EARLY ADAPTATIONS TO ECCENTRIC AND HIGH-VELOCITY TRAINING ON STRENGTH AND FUNCTIONAL PERFORMANCE IN COMMUNITY-DWELLING OLDER ADULTS

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ABSTRACT
Leszczak, TJ, Olson, JM, Stafford, J, and Di Brezzo, R. Early adaptations to eccentric and high-velocity training on strength and functional performance in community-dwelling older adults. J Strength Cond Res 27(2): 442–448, 2013—The authors examined whether an eccentric training program or a high-velocity training program was more beneficial in regards to function and strength. Nineteen community-dwelling older adults, between the ages of 65 and 89 years, from a local senior center participated in the 8-week exercise program. All participants were randomly assigned to either an eccentric or a high-velocity training group. A doubly multivariate analysis of variance with 1 between-subjects factor and repeated measures was used to examine group and time differences. This analysis revealed that no differences existed between the groups (p > 0.05). However, there were within-group differences for both the high-velocity and the eccentric groups. For both groups, walking speed, 8-ft up-and-go time, chair stand, leg extension strength, leg curl strength, and leg press strength increased from preintervention to postintervention (p < 0.05). This suggests that a high-velocity training program provides similar results as an eccentric training program but with less total work. The eccentric training group trained at a higher percentage of their 1RM and tested with higher loads, which suggests that a longer exercise program would show the eccentric training group to be stronger and more functional. Fitness practitioners dealing with an older adult population should focus on training with all types of training velocities. Not only are these types of training modalities safe for this population but they also can improve their ability to perform activities of daily living.

KEY WORDS aging, elderly, eccentric resistance training, high-velocity resistance training, exercise

INTRODUCTION
Functional status (i.e., ability to perform activities of daily living [ADLs]) will decline with age, which will negatively affect the way an older adult can perform ADLs. The decrease in tasks such as dressing and undressing, functional transfers, and toileting (to name a few) are vital to the independency of our older adult population. Exercise programs have shown to increase muscular strength and power, which are important components for improving functional status in this population; however, the most effective training techniques are unknown.

High-velocity resistance training is a type of training program that focuses on the concentric velocity of movement. The prescribed movement velocity is to perform the concentric portion as fast as possible (23), followed by a 2- to 3-second eccentric phase. When compared with traditional strength training, this will decrease the overall work that an individual has to perform while still attaining the normal muscular adaptations that occur with resistive exercise. The literature suggests that high-velocity resistance training is a more advantageous way to improve physical performance and functional measures, and reduce the risk of disablment in older adults (2,3,5–7,9,11–13,19,20,23). Research by Sayers et al. (25) suggests that the velocity component of the movement is a better predictor of performance than the resistance, which is very important as it relates to the older adult population. In fact, research by Bean et al. (3) found that leg power predicted 15–30% of the variance in physical performance of older adults, especially as it relates to stair climb time, chair stand time, tandem gait, and habitual gait. Others suggest that a high-velocity program will increase muscular power more than a traditional training program...
Eccentric training is another type of exercise program that has shown to be beneficial. Increased interest in eccentric training stems from findings that eccentric actions create different neural responses than do concentric actions (8). Muscles are also able to produce greater absolute force contracting eccentrically than concentrically (26). A meta-analysis of studies comparing eccentric and concentric (traditional) training by Roig et al. (22) found that eccentric training produces greater absolute and eccentric strength gains if the training is performed at a high intensity.

Research by LaStayo et al. (16) showed that an eccentric training program was tolerable and also improved measures of function and strength in a group of older adults. This particular research compared an eccentric-only training program to a concentric/eccentric training program completed over 11 weeks. The results indicated that strength, timed up and go, and stair descent were significant between groups (16), with the eccentric-only group also experiencing significant changes in strength, fiber area, timed up and go, and balance (16). Similar to LaStayo et al. (16), Marcus et al. (18) found that an eccentric training program improved quadriceps strength and 6-minute walk distance in a group of postmenopausal women. These results indicate that the strength and function of older adults can improve using an eccentric training program; more importantly, as the authors mention, this program was performed with low levels of exertion (18).

Numerous studies have indicated eccentric and high-velocity training programs to be beneficial for older adults. Eccentric training is important for improving force output and increasing muscular strength—factors that are important in performing ADLs—whereas high-velocity training can improve function and strength. Although there are several studies that have tested eccentric and high-velocity training separately on measures of strength and function, to our knowledge there are no studies comparing the 2 types of programs in the older adult population. Research suggests that the total work performed using high-velocity training is less than eccentric training; therefore, the purpose of this study was to compare an eccentric training program and a high-velocity resistance training program on measures of strength and function in community-dwelling older adults. We hypothesized that the eccentric training group would improve significantly more on measures of strength than the high-velocity group. We also hypothesized that the high-velocity group would improve significantly more on measures of function compared with the eccentric group.

