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ORIGINAL ARTICLE

Effects of High- vs. Low-Velocity Dual-Task Resistance Training on Functional Performance in Older Adults

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ABSTRACT
Background. Recent evidence suggests that multi-component exercises, especially those involving a dual-task of both motor and cognitive elements, are superior to single-task methods by concurrently stimulating both skill sets. However, the optimal movement velocity within these dual-task programs remains unclear. **Objectives.** This research aimed to compare the effect of high-velocity dual-task resistance training (HVDRT) and low-velocity dual-task resistance training (LVDRT) on the functional fitness of older adults. **Methods.** Forty-five participants were randomly assigned to HVDRT, LVDRT, or a Control (Con) group (n=15 each). Functional fitness was assessed using the 30-second Chair Stand Test, Arm Curl Test, 6-Minute Walk Test, Chair Sit-and-Reach Test, Back Scratch Test, and 8-Foot Up-and-Go Test. The 8-week training program for HVDRT and LVDRT comprised 24 sessions, each lasting 60–70 minutes. **Results.** Mixed-model ANOVA revealed that both HVDRT and LVDRT had a significant effect compared to the control group on upper body strength, aerobic endurance, and balance and agility ($p < 0.001$). No significant differences were observed in lower body strength, lower body flexibility, and upper body flexibility between groups ($p > 0.05$). Furthermore, HVDRT demonstrated a significantly greater effect on upper body strength compared to LVDRT ($p=0.038$), but no other significant differences were found between the two training velocities. **Conclusion.** Both HVDRT and LVDRT significantly improve specific factors of functional fitness in older adults compared to a control group. While HVDRT led to greater increases in upper body strength, there is no substantial difference between the two training velocities for most functional outcomes. Therefore, trainers can utilize either method to enhance functional fitness in this population, though high-velocity movements may provide additional benefits for specific strength parameters.

INTRODUCTION

The aging population is experiencing a gradual decline in functional fitness (FF), which encompasses various components such as muscular strength, flexibility, balance, agility, gait velocity, and cardiorespiratory fitness (1). Beyond individual health, this decline represents a major socio-economic challenge, with falls accounting for 54% of unintentional injury-related deaths in seniors, costing the healthcare system an estimated $142 billion annually (2). FF is typically defined as the capacity to carry out daily activities without difficulty and serves as a significant independent risk factor for premature mortality (1).

Exercise is widely acknowledged as a robust strategy for enhancing FF in older adults.

However, improvements in strength or aerobic endurance do not always translate to better functional capacity, leaving the optimal exercise mode under debate (3). Emerging evidence suggests that multimodal interventions—particularly dual-task training, which combines cognitive and motor demands—may better simulate real-life scenarios and yield superior functional outcomes (3, 4). Such protocols have demonstrated efficacy in promoting brain activity (e.g., prefrontal cortex engagement), neurogenesis via brain-derived neurotrophic factor (BDNF), and improved neuromuscular coordination (5-7). Dual-task paradigms vary in complexity and energy requirements. While cognitive-motor training involving resistance exercise may place greater demands on neuromuscular control, it also offers enhanced benefits in terms of cognitive engagement and postural responsiveness compared to aerobic or balance training alone (8). Despite these advantages, research on dual-task interventions combining resistance and cognitive components remains limited.

Muscle mass declines by 20–30% between adulthood and old age (9), with a disproportionate reduction in fast-twitch (Type II) fibers due to neuromuscular denervation. Consequently, power declines more rapidly than strength (10, 11). This is of particular concern since muscular power is more closely associated with fall prevention. High-velocity resistance training has been proposed to counteract these deficits by enhancing rapid neuromuscular recruitment and balance control (12, 13). While both high- and low-velocity resistance training can improve strength (14, 15), evidence on their relative effectiveness for functional performance remains inconsistent.

