populations [30,31]. Computerized posturography involves assessing one's balance and postural control using center of pressure data acquired from force platforms as opposed to subjective evaluation using visual observation or assessing how long someone can maintain balance using time watch. Data obtained using computerized posturography can identify more sensitive changes in postural control which involves very fine movement of the body that could not be noticed using only visual observation. Few studies have also reported improvement of cognitive function in older adults after long-term resistance training [32-34]. Moreover, recent evidence suggests that this risk of falls in older adults increases while performing a concurrent dual-task [19-25] implying the involvement of both motor and cognitive challenges faced by this population while performing an activity of daily living like walking.

While previous studies have focused on measuring the effectiveness of long-term resistance training for older adults on specific measures of gait, balance and cognition, very few have examined the effectiveness of a short-term program using a more comprehensive quantitative approach. This is important as long-term programs need more personnel and financial resources to be implemented. Examining the effectiveness of a short-term program is also more important from a clinical perspective. Short-term programs are also sometimes implemented at a community- level and the effectiveness of such programs is often unknown. Though a previous study has shown that a 12 week program requiring participants to complete a single set of resistance exercise in several major muscle groups can improve functional performance measures, few studies have examined the impact of an intervention of short duration like four weeks[35]. Moreover, the impact of resistance training on dual task performance during gait has not been studied in spite of performing a concurrent task while walking is a common among older adults. The current study aims to address these knowledge gaps by using comprehensive quantitative measures including instrumented measures of gait and balance. The purpose of the current study was to determine the impact of a 4-week resistance training program for older adults on measures of functional performance, cognition, static postural control and gait. We hypothesized after four weeks of resistance training, older adults will show improvement in functional performance, cognition, static postural control and gait.

Materials and Methods

Participants

Ten participants recruited for this pilot study via convenience sampling took part in a 4- week resistance training intervention but one participant dropped out due to health concerns unrelated to the intervention. Nine participants (seven females; mean±SD age, 73.4±7.37 years; height, 1.63±0.9m; mass, 70.22±13.97kg) completed the intervention. Inclusion criteria were: i) age ≥ 60 years; ii) body mass index score < 40kg/m^2; and iii) no history of osteoporosis. Participants were excluded from the study on the following criteria: i) current smoking; ii) having sustained a low trauma fragility fracture in the past six months; iii) any medical condition known to influence bone metabolism or fracture risk. Written consent approved by Elon University's institutional review board was obtained from all participants prior to participation.

Exercise Intervention

The intervention used in this investigation is an adaptation of that described by Nelson (2005)[36]. Each resistance training session lasted 30-45 min consisting of the following exercises:squats, standing leg curl, knee extension, lateral hip raises, bicep curls, overhead press, upward row, heel raises. two sets of 8 repetitions were performed for each activity except heel raises, which was done by performing one set of 20 repetitions. The knee extensions and lateral hip raises were performed while wearing ankle weights (5-10lbs). The bicep curls, overhead press and upward rows were performed using dumbbell weights (4-10 lbs). Training was conducted in group session by a trained exercise leader once per week. All participants were instructed to use a resistance equal to a 4 out of 5 point Exercise Intensity Scale. This intensity is a described as "Hard: More than moderate at first, and becomes difficult by the time you complete six or seven repetitions." Participants were instructed to add resistance in 1lb increments when their perceived effort was reduced to 3 or lower.

