

RESEARCH

Weighted Vest Training in Community-Dwelling Older Adults: A Randomized, Controlled Pilot Study

Justin T. Mierzwicki

Lebanon Valley College, Department of Physical Therapy, Annville PA, US
mierzwic@lvc.edu

Objectives: To determine if weighted vests dosed at 10% of body weight, when added to a home exercise program, provides stimulus sufficient to improve strength, sit to stand performance, and aerobic capacity in community-dwelling older adults.

Methods: Nineteen participants (mean age = 68.7 +/- 5.9 SD) were randomly assigned in a 1:1 fashion into either an exercise only control group or an exercise plus weighted vest at 10% of body weight intervention group. All participants performed the same home exercise program consisting of eight open and closed kinetic chain lower extremity exercises, and a 30 minute walking program, 3x/wk for 12 weeks. Pre and post intervention data collection included: lower extremity muscle strength dynamometry, five time sit to stand, 30 second chair rise, two minute step and six minute walk tests.

Results: Statistically significant improvements ($p < 0.05$) were noted in 100% of weighted vest group and 42% of control group dependent variables. Between groups comparison demonstrated statistically significant improvements in the vest group relative to control group in 5/12 dependent variables ($p < 0.05$). Weighted vest intervention resulted in exceeding minimally clinically important differences in 6-minute walk test, 2-minute step test and 30-second chair rise test performance. Based on participant report, one half of weighted vest users reported difficulty with vest donning and doffing.

Conclusions: Weighted vest use during exercise resulted in statistically and clinically greater improvements in strength, sit to stand performance, and aerobic capacity than exercise alone. Further research is required to determine optimal weighted vest dosage parameters to maximize functional gains while reducing the need for assistance with vest management.

Keywords: weighted vest; community-dwelling older adults; functional mobility; aerobic capacity; functional performance

Introduction

Declines in muscle strength, development of osteoporosis, falls, fractures, declines in mobility and impaired activities of daily living are common in the older adult population (Guccione Wong and Avers 2012; Lopopolo et al. 2006). Resistance training and aerobic exercise are commonly utilized interventions to combat these age-related changes (Lopopolo et al. 2006). Limited equipment availability and access and transportation concerns, all frequently present in the older adult population, may restrict access to appropriately dosed exercise. Weighted vests have been used as an intervention to improve strength and function in the older adult population (Bean et al. 2002; Bean et al. 2004; Greendale et al. 1993; Greendale et al. 2000; Salem et al. 2004; Shaw and Snow 1998; Snow et al. 2000). Recent research on weighted vest use has investigated its impact on body composition (Normandin et al. 2018), bone metabolism (Hamaguchi et al. 2017; Klentrou et al. 2007; Roghani et al. 2013), and lower extremity biomechanics (Mair et al. 2014; Puthoff et al. 2006). As a versatile intervention, weighted vests may optimize access to exercise modalities, at a low cost, in a home exercise program setting. Prior studies utilizing varied weighted vest dosages have demonstrated differing outcomes.

Bean et al. (2004), demonstrated that high velocity exercise using weighted vests improved development of lower extremity power and chair rise performance following a 12-week intervention. Shaw and Snow (1998) utilized weighted vests to supplement resistance training. Intervention group participants demonstrated an increase in lower extremity strength by 16–33%, and muscle power by 13% after 9 months. Being that the weighted vest was a component in a larger intervention program and at vest dosages ranging from 5–20% of body weight, the independent contribution of the vest itself was not able to be determined (Shaw and Snow 1998). In a population of older adults with osteoporosis, Snow et al. (2000), found that the use of weighted vests and jump training increased bone mineral density by 3.2–4.4% after 5 years.

Salem et al. (2004) utilized weighted vests at 0, 5 and 10 % of body weight to determine the effect of resistance on hip, knee and ankle mechanics associated with forward and lateral step up exercises. Peak hip, knee and ankle moments, powers and impulses were greater in the 10% body weight group than the 5% and 0% of body weight groups.