Several studies highlight the efficacy of resistance training in improving functional outcomes such as stair climbing and rising from a chair (16). As emphasized by the National Strength and Conditioning Association, integrating high-velocity protocols into older adults' training regimens may address neuromuscular limitations unresponsive to slower routines (17). Strikingly, despite the well-documented benefits of resistance training—such as improved quality of life, functional independence, and cognitive capacity—only a small proportion of older adults regularly engage in such programs (17). Furthermore, recent studies have reported that dual-task resistance-cognitive interventions outperform resistance-only programs in improving outcomes (18, 19). Nevertheless, despite these initial steps, a significant knowledge gap remains regarding the integration of movement velocity within a concurrent cognitive-motor framework (i.e., performing dual-tasks during the resistance exercise itself) in healthy, community-dwelling older adults (20, 21). While Coelho-Júnior et al. (2021) provided foundational evidence by comparing low-speed versus high-speed resistance training, their work was restricted to frail, institutionalized, and clinical populations with pre-existing multisystem impairments (8).

To date, research comparing the effectiveness of high-speed versus low-speed resistance training (RT) protocols—specifically within a dual-task cognitive-motor framework—remains limited. There remains a distinct need to investigate how these velocity-specific protocols influence broader functional fitness outcomes when performed under dual-task conditions in community-dwelling older adults. Therefore, this study aimed to compare the effect of high- vs. low-velocity dual-task resistance training on functional performance in older adults. Regarding the specific effects of movement velocity on neuromuscular adaptations, it was hypothesized that both HVDRT and LVDRT protocols would lead to significant improvements in functional fitness parameters as assessed by the Senior Fitness Test (SFT). Also, the high-velocity dual-task intervention would show greater improvements compared to the low-velocity regimen.

MATERIALS AND METHODS

Study design. This study utilized a quasi-experimental, three-arm, parallel-group design. Although participants were selected via convenience sampling due to the practical constraints of recruiting community-dwelling older adults, the internal validity of the study was maintained through random allocation.

Participants. Participants were recruited across Neyshabur, Iran, between April 10 and June 18, 2025. Recruitment methods included social media advertisements (Instagram), posters at local health centers, and direct outreach at public offices (e.g., Department of Sports and Youth Affairs, Tax Administration, Department of Education) and community organizations

(Elderly Cohort Center, Senior Centers). The sample size was estimated using G*Power (3.1.9.2) for a repeated-measures ANOVA (within-between interaction). Based on a medium effect size (f = 0.35, eta-squared ≈ 0.11) derived from the comparable studies with alpha = 0.05 and power = 0.80, a minimum of 39 participants was required (22, 23). To account for an anticipated 10% dropout rate, 45 participants were initially enrolled.

Of the 65 initial volunteers, 17 were excluded during screening for not meeting the criteria, and 3 declined participation. Consequently, 45 independently living older adult males (aged 60–75 years) were enrolled. Inclusion criteria required: (a) no contraindications for resistance training, and (b) physician-confirmed physical and cognitive ability to follow instructions. Exclusion criteria included diagnosed musculoskeletal, neurological, or cardiovascular conditions; recent injury-induced movement limitations; use of assistive walking devices; or participation in structured exercise programs within the preceding 6 months. To ensure unbiased distribution, the 45 eligible participants were randomly assigned (1:1:1 ratio) to one of three groups: High-velocity dual-task resistance training (HVDRT, n = 15), Low-velocity dual-task resistance training (LVDRT, n = 15), and a Control Group (Con, n = 15). An independent researcher generated the allocation sequence using computer-based randomization. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes.

Procedures. Following written informed consent, baseline demographic data (age, weight, height via scale and stadiometer), medical history, and physical activity background were collected via structured questionnaires and interviews. Participant characteristics are presented in Table 1. All baseline assessments occurred at the Sib Salamat Corrective Exercise Center (Neyshabur, Iran) across five consecutive days (≤9 participants/day). Prior to testing, participants attended a 45-minute orientation session detailing the study objectives, training program, equipment, exercises, and assessment procedures to ensure familiarity and safety. Functional performance was then assessed using the Senior Fitness Test (SFT) battery. Both high-velocity dual-task resistance training (HVDRT) and low-velocity dual-task resistance training (LVDRT) groups commenced their respective structured dual-task resistance training programs at the Sib Salamat Center. Control Group (Con): Instructed to maintain usual daily activities and refrain from initiating structured exercise. To control for attention and engagement, this group attended weekly 45-minute educational sessions. These sessions covered the benefits of physical activity, general resistance training principles, and safe movement strategies for daily living (e.g., posture awareness, proper lifting/carrying techniques). Critically, these sessions involved no physical exercise instruction or practice beyond basic safety advice. SFTs were conducted following the intervention period.