Instrumentation, Assessments and Outcome Measures

Functional performance, cognition, static postural control and gait assessments were conducted before (PRE) and immediately after (POST) the training period. Functional performance was tested using: a) one trial of 5-times Sit-to-Stand test in which participants were asked to stand and sit in a chair (fixed seat height from floor: 18.5 inches/47 cm) five times as quickly as possible and the time taken to complete the task was recorded using a stop watch[37,38]. b) one trial of 6-minute walk test in which participants walked for six minutes to cover as much distance as they can in a tiled hallway using a marked 30m walkway[39,40].

c) Grip strength was assessed in both hands using an adjustable, hand-held grip strength Jamar dynamometer (Sammons Preston Roylan, Chicago, IL). Each participant stood holding the arm to be tested with the elbow flexed at 90°. The participant was instructed to squeeze the dynamometer as hard as possible and held it for 1s. The participant completed three trials in each hand separated by at least a 30-second recovery period[41]. The average of the three trials for each hand was used for data analyses. Working memory and selective attention was tested as part of Cognition assessment. For working memory, participants counted backwards by intervals of seven from a randomly presented 3-digit number for 60s while sitting. The total number of responses and the number of wrong responses were analyzed[21,24,42]. For selective attention, the Stroop test was used where the participants had to identify the color of the word instead of the actual word as quickly as possible.[43-45]. The reaction time and accuracy were analyzed. One trial each of working memory and selective attention were used. For both functional performance and cognition assessments, participants were given the instructions and allowed to practice once before data was collected. Static postural control testing was done using the modified clinical test of sensory interaction on balance test on the Balance System SD (Biodex Medical Systems, Inc., Shirley, NY). Participants were tested under four conditions for 30s each with 10s rest between conditions: standing with eyes open/closed and on firm/foam surface in that order. The participants were told to stand with their feet shoulder width apart. This position was marked and used for all the conditions. Center of pressure data was collected. Using the Biodex's Patient Data Collection software, the center of pressure data was extracted. Dependent variables related to antero-posterior and medio-lateral displacement and velocity, 95% elliptical sway area and path length were calculated using custom-written script in Matlab (MathWorks, Inc., Natick, MA)[31]. Sway index was obtained from the Balance System SD. Gait was assessed using a 14' long and 2' wide GAITRite system (CIR Systems Inc., Sparta, NJ). Participants performed five barefoot walking trials at their self-selected pace in single- and dual- task conditions. Participants started 2m before and walked 2m past the mat area to achieve steady state walking pattern. The average number of steps per trial were seven. For dual-task condition, participants walked while subtracting serial 7s from a randomly presented 3-digit number. Two practice trials were given for both conditions. However, no instructions were given to the participants to prioritize walking or counting backwards during the dual task condition as instruction to prioritize has been shown to affect gait performance[46]. An average of all the five trials was used for data analysis. The average of right and left limbs was used for further analyses. Outcome variables included absolute (mean) measures of velocity, cadence, step time, length, and width, single and double support time and % of swing phase and coefficient of variation of velocity, step time, length and width. The coefficient of variation was calculated as 100*standard deviation/mean[47].

Statistical Analyses

Normality was confirmed using the Kolmogorov–Smirnov test. Subsequently, a paired- sample t-test was performed. An α-value of 0.05 was used. Given that a number of dependent variables were used for each category, Bonferroni correction (α/number of dependent variables in a category) was applied to obtain a threshold P value for each category. Statistical power value was then calculated using this threshold P value obtained after Bonferroni correction. Testing for normality and t-test were run using SPSS 22 (IBM, Inc., Armonk, NY). Effect size and power calculations were performed using G*Power software (Version 3.1.6; Universität Kiel, Germany) [53].