Greendale et al. (2000), compared interventions using weighted vests dosed at 3 and 5% of body weight, 2 hours per day, 4 days per week, without a specific training regimen, in high functioning community dwelling older adults. Both loads were found to be ineffective at improving measures of strength and function (Greendale et al. 2000). In the literature to date, weighted vest dosages have ranged from 0–20% of body weight (Greendale et al. 2000; Hamaguchi et al. 2017; Salem et al. 2004; Shaw and Snow 1998) with no optimal dosage having been established for the use of this intervention in community dwelling older adults.

Loads of up to 20% of body weight may be difficult for older adults to don and doff (Puthoff et al. 2006) and loads of 3–5% of body weight have been demonstrated to be insufficient stimulus to increase strength and functional performance (Greendale et al. 2000). The purpose of this randomized, controlled pilot study was to determine if the use of a weighted vest dosed at 10% of body weight, when added to a home exercise program, provides stimulus sufficient to improve strength, sit to stand performance, and aerobic capacity in community-dwelling older adults.

Materials and Methods

Subjects

The research proposal was reviewed and received approval by the Lebanon Valley College Institutional Review Board, and participants were then recruited utilizing an email distribution list of former members of the Lebanon Valley College fitness center. Inclusion criteria included: age >60 years, any gender, any race/ethnicity, medically stable as defined by being cleared for physical activity by their primary care physician, independent with functional mobility tasks without the use of an assistive device, and residing in an independent living setting. Exclusion criteria included living in an assisted living or skilled nursing facility setting, inability to safely transfer and ambulate without needing assistance from another person, lack of physician clearance for participation in physical activity, actively receiving skilled physical therapy services, and concurrent participation in another exercise program at the time of the study. Respondents meeting inclusion criteria with continued interest in the study were educated in the research methodology, risks, potential benefits, and informed consent was obtained.

Twenty one individuals volunteered to participate in the study, two of which were excluded due to unresolved medical conditions identified at the time of medical screening. The remaining nineteen participants (9 Male, 10 Female, mean age 68.12 years, SD 5.84) were prospectively randomly assigned in a 1:1 format, into either a weighted vest intervention group (n = 10) or an exercise only control group (n = 9).

Measurements

Pre-intervention data were collected three days prior to intervention initiation, and post-intervention data were collected three days after intervention completion. Pre-post intervention data collection included: bilateral lower extremity hip flexion, hip abduction and hip extension muscle strength dynamometry (Hoggan MicroFET2 handheld dynamometer); 5-time sit to stand test (5×SST); 30-second chair rise test (30-sec CRT); one leg stance heel rise test; 2-minute step test (2MST); and 6-minute walk test (6MWT).

Hand-held dynamometry was performed with the participant lying on a plinth. All measurements were performed in a gravity minimized position. Break tests, with the hip positioned in neutral, were performed. Participants were instructed to increase resistance over the course of approximately 3 seconds for each muscle group, and peak force in kilograms was recorded.

The 5×SST was performed with the arms crossed on the chest, with the participant fully rising from and lowering to a 17-inch height armless chair as quickly as possible. The length of time to complete 5 full repetitions was recorded. After a 2 minute seated recovery period, the 30-sec CRT was performed with arms crossed across the chest, fully rising and lowering from the same 17-inch height armless chair. The total number of repetitions completed in 30 seconds was recorded. The final repetition was counted as complete if the participant had begun their descent from stand to sit prior to the timer reaching 30 seconds.

The one leg stance heel rise test was performed once with each lower extremity. The test position utilized was: stance knee extended and the contralateral lower extremity placed in 90 degrees of flexion at the hip and knee. The participant performed heel rises with the stance lower extremity as many times as possible. The test for each lower extremity was ended when there was a 50% reduction in ankle excursion, a loss of balance requiring placement of the contralateral foot on the floor or if the participant placed their contralateral lower extremity in contact with their stance lower extremity to stabilize themselves. Participants were allowed to place 1 finger on a plinth to steady themselves, however, if they leaned heavily on the plinth, testing was discontinued.