Measurements. The participants' height was measured using a wall-mounted stadiometer (Seca 222, Terre Haute, IN) and recorded to the nearest 0.5 cm. Their body mass was measured to the nearest 0.1 kg using a digital scale (Tanita, BC-418MA, Tokyo, Japan) (24).

Strength Assessment and 1RM Estimation. To ensure participant safety and mitigate the risk of musculoskeletal injury in the elderly cohort, the 1-repetition maximum (1RM) was indirectly estimated using a standardized 10-repetition maximum (10RM) protocol. Following a dedicated familiarization session, participants performed a specific warm-up consisting of 10 repetitions at a light, self-selected load. The 10RM was then determined through a maximum of five progressive trials, with 3-minute rest intervals between attempts to prevent fatigue-related bias. A successful 10RM was defined as the maximum load lifted for exactly 10 repetitions through a full range of motion with strict technical form. For the exercises (Leg Press, Bench Press, and Lat Pulldown, Leg Extension, and Biceps Curls), the 1RM was calculated using the following equation: Weight Lifted (10RM) ÷ (1.0278 - (0.0278 × 10)) (25). For the seated calf raise, the load is matched to the single-leg leg extension load (26).

Functional Fitness Assessment. We assessed functional performance using the Senior Fitness Test (SFT), a validated, standardized battery specifically designed for adults aged ≥60 years (27). The SFT measures key domains critical for independent living: lower and upper body strength, aerobic endurance, lower and upper body flexibility, and dynamic balance/agility. Its reliability and validity are well-established (28, 29). Participants performed the following tests in a standardized order after familiarization:

30-Second Chair Stand: Assessed lower body strength. Participants sat on a chair (height 43.2 cm), feet shoulder-width apart, arms crossed over the chest. They performed as many full stand-ups as possible within 30 seconds. The score was the total number of correct repetitions.

30-Second Arm Curl: Assessed upper body strength. Participants sat on a chair, holding a dumbbell (men: 4 kg; women: 2.5 kg) in their dominant hand, arm extended. They performed as many controlled bicep curls (full flexion and extension) as possible within 30 seconds. The score was the total number of correct repetitions.

6-Minute Walk Test (6MWT): Assessed aerobic endurance. Participants walked as far as possible around a 45.7-m rectangular course for 6 minutes. Individuals were encouraged to regulate their own pace and were permitted to stop for rest if desired. The score was the total distance walked (m).

Chair Sit-and-Reach: Assessed lower body flexibility. Participants sat on the front edge of a chair, one leg extended straight (knee locked, heel on floor, ankle ~90° dorsiflexion), the other foot flat on the floor. Reaching slowly forward with one hand on top of the other (fingertips aligned), they attempted to touch their toes while keeping the back straight. The distance (cm) from fingertips to toe (negative = short, 0 = touch, positive = beyond) was measured after a 2-second hold.

Back Scratch Test: Assessed upper body flexibility. Participants reached one hand behind the head and down the back, and the other hand behind the back and upwards, attempting to touch fingertips. The distance (cm) between the middle fingers of both hands was measured.

8-Foot Up-and-Go: Assessed dynamic balance, agility, and mobility. Participants rose from a seated position (chair height 43.2 cm), walked as quickly as possible around a cone 2.44 m away, and returned to sit down. The time (s) to complete the task were recorded.

All tests were administered and scored according to Rikli and Jones' (2001) protocols by trained assessors.

Intervention. Based on evidence indicating optimal efficacy for protocols of 1-12 weeks, 3 sessions/week, and 31-60 minutes/session (30), we implemented an 8-week program (3 sessions/week on non-consecutive days; 24 sessions total). Each session lasted 55-65 minutes, including warm-up and cool-down. We selected exercises targeting major upper and lower body muscle groups, informed by their frequent use and demonstrated efficacy in improving strength and muscle mass in older adults (25, 29, 30). The program included: Leg Press (Multi-joint lower body), Leg Extension (Single-joint lower body), Bench Press (Multi-joint upper body), Lat Pulldown (Multi-joint upper body), Biceps Curl (Single-joint upper body), and Seated Calf Raise (Single-joint lower body). It is important to mention that the leg press and leg extension were prioritized due to the pronounced age-related strength loss in the quadriceps (26) and the reduced spinal loading compared to barbell squats (31).