Results

Functional Performance: The 6-minute walk test, five times Sit to Stand and grip strength scores did not change significantly as a result of the intervention (Table 1). The effect sizes for these measures were weak (< 0.3). Cognition (Working memory): The total number of responses significantly increased (by 40.4%; P = .001; effect size = 0.99) but the number of wrong responses did not differ significantly from PRE to POST (Table 1). Cognition (Selective attention): The reaction time and accuracy scores did not differ significantly from PRE to POST (Table 1). The effect size for the variables that did not show a significant change were weak (< 0.3) to moderate (< 0.7). Static Postural Control: No significant changes were seen from PRE to POST for the sway-related variables when standing on a firm surface with eyes open and closed (Table 2). The effect size for most of these variables were weak (< 0.3). No significant changes were seen from PRE to POST for the sway-related variables when standing on a foam surface with eyes open and closed (Table 3). The effect size for the variables in this category were weak (< 0.3) to moderate (< 0.7). Only the maximum displacement in the antero-posterior direction when standing with eyes closed on foam surface had strong effect size (0.8). Gait (Single task): No significant differences were found for any of the absolute or variability measures of the gait parameters (Table 4). Effect sizes for absolute measures were mostly moderate (<0.7) but the effect sizes for variability measures were moderate to high (>0.7). Gait (dual task): No significant differences were foundfor the absolute measures of the gait parameters in dual task condition (Table 5). Effect sizes for absolute measures were weak (<0.3). There was a significant increase in step time variability (p = 0.009) with none of the other measures showing significant change. The effect sizes for variability measures were weak (<0.3) to moderate (<0.7). Also, there were no significant differences in the total number of responses and total number of wrong responses during gait trials (Table 1). Effect size for these variables were weak (<0.3).

				P value	After Bonferroni correction	Effect size	Power (%)
Functional performance	5 times Sit to Stand (s)	11.48 (0.82)	11.20 (1.23)	.379	NS	0.09	2.20
	6 minute walk test (m)	489.9 (20.2)	491.7 (33.7)	.434	NS	0.02	1.42
	Grip strength on Right (lbs)	28.11 (3.69)	27.33 (3.97)	.448	NS	0.07	1.95
	Grip strength on Left (lbs)	27.11 (3.90)	25.33 (3.99)	.397	NS	0.15	3.14
Cognition	Total number of responses *	11.6 (1.3)	16.2 (1.5)	.001	Significant	0.99	100
	Number of wrong responses	1.0 (0.3)	1.2 (0.3)	.297	NS	0.22	4.69
	Reaction time (ms)	1882.20 (95.13)	2065.10 (221.80)	.172	NS	0.36	10.07
	Accuracy	0.99 (0.01)	0.97 (0.02)	.290	NS	0.42	13.84
Cognition while walking	Total number of responses	5.60 (1.32)	5.33 (0.51)	.523	NS	0.09	4.24
	Number of wrong responses	0.76 (0.51)	0.51 (0.53)	.111	NS	0.16	6.23

					After Bonferroni correction	Effect size	Power (%)
Static postural control (Eyes Open Firm Surface)	Maximum AP displacement (cm)	1.92 (0.25)	2.19 (0.41)	.171	NS	0.27	3.77
	Maximum ML displacement (cm)	1.57 (0.28)	1.72 (0.53)	.349	NS	0.12	1.53
	95% elliptical sway area (sq. cm)	2.32 (0.59)	2.72 (1.22)	.331	NS	0.14	1.73
	Total path length (cm)	47.00 (6.84)	53.99 (14.11)	.241	NS	0.21	2.65
	Mean ML velocity (cm/s)	0.78 (0.15)	0.95 (0.30)	.198	NS	0.24	3.16
	Mean AP velocity (cm/s)	1.07 (0.17)	1.22 (0.32)	.275	NS	0.20	2.49
	Sway index	0.83 (0.12)	0.88 (0.17)	.344	NS	0.11	1.43
Static postural control (Eyes Closed Firm Surface)	Maximum AP displacement (cm)	2.79 (0.46)	3.07 (0.58)	.242	NS	0.18	2.21
	Maximum ML displacement (cm)	2.53 (1.21)	1.58 (0.44)	.219	NS	0.35	6.00
	95% elliptical sway area (sq. cm)	3.89 (1.74)	3.63 (1.30)	.432	NS	0.06	1.04
	Total path length (cm)	57.76 (10.84)	63.86 (10.58)	.177	NS	0.19	2.35
	Mean ML velocity (cm/s)	0.87 (0.24)	0.83 (0.16)	.398	NS	0.07	1.11
	Mean AP velocity (cm/s)	1.39 (0.32)	1.69 (0.23)	.081	NS	0.36	6.35
	Sway index	1.04 (0.19)	1.08 (0.16)	.368	NS	0.08	1.19

AP – Antero-posterior; ML – Medio-lateral; NS – Not significant; After Bonferroni correction (α/number of dependent variables in a category), threshold *P* value was .007 for both the categories; Power value was calculated using the threshold *P* value obtained after Bonferroni correction.