The 2MST was performed by placing a piece of tape on the wall, midway between the participants' patella and iliac crest. The participant was instructed to step in place as many times as possible in two minutes while facing the wall. The total number of repetitions completed in two minutes were recorded, however, repetitions during which the subject's knee did not reach the line on the wall were not recorded. Participants were permitted to take standing rest breaks, as needed, to allow test completion.

The 6MWT was performed utilizing the methodology and script published by the American Thoracic Society (Crapo, Enright and Zeballos 2002).

During post-intervention data collection, all subjects completed a brief, oral qualitative survey regarding their experience. Intervention group participants were asked additional questions regarding ease of weighted vest usage.

Intervention

All study participants were provided with, and instructed in proper performance of a home exercise program (See **Table 1** for exercise prescription). Participants were instructed to perform the exercise program three times per week for 12 weeks. Bilateral exercises were performed 3 sets of 8–12 repetitions, whereas unilateral exercises were performed 3 sets of 8–12 repetitions with each lower extremity. Exercises were selected to target muscle groups involved in functional activities. Salem et al. (2004) reported that training a forward step up preferentially trains hip extensor muscles, while performing a lateral step up preferentially trains plantarflexor muscles. These movements were incorporated into the exercise program, as these muscle groups are involved in performing sit to stand and gait activities. After completing the required exercises, participants were then instructed to walk for 30 minutes using an RPE of 13/20 on the Borg Scale to guide walking intensity. All participants were asked to track adherence to the prescribed exercise program in a weekly log.

Table 1: Exercises performed by Control and Intervention Groups.

Intervention	Parameters
Walking	30 minutes, RPE \leq 13/20
Repeated Sit to Stand	3 sets of 8–12 reps
Bilateral Mini Squat	3 sets of 8–12 reps
Standing Bilateral Heel Raise	3 sets of 8–12 reps
Standing Hip Flexion	3 sets of 8–12 reps with each LE
Standing Hip Extension	3 sets of 8–12 reps with each LE
Standing Hip Abduction	3 sets of 8–12 reps with each LE
Forward Step Up (8 inch step)	3 sets of 8–12 reps with each LE
Lateral Step Up (8 inch step)	3 sets of 8–12 reps with each LE



Figure 1: Uni-Vest Weighted Vest. www.allegromedical.com.

Participants assigned to the intervention group were issued a weighted vest (Uni-Vest Professional Weighted Vest, Flex-Metal additional weights; www.allegromedical.com, **Figure 1**) with the load adjusted to 10% of the participant's measured body weight, and were instructed to utilize the weighted vest during the performance of all study related exercises and walking activities.

Data Analysis

Statistical analyses were performed utilizing IBM SPSS 23 software. Within group analysis of dependent variable changes pre-post intervention were performed utilizing paired samples *t*-tests. Between group analyses of pre-post intervention change scores for each dependent variable was performed utilizing independent samples *t*-tests.

Results

Preliminary data were collected for nineteen participants. Two participants in the weighted vest intervention group withdrew due to medical conditions unrelated to the study (one vascular stent revision, one due to appendectomy) resulting in control group $n = 9$ and intervention group $n = 8$ completing pre and post intervention data collection and intervention. No participants in either group experienced injury or discomfort as a result of participation in this study. Four participants (1 male, 3 female) in the intervention group reported difficulty donning and doffing their weighted vest. See **Table 2** for descriptive statistics.

Paired samples *t*-tests were performed to determine pre-post intervention improvements within the intervention and control groups. All dependent variables in the weighted vest intervention group achieved statistically significant improvements: 5×SST ($p = 0.000$), 30-sec CR ($p = 0.000$), 2MST ($p = 0.000$), OLS Heel rise-R ($p = 0.017$), OLS Heel rise-L ($p = 0.005$), 6MWT ($p = 0.001$), Hip Ext-R ($p = 0.002$), Hip Ext-L ($p = 0.002$), Hip Flex-R ($p = 0.024$), Hip Flex-L ($p = 0.002$), Hip Abd-R ($p = 0.015$) and Hip Abd-L ($p = 0.005$). Five out of twelve dependent variables in the control group demonstrated statistically significant pre-post intervention improvement: 30-sec CR ($p = 0.006$), 2MST ($p = 0.003$), OLS Heel rise-R ($p = 0.037$), OLS Heel rise-L ($p = 0.007$), and 6MWT ($p = 0.012$). See **Table 3** for comparison details.