Training volume (Sets × Reps × Load) was equated between the HVDRT and LVDRT groups. Movement velocity was strictly controlled using an audible Android metronome application (32). Progression was managed through weekly increases in training volume (sets × repetitions) as detailed in Table 2. In the HVDRT, participants performed 8 sets of 3-5 repetitions at 70-75% 1RM. The concentric phase was executed as fast as possible (maximal intended velocity), followed by a ~2.5-second eccentric phase. On the other hand, in the LVDRT, participants performed 4 sets of 8-10 repetitions at 70-75% 1RM. Both concentric and eccentric phases lasted ~2.5 seconds each (32, 33). During all sets of all resistance exercises, participants concurrently performed a validated cognitive task: counting backward by threes (34, 35). This task engages working memory, attention, and numerical processing, activating prefrontal and parietal cortical regions critical for executive function (34, 36, 37), and is sensitive to age-related differences in dual-task performance (35). Accordingly, participants were given a random starting number between 300 and 900. They counted backwards aloud by three (e.g., 300, 297, 294...) continuously for 30 seconds during exercise sets. The number of correct subtractions within the 30-second epoch was recorded as the score. Performance was monitored to ensure task engagement without compromising exercise safety or form (37).

Statistical Analysis. Descriptive statistics characterized baseline data for each group, including age, height, weight, and body mass index. Continuous variables were summarized using means and standard deviations (M ± SD). The Shapiro-Wilk test assessed the normality of the distribution. Primary analyses compared variable means across groups and time points using mixed-model ANOVA, supplemented by one-way ANOVA, dependent t-tests, and Bonferroni-adjusted post-hoc tests where appropriate. Statistical significance was set at *p* ≤ 0.05 for all inferential tests. Analyses were performed in SPSS (Version 26; IBM Corp.) with supplementary visualization in Excel 2013. All outcome estimates are reported with 95% confidence intervals (CIs).

Table 1. Participants' Characteristics.

Variable	HVDRT (n=15)	LVDRT (n=15)	Con (n=15)	p-value
Age (year)	67.86±3.50	66.40±4.35	68.60±4.51	0.344
Height (m)	1.69±0.06	1.68±0.05	1.66±0.04	0.923
Weight (kg)	83.62±10.14	84.15 ± 9.85	82.35±9.14	0.262
Body mass index (kg / m²)	29.32±3.76	29.35±3.60	29.90±3.72	0.890

Note: Data are presented as Mean ± Standard Deviation (SD). **Con:** Control Group; **HVDRT:** High-Velocity Dual-Task Resistance Training; **LVDRT:** Low-Velocity Dual-Task Resistance Training; **BMI:** Body Mass Index. **p-values** represent the results of the one-way ANOVA for baseline differences.

Table 2. Resistance Training Program Progression in High and Slow Velocity Dual Task Resistance Training Groups (8 Weeks)

Training Group	Load	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
LVDRT	at 70-75% 1RM	1 set, 8 reps	1 set, 8 reps	2 sets, 8 reps	2 sets, 8 reps	3 sets, 8 reps	3 sets, 8 reps	4 sets, 8 reps	4 sets, 8 reps
HVDRT	at 70-75% 1RM	2 sets, 4 reps	2 sets, 4 reps	4 sets, 4 reps	4 sets, 4 reps	6 sets, 4 reps	6 sets, 4 reps	8 sets, 4 reps	8 sets, 4 reps

HVDRT: High-Velocity Dual-Task Resistance Training; **LVDRT:** Low-Velocity Dual-Task Resistance Training; **1RM:** One-Repetition Maximum. Training load was maintained at 70–75% of 1RM for both HVDRT and LVDRT groups.

RESULTS

There were no significant differences in participant characteristics (age, height, weight, body mass index) between the experimental (HVDRT and LVDRT) and control groups ($p > 0.05$). Similarly, baseline comparisons for all measured variables showed no significant inter-group differences ($p > 0.05$), as detailed in Table 1. Figure 2 illustrates the functional performance changes from baseline to the 8-week follow-up across all groups.

Lower limb strength was assessed via a mixed-model ANOVA (time x group). As shown in Fig. 2.a, there was a significant main effect of time ($F(1,42) = 44.488$, $p < 0.001$, partial eta squared = 0.514) and a significant time × group interaction ($F(2,42) = 15.939$, $p < 0.001$, partial eta squared = 0.431). However, the main effect of group did not reach statistical significance ($F(2,42) = 0.669$, $p = 0.518$, partial eta squared = 0.031).