**METHODS**

**Experimental Approach to the Problem**
The goal of this study was to compare an 8-week eccentric training program and a high-velocity training program to examine early adaptations and see if differences existed between the 2 groups on measures of strength and function in community-dwelling older adults. These data were analyzed using a doubly multivariate analysis of variance (MANOVA) to determine whether improvements occurred over time and to see if there were significant differences between the groups. All participants were involved in a 3-day-per-week exercise program where estimated IRM strength testing occurred on the Monday of each week to keep progressions consistent with the prescribed exercise intensity. Testing for strength and function occurred at the beginning and end of the intervention to see if changes occurred over time. The dependent variables in the study consisted of maximal walking speed, 8-ft up-and-go time, chair stand, seated leg press strength, seated leg extension strength, and seated leg curl strength.

**Subjects**
A total of 21 older adults over the age of 65 years (age 65–89 years) were recruited through flyers and word of mouth from a community wellness center located in Northwest Arkansas. From that sample, a total of 19 older adults (age 74.89 ± 8.50 years) consented to the research project.

Table 1 shows baseline results indicating that the 2 groups (eccentric and high velocity trained) were similar before the intervention started. The 2 individuals who did not complete the program dropped out because of personal issues, resulting in 19 of 24 completed sessions and a 90% adherence rate. All testing and training protocols were approved by the University of Arkansas Institutional Review Board, and participants were briefed as to any risks or benefits involved in the project before giving written informed consent.

All participants were randomly assigned to an eccentrically trained group (5 women and 5 men) or a high-velocity trained group (6 women and 3 men). All participants were screened to ensure they were not categorized as high risk per the American College of Sports Medicine. Exclusion criteria included the following: (a) younger than 65 years; (b) known cardiovascular, metabolic, pulmonary, or musculoskeletal disease; (c) any known factors that would limit them from exercise; (d) currently engaged in a strenuous lower-body exercise routine, and (e) not willing to participate in the exercise program 3 times per week. The participants were currently active and participated in some type of an exercise program ranging from walking 2 miles per day, to playing pool, to performing low-intensity resistance training. All participants had limited knowledge of exercise programming and, at the time, did not follow a defined exercise prescription. During the research project, all participants were told to refrain from lower-extremity exercises other than the 3 exercises in the program.

**Procedures**

*Testing.* Estimated IRM strength testing on seated leg press, seated leg extension, and seated leg curl took place on
### Table 1. Baseline descriptive statistics.*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Eccentric group (n = 10)</th>
<th>High-velocity group (n = 9)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>75.60 ± 8.01</td>
<td>74.11 ± 8.49</td>
<td>0.52</td>
</tr>
<tr>
<td>Height (in.)</td>
<td>66.33 ± 3.48</td>
<td>66.00 ± 3.27</td>
<td>0.84</td>
</tr>
<tr>
<td>Weight (lb)</td>
<td>187.76 ± 45.99</td>
<td>151.49 ± 30.91</td>
<td>0.06</td>
</tr>
<tr>
<td>Gait (a)</td>
<td>4.53 ± 0.77</td>
<td>4.42 ± 0.56</td>
<td>0.74</td>
</tr>
<tr>
<td>8-ft up and go (s)</td>
<td>5.86 ± 0.99</td>
<td>5.78 ± 0.96</td>
<td>0.87</td>
</tr>
<tr>
<td>Chair stand (number completed)</td>
<td>13.8 ± 4.16</td>
<td>14.78 ± 3.86</td>
<td>0.60</td>
</tr>
<tr>
<td>Leg extension strength (lb)</td>
<td>64.40 ± 26.64</td>
<td>58.22 ± 17.33</td>
<td>0.56</td>
</tr>
<tr>
<td>Leg curl strength (lb)</td>
<td>83.80 ± 34.79</td>
<td>67.11 ± 13.50</td>
<td>0.19</td>
</tr>
<tr>
<td>Leg press strength (lb)</td>
<td>362.40 ± 129.37</td>
<td>292.33 ± 111.15</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*Data are expressed as mean ± SD.

The 8-ft up-and-go test was used to test agility and is part of the Senior Fitness Test protocol (21). The equipment used for this test was a cushioned chair with a 16-in. seat height and a cone that was placed 8 ft from the front leg of the chair. Each participant was told to sit in the middle of the chair with his or her hands on thighs and one foot slightly ahead of the other, body leaning forward. There were 3 trials, with the first being practice and then the fastest of the second and third was used for data collection. The test administrator showed each participant how to perform the test before it started so they knew exactly how they were supposed to walk around the cone. Upon starting the test, the administrator used the phrase, “ready, set, go” and on the word “go” the participants started. They were instructed to walk as fast and carefully around the cone as possible (21). Each participant performed the test 2 times and the best time was kept for data analysis. This test is reliable with a test-retest reliability of $R = 0.95$ (21).