Levene's test was performed for all dependent variables, and indicated equality of variances within the intervention and control groups ($p > 0.05$). Between groups independent samples *t*-tests were performed utilizing gain score analyses for each dependent variable. Statistically significant differences favoring the intervention group were identified in 30-sec CRT ($p = 0.15$), 2-minute step test ($p = 0.013$), 6-minute walk test ($p = 0.004$), right hip extension dynamometry ($p = 0.019$) and left hip abduction dynamometry ($p = 0.037$). There were no dependent variables for which the degree of statistical change of the control group exceeded that of the intervention group. See **Table 4** for full statistical analysis.

Minimally Clinically Important Differences (MCID) have been calculated for 5× sit to stand to be >2.3 second change (Meretta et al. 2006), 30 second chair rise test $>2-2.6$ repetition change (Wright et al. 2011),

and 6 minute walk test distance >58.21 meters (Perera et al. 2006). Intervention group participants exceeded MCID for all three clinical measures. Intervention group mean change was 3.08 seconds for 5× sit to stand, 6.25 repetitions for 30 second chair rise, and 92.54 meters for the 6 minute walk test. The control group exceeded MCID for only the 30 second chair rise test with a mean improvement of 3.0 repetitions.

Table 2: Baseline Characteristics for Subjects Stratified by Exercise Program.

Characteristic	Vest-Intervention Group (n = 8)	Non-Vest Control Group (n = 9)
Age, years (+/-SD)	67.25 +/- 4.37	68.89 +/- 7.37
BMI, kg/m ² (+/-SD)	27.48 +/- 6.15	30.02 +/- 8.46
Gender	M = 5, F = 3	M = 3, F = 6
Adherence, % of sessions completed (+/-SD)	93.00 +/- 7.37	94.75 +/- 6.39

SD = Standard Deviation, BMI = Body Mass Index, M = male, F = female.

Table 3: Within-Group Mean Change Pre-Post Intervention-Paired *t*-test Results.

Dependent Variable	Randomized Group	Mean Δ	Standard deviation	t-statistic	df	Significance (2-tailed) p-value
5×SST (sec)	Intervention	3.084	0.853	10.277	7	0.000*
	Control	1.564	2.259	2.078	8	0.071
30 sec CR (reps)	Intervention	-6.25	2.435	-7.26	7	0.000*
	Control	-3.00	2.449	-3.674	8	0.006*
2 -MST (steps)	Intervention	-23.75	6.36	-10.556	7	0.000*
	Control	-12.778	9.271	-4.135	8	0.003*
OLS Heel rise-R (reps)	Intervention	-8.5	7.76	-3.096	7	0.017*
	Control	-7.778	9.311	-2.506	8	0.037*
OLS heel rise-L (reps)	Intervention	-11.5	7.928	-4.103	7	0.005*
	Control	-9.778	8.167	-3.592	8	0.007*
6 MWT (meters)	Intervention	-92.454	45.249	-5.785	7	0.001*
	Control	-30.209	28.144	-3.22	8	0.012*
Hip Ext-R (kg)	Intervention	-6.356	3.706	-4.851	7	0.002*
	Control	-1.618	3.691	-1.315	8	0.225
Hip Ext-L (kg)	Intervention	-5.567	3.287	-4.79	7	0.002*
	Control	-3.896	5.135	-2.276	8	0.052
Hip Flx-R (kg)	Intervention	-4.507	4.450	-2.865	7	0.024*
	Control	-4.02	6.941	-1.738	8	0.120
Hip Flx-L (kg)	Intervention	-7.553	4.31	-4.956	7	0.002*
	Control	-4.143	5.944	-2.091	8	0.070
Hip Abd-R (kg)	Intervention	-9.095	8.083	-3.182	7	0.015*
	Control	-1.588	7.304	-0.652	8	0.533
Hip Abd-L (kg)	Intervention	-5.307	3.697	-4.06	7	0.005*
	Control	-0.085	5.396	-0.048	8	0.963