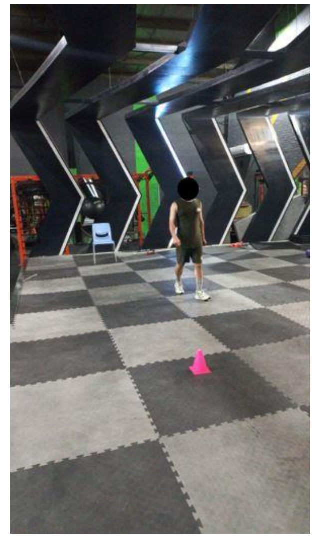
In contrast, lower limb flexibility (Fig. 2.b) showed no significant changes for time ($F(1,42) = 3.521$, $p = 0.068$, partial eta squared = 0.077), group ($F(2,42) = 0.401$, $p = 0.672$, partial eta squared = 0.019), or the time × group interaction ($F(2,42) = 0.025$, $p = 0.975$, partial eta squared = 0.001).

For upper limb strength (Fig. 2.c), the analysis revealed a significant main effect of time ($F(1,42) = 98.263$, $p < 0.001$, partial eta squared = 0.701), and group ($F(2,42) = 7.103$, $p < 0.002$, partial eta squared = 0.253). Additionally, a significant time × group interaction was observed ($F(2,42) = 23.908$, $p < 0.001$, partial eta squared = 0.532), suggesting distinct patterns of upper limb strength changes across groups over time.

Regarding upper limb flexibility (Fig. 2.d), the analysis demonstrated a significant main effect of time ($F(1,42) = 17.291$, $p < 0.001$, partial eta squared = 0.292) and a significant time × group interaction ($F(2,42) = 14.225$, $p < 0.001$, partial eta squared = 0.368). No significant main effect of group was observed ($F(2,42) = 0.060$, $p = 0.941$, partial eta squared = 0.003).

(**a**) Arm Curl Test (reps)

(**b**) Back Scratch Test (cm)



(**c**) 8-Foot Up-and-Go Test (s)

(**d**) 30-Second Chair Stand Test (reps)

(**e**) Chair Sit-and-Reach Test (cm)

Figure 1. Components of the Senior Fitness Test (SFT) battery are used for functional fitness assessment. (a) Arm curl test (measured in repetitions); (b) Back scratch test (measured in centimeters); (c) 8-foot up-and-go test (measured in seconds); (d) 30-second chair stand test (measured in repetitions); (e) Chair sit-and-reach test (measured in centimeters).

Aerobic endurance (Fig. 2.e) revealed a significant main effect of time ($F(1,42) = 74.143$, $p < 0.001$, partial eta squared = 0.638) and a significant time × group interaction ($F(2,42) = 28.942$, $p < 0.001$, partial eta squared = 0.580). The main effect of group remained non-significant ($F(2,42) = 1.501$, $p = 0.235$, partial eta squared = 0.067).

Finally, dynamic balance and agility (Fig. 2.f), exhibited significant effects across all parameters: time ($F(1,42) = 385.666$, $p < 0.001$, $\eta^2p = 0.902$), group ($F(2,42) = 196.894$, $p < 0.001$), partial eta squared = 0.904), and time × group interaction ($F(2,42) = 105.298$, $p < 0.001$, partial eta squared = 0.834).