The chair stand test was used to test leg strength and is also part of the Senior Fitness Test protocol (21). It was administered using a 16-in. chair without arms and was placed against a wall to prevent movement. Participants were told to sit in the middle of the chair, feet flat on the floor, hips and knees flexed at 90°, and arms across the chest in the cross pattern. The test started when the tester said “go” and the participants were told to perform as many chair stands as possible within 30 seconds. A complete chair stand was considered standing to the erect position with body straight and then sitting back down (21). A practice trial was given to ensure proper form. The total number of stands completed was the outcome measure used for this test, and participants only completed 1 trial. This test is a reliable measure with a test-retest reliability of $R = 0.89$ (14).

The estimated 1RM test was used to measure strength throughout the 8-week exercise program. Every Monday, each participant was tested on the seated leg press, seated leg extension, and seated leg curl. The purpose of this test was to measure strength at the beginning of the week to calculate the correct resistance for the Wednesday and Friday workout sessions. This was done so each person was able to have a progressive overload each week. The equipment used to obtain these values for testing and training purposes was the Keiser AIR250 line (Keiser Corporation, Fresno, CA, USA). For each of the tests, the subject was positioned comfortably in the equipment and the estimated 1RM value was obtained by progressively increasing the resistance until he or she reached a repetition value between 3 and 12 repetitions. The weight value and the number of repetitions were then used in
The participants were educated on muscle soreness with this type of exercise training; therefore, before and after each training session, they were encouraged to perform a light aerobic activity (e.g., walk) for 5–10 minutes around an indoor track as a warm-up and cool-down. Each training session was ~15 minutes excluding the warm-up and cool-down. Training sessions were at least 48 hours apart.

### Statistical Analyses

Data were analyzed using SAS 9.2 statistical software (SAS Institute, Inc., Cary, NC, USA). At preintervention, all data were analyzed to ensure a normal distribution and to identify any outliers that would skew the normality of that data set. The test statistic used was the Shapiro-Wilk goodness-of-fit test (W-statistics, \( p > 0.05 \)). At post-intervention, the same data were analyzed to see if the dependent variables improved after the exercise intervention. A doubly MANOVA with 1 between-subjects factor and repeated measures was used. This analysis was chosen because it examined group and time differences on the dependent variables, strength and function. Post hoc analyses were performed using a series of 1-way analyses of variance to see where differences existed on each of the individual dependent variables. Significance was set at \( p < 0.05 \), and data were reported as mean ± SD.

### RESULTS

At preintervention, there were no significant differences between the groups that would signify outliers to the data set (\( p > 0.05 \)). The results of the MANOVA indicate a significant overall effect, \( F(6, 12) = 625.13, p < 0.001 \). Follow-up analysis indicates that the time-by-training-group interaction was not significant, \( F(6, 12) = 0.41, p = 0.86 \). Additionally, no training group effect was found, \( F(6, 12) = 0.99, p = 0.47 \). However, the influence of time was significant, \( F(6, 12) = 11.52, p < 0.001 \).
Early Adaptations to Eccentric and High-Velocity Training

The finding that there was no training group effect is important because it means that the 2 groups did not differ on preintervention or postintervention measures. Post hoc analysis of the significant time effect indicates that all the measures of strength and function improved. The combined walking speed for the eccentric and the high-velocity groups at preintervention was 4.47 seconds, and at postintervention it was 4.20 seconds, \( F(1, 17) = 8.10, p = 0.01 \). The 8-ft up-and-go test for the eccentric and the high-velocity groups at preintervention was 5.82 seconds, and at postintervention it was 5.52 seconds, \( F(1, 17) = 6.16, p = 0.02 \). The chair stand variable improved from 14.26 stands at preintervention to 16.61 stands at postintervention, \( F(1, 17) = 14.24, p < 0.01 \). Lastly, the combined amount of weight pushed for the seated leg press at preintervention was 329.21 lb, and at postintervention it was 472.58 lb, \( F(1, 17) = 53.97, p < 0.01 \); the seated leg curl at preintervention was 75.89 lb, and at postintervention it was 100.84 lb, \( F(1, 17) = 42.29, p < 0.01 \); and the seated leg extension at preintervention was 61.47 lb, and at postintervention it was 88.57 lb, \( F(1, 17) = 60.26, p < 0.01 \). Table 2 shows the actual values for each group at postintervention.

**DISCUSSION**

There are 2 important findings from this research. The first is that there were no differences between the 2 groups at posttesting after the exercise interventions, suggesting that neither exercise program was superior to the other. The second was that each group significantly improved on measures of walking velocity, 8-ft up and go, chair stand, leg extension strength, leg curl strength, and leg press strength from their respective exercise programs indicating that both types of exercise training programs are advantageous for an older adult population.