* denotes statistical significance, $p < 0.05$, 95% confidence interval.

sec = seconds, reps = repetitions, kg = kilograms, df = degrees of freedom, Δ = change.

Table 4: Between Samples Gain Score Analysis-Independent Samples *t*-test Results.

Dependent Variable	Intervention Group (mean Δ)	Control Group (mean Δ)	t-statistic (15df)	Significance (2-tailed) p value
5xSST (sec)	-3.08 [‡]	-1.56	1.787	0.094
30 sec CRT (reps)	6.25 [‡]	3.00 [‡]	-2.738	0.015*
2-MST (steps)	23.75	12.78	-2.806	0.013*
OLS Heel rise-R (reps)	8.50	7.78	-0.172	0.865
OLS heel rise-L (reps)	11.5	9.78	-0.440	0.666
6 MWT (meters)	92.54 [‡]	30.21	-3.456	0.004*
Hip Ext-R (kg)	6.36	1.62	-2.637	0.019*
Hip Ext-L (kg)	5.57	3.90	-0.787	0.443
Hip Flx-R (kg)	4.51	4.02	-0.170	0.868
Hip Flx-L (kg)	7.55	4.14	-1.338	0.201
Hip Abd-R (kg)	9.09	1.59	-2.012	0.063
Hip Abd-L (kg)	5.31	0.09	-2.296	0.037*

* denotes statistical significance favoring intervention over control, $p < 0.05$, 95% confidence interval.

[‡]denotes exceeding minimal clinically important difference threshold sec = seconds, reps = repetitions, kg = kilograms, Δ = change.

Discussion

The major finding of this study was that utilization of a weighted vest during exercise resulted in greater statistically significant and clinically important improvements in strength, functional mobility, and aerobic capacity than exercise alone. All study participants performed the same eight exercises and 30-minute walking program, three times per week for 12 weeks. The only methodological difference between the two groups was the utilization of a weighted vest dosed at 10% of body weight during the intervention groups' exercise program. With exercise being a proven intervention to address strength, aerobic capacity and functional mobility, it was expected that both groups would demonstrate some degree of improvement in all of these domains. The striking finding was the distribution of the differences between the two groups.

Within the intervention group, 100% (12/12) of dependent variables achieved statistically significant improvement and met MCID for 100% (3/3) of dependent variables for which MCID data is available. The control group reached statistical significance for 41.67% (5/12) of dependent variables, and MCID for only 33% (1/3) of dependent variables.

The weighted vest intervention group demonstrated statistically significant improvements in only 33% (2/6) lower extremity dynamometric strength measurements relative to the control group. This may be explained by the fact that the weighted vest load was applied to the trunk and pelvis, not directly to the lower extremity performing the exercise, which may have limited strength gain differences between groups. There was not a statistically significant difference between groups for the 5x sit to stand test. Considering that 5x sit to stand is a measure of functional lower extremity strength, and there was not a significant difference in mean strength change between groups, these sets of findings correlate.

The weighted vest intervention group demonstrated statistically significantly greater improvement than the control group for change in 30-second chair rise performance. The 30-second chair rise test may measure lower extremity endurance in addition to strength. This aligns with the observation that the intervention group demonstrated statistically significantly greater improvements than the control group in the 2-minute step and 6 minute walk tests, both measures of aerobic capacity.