					After Bonferroni correction	Effect size	Power (%)
Static postural control (Eyes Open Foam Surface)	Maximum AP displacement (cm)	3.54 (0.45)	3.47 (0.49)	.242	NS	0.05	0.98
	Maximum ML displacement (cm)	3.15 (0.49)	2.45 (0.31)	.072	NS	0.57	21.18
	95% elliptical sway area (sq. cm)	6.83 (1.87)	5.81 (1.62)	.256	NS	0.19	2.35
	Total path length (cm) *	83.58 (9.19)	75.49 (9.02)	.042	NS	0.30	4.49
	Mean ML velocity (cm/s) *	1.44 (0.15)	1.20 (0.14)	.040	NS	0.55	18.88
	Mean AP velocity (cm/s)	1.98 (0.27)	1.86 (0.25)	.138	NS	0.15	1.84
	Sway index	1.39 (0.18)	1.28 (0.17)	.220	NS	0.21	2.64
Static postural control (Eyes Closed Foam Surface)	Maximum AP displacement (cm) *	9.35 (0.60)	7.95 (0.56)	.009	NS	0.80	74.61
	Maximum ML displacement (cm)	7.06 (0.96)	5.69 (0.78)	.064	NS	0.52	15.89
	95% elliptical sway area (sq. cm) *	42.81 (7.63)	34.12 (6.77)	.023	NS	0.40	7.99
	Total path length (cm)	199.14 (23.62)	179.13 (18.62)	.103	NS	0.31	4.76
	Mean ML velocity (cm/s) *	3.26 (0.40)	2.63 (0.37)	.037	NS	0.55	18.88
	Mean AP velocity (cm/s)	5.03 (0.63)	4.76 (0.45)	.270	NS	0.16	1.96
	Sway index	3.53 (0.27)	3.24 (0.31)	.068	NS	0.33	5.34

					After Bonferroni correction	Effect size	Power (%)
Absolute (Mean) gait measures (Single task)	Velocity (cm/s)	116.80 (7.80)	126.86 (6.98)	.150	NS	0.46	10.05
	Cadence (steps/min)	115.00 (3.77)	118.46 (3.57)	.235	NS	0.31	4.18
	Step time (s)	0.53 (0.02)	0.51 (0.02)	.229	NS	0.33	4.70
	Step length (cm)	60.76 (3.18)	64.01 (2.79)	.108	NS	0.36	5.60
	Step width (cm)	10.75 (0.95)	10.10 (0.72)	.073	NS	0.26	3.11
	Single support time (s)	0.40 (0.01)	0.39 (0.01)	.359	NS	0.33	4.70
	Double support time (s)	0.26 (0.02)	0.24 (0.02)	.136	NS	0.33	4.70
	Swing phase %	37.68 (0.48)	38.49 (0.53)	.103	NS	0.53	15.15
Variability gait measures (Single task)	Velocity CV (%) *	4.55 (0.77)	2.82 (0.31)	.049	NS	0.98	100.00
	Step time CV (%) *	3.14 (0.49)	1.96 (0.20)	.014	NS	1.00	100.00
	Step length CV (%)	2.57 (0.37)	1.97 (0.20)	.146	NS	0.67	49.32
	Step width CV (%)	10.24 (1.36)	11.76 (1.96)	.219	NS	0.30	7.30

CV – Coefficient of variation; * significant difference before Bonferroni correction ($P < .05$); NS – Not significant; After Bonferroni correction (α/number of dependent variables in a category), threshold *P* value was .006 for Absolute measures and 0.0125 for Variability measures; Power value was calculated using the threshold *P* value obtained after Bonferroni correction.