Our first hypothesis was that the eccentric training group would improve significantly more on measures of strength than the high-velocity group. Our research does not support this hypothesis as the groups achieved similar strength gains. Research by Marcus et al. (18) found that postmenopausal women who participated in an eccentric training program were able to improve knee extensor strength more than controls. They found that a 12-week exercise program using a specialized eccentric ergometer could increase knee extensor strength significantly more than in the control group. Our research did not find the eccentric training group to improve strength significantly more than the high-velocity group. This could be because of the fact that our comparison group was exercised (high velocity) trained), as compared with the research by Marcus et al. (18) in which a nonexercised control group was used during the 12-week intervention. The duration of the program being 8 weeks could be another reason that the results are different. Although other research using an 8-week duration found differences between eccentric and concentric training programs on isometric strength (17), our program found similar adaptations for the 2 programs over the same length of time. Therefore, high-velocity and eccentric training programs should be compared over a longer duration to see if eccentric training would improve strength outcomes more than high-velocity training.

The current research used an exercise intensity for the eccentric training group that was 75% of each participant's estimated 1RM, which is in agreement with the research by Krishnathasan and Vandervoort (15) who suggest using an intensity between 70 and 100% of 1RM. We chose the intensity of 75% because the participants were still establishing a base strength level and the program was only 8 weeks long. Although research by Marcus et al. (18) suggests that the external load must be greater than the maximal amount they can move concentrically (which is true for eccentric training), we felt that the participants needed to progress up to 100% of their 1RM. This resistance was also chosen based on the ability of the participant to perform 8–12 repetitions. Furthermore, Krishnathasan and Vandervoort (15) suggest that when older adults perform eccentric movements, they need to have a spotter who can help in moving the resistance safely during the concentric phase (15). Therefore, although we followed the recommendations for eccentric training programs, the intensity that we chose (75%) might have limited our findings causing our eccentric group to have lower strength values than they would have had if they had trained at 100% of estimated 1RM.

Our second hypothesis was that the high-velocity group would perform better on measures of function than the eccentrically trained group, and as the results indicated, there were no significant differences between the groups. Initially, we thought that function would improve in the high-velocity group more than the eccentric group because the velocity at which the participants trained was similar to the velocity of movements on the functional tests. According to Sayers and Gibson (24), lower loads and higher velocity training will mimic functional movements more than other training methods because of the fact that normal functional transfers are usually performed at a lower percentage of 1RM. Although our research used a lower resistance for the high-velocity training group, we did not find differences between the 2 groups. This may be because of the short intervention program (only 8 weeks), although other researchers have used short exercise programs. Research by Henwood and Taaffe (12) found that an 8-week high-velocity training program for older adults improved measures of functional performance and strength when compared with a control group. Similarly, Bottaro et al. (5) found that a 10-week high-velocity exercise program improved measures of functional performance and strength when compared with a traditional strength training program; however, they used a higher resistance (60% of 1RM) as compared with the current study (50% of 1RM). Although the current research did not find differences between the groups, we did find within-group differences indicating that the 2 exercise...
programs improved measures of function and strength, similar to Henwood and Taaffe (12) and Bottaro et al. (5).

**Practical Applications**

It has been well documented that physical activity at any level has many positive effects on the older adult population. Our research compared eccentric and high-velocity training, and although it is important to understand which program is better to improve functional strength and balance, we need to get our older adult population exercising. This research is important because it provides a practical means to exercising with older adults because these types of movements can be used in senior centers, retirement facilities, or personal residences, and it is not necessary to have expensive equipment to move and function at a higher capacity. For example, the same types of movements can be performed using body weight, weighted vests, medicine balls, or ankle weights.

Based on this research, we recommend that both types of exercise (high-velocity training and eccentric training) be incorporated into exercise programs for older adults. Because not all people like to use the same type of resistance training program, these 2 programs provide options to limit burnout and staleness. These training approaches can be used with any muscle group, but we recommend targeting the major muscle groups of the legs for older adults. In this study, the muscles that extend the hip and knee, and those that flex the hip and knee, were the focus; fortunately, these muscle groups can be trained without relying on expensive equipment. For example, if an older adult wanted to exercise these same muscles, he or she can perform 3 specific movements (standing hip flexion, standing hip extension, and chair standing) using a high-velocity or an eccentric training protocol. Repeated chair stand, in particular, is one of the best exercises that an older adult can perform (in the privacy of their home) to mimic functional movements. By using both types of programs, he or she can improve strength while still performing functional movements at a speed similar to that of the ADLs, such as standing up from the couch, walking from the kitchen to the living room, climbing stairs, or getting into and out of a car.

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**References**