Prior studies investigating the use of weighted vests in community-dwelling older adults used loads ranging from 0–20% of body weight (Greendale et al. 2000; Hamaguchi et al. 2017; Salem et al. 2004; Shaw and Snow 1998), and ideal loading parameters have not been determined. Loads ranging from 3–5% of body weight have demonstrated ineffectiveness in improving strength, functional improvement, or bone turnover (Greendale et al. 2000). Studies demonstrating effectiveness of weighted vest intervention

in improving body composition (Klentrou et al. 2007), body composition and leg power (Normandin et al. 2018), and lower body strength, power, and lean mass (Shaw and Snow 1998) have used loads as high as 20% of body weight. However, two biomechanical studies demonstrated that maximal impulse generation during weighted vest exercise (Salem et al. 2004) and peak power output during weighted vest exercise in older women (Mair et al. 2006) occur at 10% of body weight. While some kinetic variables and challenges to aerobic capacity are greater with 15–20% body weight (Puthoff et al. 2006), loads of up to 20% may become difficult for an older adult to safely utilize (Puthoff et al. 2006). Taking all of these factors into consideration, 10% of body weight was chosen to be the load of choice for this pilot study's intervention.

Exercise-induced musculoskeletal injury rates have been reported as 10% in middle-aged adults (Surakka et al. 2003) and 13.8% in sedentary older adults (Little et al. 2013). In the present study, half of the weighted vest group participants reported requiring assistance to don and doff their weighted vests due to difficulty lifting it over head. Despite difficulty with donning and doffing, there were no reported injuries and there was no significant difference in adherence between the intervention and control groups. It is possible that participants in the present study had a higher baseline level of physical activity or experience with exercise due to prior fitness center membership utilization than participants in prior studies. It is also possible that combining a weighted-vest with carefully selected exercises is a safe, low-risk method of exercise delivery in older adults.

The appeal of using weighted vests in the older adult population is that it offers overload, without requiring transportation to a gym to access expensive equipment. The weighted vests' utility, however, is lessened when the load is so great that users require assistance to don and doff. Excessive vest loads may be unwieldy, potentially reducing its applicability on a larger scale since not all older adults have persons that could provide assistance with weighted vest management.

All of these findings must be considered while also taking into account this study's limitations. First is small sample size, limited by participant availability and availability of weighted vests. Grant funding for this pilot study was received, but only allowed for the purchase of 10 vests. This limited the intervention group to a maximum of 10 participants, two of which withdrew from the study. Despite the fact that 3 female and 1 male participants reported difficulty donning and doffing their weighted vest, small sample size limits this study's ability to suggest gender-related differences in weighted vest applicability. Additionally, uneven representation of male and female participants in the intervention and control groups may skew results. All participants were Caucasian, limiting generalizability to other ethnic populations. One additional limitation to the study was that the load for the weighted vest was held constant at 10% of body weight for the duration of the study. Not allowing for a several week acclimation period to slowly increase the load to the desired 10% of body weight, may have contributed to participant difficulty with donning and doffing the vest. This methodology may have also blunted the degree of improvement attained by the intervention group, since a progressive increase in overload was not administered over the course of the study.

Conclusions

This study contributes to a body of evidence supporting the use of weighted vests as an intervention to improve lower extremity strength, sit to stand performance, and aerobic capacity in community-dwelling older adults. Weighted vests are a relatively inexpensive (\$108–173 USD, size dependent [www.allegromedical.com]) means by which to apply overload to functional exercises as part of a home exercise program. Further research should attempt to investigate the minimum effective dosage of weighted vest loading, both from a length of intervention and percentage of body weight perspective. Identifying this optimal load may maximize outcomes, minimize the need for some participants to seek assistance with vest donning and doffing, thereby increasing the applicability of this intervention to a larger segment of the older adult population. Other areas of future study with regard to utilization of weighted vests are to examine its impact on functional outcomes in individuals with geriatric syndromes such as frailty and sarcopenia, as well as its applicability in institutional settings.

Weighted vests are safe, portable, and relatively inexpensive devices that can facilitate improvements in strength, sit to stand performance, and aerobic capacity in community-dwelling older adults.