			Post	*P* value	After Bonferroni correction	Effect size	Power (%)
Absolute (Mean) gait measures (Dual task)	Velocity (cm/s)	99.20 (13.23)	93.16 (8.62)	.296	NS	0.18	1.91
	Cadence (steps/min)	98.92 (7.9)	101.00 (4.87)	.345	NS	0.11	1.24
	Step time (s)	0.64 (0.08)	0.62 (0.04)	.266	NS	0.11	1.24
	Step length (cm)	56.40 (3.74)	57.68 (3.13)	.405	NS	0.12	1.32
	Step width (cm)	12.57 (1.64)	12.28 (1.04)	.358	NS	0.07	0.96
	Single support time (s)	0.45 (0.03)	0.43 (0.02)	.200	NS	0.26	3.11
	Double support time (s)	0.42 (0.10)	0.36 (0.04)	.209	NS	0.26	3.11
	Swing phase %	35.83 (1.41)	35.60 (0.69)	.411	NS	0.07	0.96
Variability gait measures (Dual task)	Velocity CV (%)	4.91 (0.72)	6.62 (1.70)	.130	NS	0.44	15.37
	Step time CV (%) *	3.38 (0.75)	4.18 (0.80)	.009	S	0.35	9.55
	Step length CV (%)	4.35 (0.76)	4.42 (1.01)	.466	NS	0.03	1.52
	Step width CV (%)	10.88 (1.39)	10.41 (1.10)	.381	NS	0.13	2.80

CV – Coefficient of variation; * significant difference before Bonferroni correction ($P < .05$); NS – Not significant; S – Significant; After Bonferroni correction (α/number of dependent variables in a category), threshold *P* value was .006 for Absolute measures and 0.0125 for Variability measures; Power value was calculated using the threshold *P* value obtained after Bonferroni correction.

Discussion

The purpose of the current study was to determine the impact of a 4-week resistance training program for older adults on measures of functional performance, cognition, static postural control and gait using comprehensive instrumented measures. While none of the measures changed significantly, effect sizes of measures of postural control under more difficult conditions and measures of gait variability under single-task were moderate to high.

Lack of significant improvement in any of the functional performance measures could have been because of the short-term of resistance training. Perhaps four weeks of resistance training isn't sufficient to notice meaningful changes in the population studied. This could partly be explained based on the nature of the tasks chosen to estimate functional performance. For example, performance in tests like five times sit to stand and 6-minute walk reflect power and endurance capacities of an older adult. Hence four weeks of resistance training may improve strength but not carryover to improvement in power and endurance. Similarly, with the hand grip strength test, four weeks of resistance training that focused mainly on improving the strength of the lower extremities may not be sufficient to produce changes in strength measurement of upper extremities. This needs to be investigated in future. Short-term resistance training did not seem to affect cognition in older adults. Though there was an increase in total number of responses, the accuracy and reaction time did not show any improvement. Increase in the total number of responses could be due to familiarity with the task. Based on the current evidence, it seems that at least 12 weeks of resistance training might be needed to see improvement in cognitive performance measured via reaction time for older adults [32-34].