Acknowledgements

I would like to thank the Lebanon Valley College Faculty Grants Committee for approving funding to purchase weighted vests, without which this research would not have been possible. I would also like to acknowledge Mr. Mark Swokel for his assistance with data analysis.

Funding Information

This research received no external funding, however, was funded by an internal Lebanon Valley College Faculty Research Grant. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish.

Competing Interests

The author has no competing interests to declare.

References

- allegromedical.com** Accessed on July 23, 2019. Available online at: <https://www.allegromedical.com/browse/browseProducts.do?searchPhrase=weighted+vest>
- Bean, J., Herman, S., Kiely, D. K., Callahan, D., Mizer, K., Frontera, W. R., & Fielding, R. A.** (2002). Weighted stair climbing in mobility-limited older people: A pilot study. *Journal of the American Geriatrics Society, 50*, 663–670. DOI: <https://doi.org/10.1046/j.1532-5415.2002.50160.x>
- Bean, J. F., Herman, S., Kiely, D. K., Frey, I. C., Leveille, S. G., Fielding, R. A., & Frontera, W. R.** (2004). Increased velocity exercise specific to task (InVEST) training: A pilot study exploring effects on leg power, balance and mobility in community-dwelling older women. *Journal of the American Geriatrics Society, 52*, 799–804. DOI: <https://doi.org/10.1111/j.1532-5415.2004.52222.x>
- Crapo, R. O., Enright, P. L., & Zeballos, R. J.** (2002). ATS Statement: Guidelines for the six-minute walk test. *American Journal of Respiratory and Critical Care Medicine, 166*, 111–117. DOI: <https://doi.org/10.1164/ajrccm.166.1.at1102>
- Greendale, G. A., Hirsch, S. H., & Hahn, T. J.** (1993). The effect of a weighted vest on perceived health status and bone density in older persons. *Quality of Life Research, 2*(2), 141–152. DOI: <https://doi.org/10.1007/BF00435733>
- Greendale, G. A., Salem, G. J., Young, J. T., Damesyn, M., Marion, M., Wang, M., & Reuben, D. B.** (2000). A randomized trial of weighted vest use in ambulatory older adults: strengths, performance and quality of life outcomes. *Journal of the American Geriatrics Society, 48*(3), 305–311. DOI: <https://doi.org/10.1111/j.1532-5415.2000.tb02651.x>
- Guccione, A. A., Wong, R. A., & Avers, D.** (2012). *Geriatric Physical Therapy*, 3rd edition. St. Louis: Elsevier Mosby.
- Hamaguchi, K., Kurihara, T., Fujimoto, M., Iemitsu, M., Sato, K., Hamaoka, T., & Sanada, K.** (2017). The effects of low-repetition and light-load power training on bone mineral density in postmenopausal women with sarcopenia: A pilot study. *BMC Geriatrics, 17*, 102. DOI: <https://doi.org/10.1186/s12877-017-0490-8>
- Klentrou, P., Slack, J., Roy, B., & Ladouceur, M.** (2007). Effects of exercise training with weighted vests on bone turnover and isokinetic strength in postmenopausal women. *Journal of Aging and Physical Activity, 15*, 287–299. DOI: <https://doi.org/10.1123/japa.15.3.287>
- Little, R. M. D., Paterson, D. H., Humphreys, D. A., & Stathokostas, L.** (2013). A 12-month incidence of exercise-related injuries in previously sedentary community-dwelling older adults following an exercise intervention. *BMJ Open, 3*, e002831. DOI: <https://doi.org/10.1136/bmjopen-2013-002831>
- Lopopolo, R. B., Greco, M., Sullivan, D., Craik, R. L., & Mangione, K. K.** (2006). Effect of therapeutic exercise on gait speed in community dwelling elderly people: a meta-analysis. *Physical Therapy, 86*(4), 520–540.
- Mair, J. L., Laudani, L., Vannozzi, G., DeVito, G., Boreham, C., & Macaluso, A.** (2014). Neuromechanics of repeated stepping with external loading in young and older women. *European Journal of Applied Physiology, 114*, 983–994. DOI: <https://doi.org/10.1007/s00421-014-2826-9>
- Meretta, B. M., Whitney, S. L., Marchetti, G. F., Sparto, P. J., & Muirhead, R. J.** (2006). The five times sit to stand test: Responsiveness to change and concurrent validity in adults undergoing vestibular rehabilitation. *Journal of Vestibular Research, 16*(4–5), 233–243.
- Normandin, E., Yow, D., Crofts, C., Kiel, J., Beavers, K. M., & Nicklas, B. J.** (2018). Feasibility of weighted vest use during a dietary weight loss intervention and effects on body composition and physical function in older adults. *Journal of Frailty and Aging, 7*(3), 198–203.
- Perera, S., Mody, S. H., Woodman, R. C., & Studenski, S. A.** (2006). Meaningful change and responsiveness in common physical performance measures in older adults. *Journal of the American Geriatrics Society, 54*(5), 743–749. DOI: <https://doi.org/10.1111/j.1532-5415.2006.00701.x>
- Puthoff, M. L., Darter, B. J., Nielsen, D. H., & Yack, H. J.** (2006). The effect of weighted vest walking on metabolic responses and ground reaction forces. *Medicine and Science in Sports and Exercise, 38*(4), 746–752. DOI: <https://doi.org/10.1249/01.mss.0000210198.79705.19>

- Roghani, T., Torkaman, G., Movasseghe, S., Hedayati, M., Goosheh, B., & Bayat, N.** (2013). Effects of short-term aerobic exercise with and without external loading on bone metabolism and balance in postmenopausal women with osteoporosis. *Rheumatology International*, *33*, 291–298. DOI: <https://doi.org/10.1007/s00296-012-2388-2>
- Salem, G. J., Flanagan, S. P., Wang, M. Y., Song, J. E., Azen, S. P., & Greendale, G. A.** (2004). Lower-extremity kinetic response to weighted-vest resistance during stepping exercise in older adults. *Journal of Applied Biomechanics*, *20*, 260–274. DOI: <https://doi.org/10.1123/jab.20.3.260>
- Shaw, J. M., & Snow, C. M.** (1998). Weighted vest exercise improves indices of fall risk in older women. *Journal of Gerontology: Medical Sciences*, *53*(1), M53–M58. DOI: <https://doi.org/10.1093/gerona/53A.1.M53>
- Snow, C. M., Shaw, J. M., Winters, K. M., & Witzke, K. A.** (2000). Long-term exercise using weighted vests prevents hip bone loss in postmenopausal women. *Journal of Gerontology: Medical Sciences*, *55A*(9), M489–M491. DOI: <https://doi.org/10.1093/gerona/55.9.M489>
- Surakka, J., Aunola, S., Nordblad, T., Karppi, S., & Alanen, E.** (2003). Feasibility of power-type strength training for middle aged men and women: self-perception, musculoskeletal symptoms, and injury rates. *British Journal of Sports Medicine*, *37*(2), 131–136. DOI: <https://doi.org/10.1136/bjism.37.2.131>
- Wright, A. A., Cook, C. E., Baxter, G. D., Dockerty, J. D., & Abbott, J. H.** (2011). A comparison of 3 methodological approaches to defining major clinically important improvement of 4 performance measures in patients with hip osteoarthritis. *Journal of Orthopaedic and Sports Physical Therapy*, *41*(5), 319–327. DOI: <https://doi.org/10.2519/jospt.2011.3515>

How to cite this article: Mierzwicki, JT. (2019). Weighted Vest Training in Community-Dwelling Older Adults: A Randomized, Controlled Pilot Study. *Physical Activity and Health*, *3*(1), pp. 108–116. DOI: <https://doi.org/10.5334/paah.43>

Submitted: 29 July 2019 **Accepted:** 08 September 2019 **Published:** 25 October 2019

Copyright: © 2019 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.

 *Physical Activity and Health* is a peer-reviewed open access journal published by Ubiquity Press.

OPEN ACCESS 