Short-term resistance training seemed to benefit static postural control under more challenging conditions for older adults. Though there was no significant change from PRE to POST after Bonferroni correction, the effect size for some of the variables when the participants stood on a foam surface was moderate (0.55) to strong (0.8). This is an important finding as in spite of the available evidence for the use of 12-week training period, four weeks is more clinically applicable. The proprioceptive, visual and vestibular sensory systems play a critical role in maintaining static postural control. Standing on a foam surface results in receiving irregular sensory input from the proprioceptive system which is compensated primarily by the visual and vestibular systems (eyes open foam surface condition) and vestibular system (eyes closed foam surface condition). Results of the current study suggest that perhaps a short-term resistance training program that primarily focused on lower extremities might help enhance the proprioceptive input which in turn helped improve postural control during both the foam conditions. Moreover, effects of short-term resistance training were primarily seen in the medio-lateral direction. This could be due to a smaller base of support present in the medio-lateral direction tending to cause greater instability. In a systematic review, Orr et al. suggested that there is limited evidence for relationship between muscle strengthening and enhancement of balance performance in older adults[48].

Four weeks of resistance training seemed to increase the consistency (reduced variability) of temporal gait characteristics among older adults except for step time variability during dual- tasking. Increase in step time variability while dual tasking could be associated with decreased gait speed [49]. Similar to static postural control, though there was no significant change from PRE to POST after Bonferroni correction, the effect size for most of the variability measures was moderate (0.54) to strong (1.00). Moreover, the reduction in temporal gait variability was seen without a compromise of the cognitive performance while walking. Similar to Topp et al. findings, the current study found no effect of resistance training on absolute measures like gait speed[14]. This was in contrast to few previous studies[10,12,48]. It is possible that these differences exist because of the differences in assessment techniques. For example, Fiatarone et al (1994) assessed gait velocity using a 6.1m walkway as opposed to using an instrumented system like GAITRite used in the current study[10]. Recent evidence also suggests that muscle quality and power output are associated with gait variability than absolute gait measures in older adults[49]. Changes in muscle quality and power output because of a 4-week resistance training paradigm could be investigated in future. Moreover, in line with the results for cognition, the short-term training did not seem to affect gait while performing a concurrent task. Increased gait variability is often associated as a risk factor of falls in older adults[50]. Results of the current pilot study suggest that short-term resistance training may have benefit gait performance in older adults by reducing the temporal gait variability. To our knowledge this is the first study to examine the effects of short-term resistance training on variability of gait using instrumented measures. We are also unaware of any studies that have examined if resistance training helps improve gait performance during dual-tasking. Our results suggest that a short-term resistance training protocol might not elicit dual-task related changes in gait, thus lending evidence to examine the effect of long-term resistance training for gait under dual-task conditions.

While results of this study cannot pinpoint if resistance training causes changes that are more central or peripheral or both, minimal effects on postural sway (during eyes open and eyes closed conditions while standing on a firm surface), cognition, gait while dual tasking could suggest that short-term resistance training might have greater peripheral effects than central. However, this hypothesis needs to be confirmed in a future study. Using EMG activity, Gabriel and colleagues suggested that the early changes due to resistance training are more central than peripheral[51].

Moreover, changes in strength due to resistance training could increase the physiologic reserve capacity (ability of the muscles to produce the required physiological tension/force) in these individuals without necessarily showing improvements in postural control and gait as the biomechanical/functional demands could be different than the physiological capabilities available to meet those demands[27]. For instance, previous research has shown that activities like using stairs placed a higher biomechanical demand than the available isometric capacity[52]. Results of the current study should be interpreted in conjunction with its limitations. First, the sample size of the study though, small, serves as a pilot for larger studies needed to establish the effectiveness of short-term resistance training to identify the important outcome measures. The effect size and statistical power values have been provided for each dependent variable. Second, lack of a control group limits our ability to tease out the true effects of intervention. The large number of assessments and measures used in the current study could serve as a platform for future studies to make appropriate choices.

Conclusion

Overall, results of the current pilot study suggest that a short-term 4-week resistance training protocol for older adults has limited benefit for functional performance, cognition and static postural control when proprioceptive information is available but could help supplement static postural control when proprioceptive sensory input is perturbed and to reduce the temporal gait variability.

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Conflict of Interest

There are no conflicts of interest to report.

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