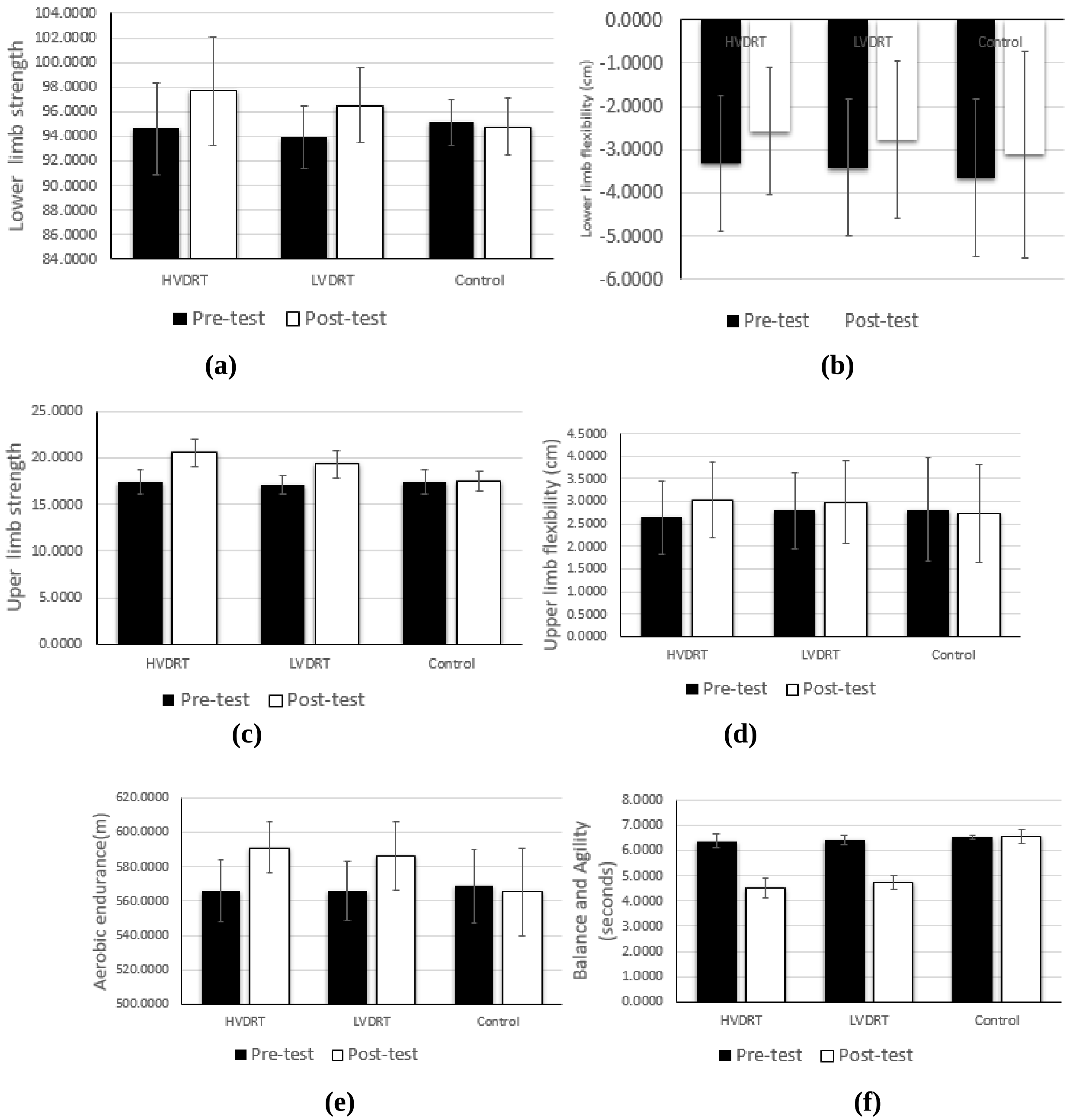


Figure 2. Changes in functional fitness parameters from baseline to 8-week follow-up. (a) Lower limb strength; (b) Lower limb flexibility; (c) Upper limb strength; (d) Upper limb flexibility; (e) Aerobic endurance; (f) Balance and agility. Data are presented as Mean ± SD. **Note:** HVDRT: High-Velocity Dual-Task Resistance Training; LVDRT: Low-Velocity Dual-Task Resistance Training; Con: Control group. $P < 0.05$ denotes statistical significance for time × group interactions. P-values for specific between-group comparisons are reported in the Results section.

DISCUSSION

The present study aimed to compare the effects of high-velocity and low-velocity resistance training combined with a dual task on the functional fitness of older adults. Our results showed that both intervention protocols significantly improved lower extremity power, as evidenced by the 30-second Chair Stand Test, when compared to the sedentary control group. Importantly, while both training velocities were effective in enhancing functional performance, the high-velocity dual task resistance training group exhibited a more pronounced trend in muscle power improvement compared to the traditional low-velocity group. Although the difference between these two training modalities did not reach statistical significance within the 8 weeks, the observed improvements across both protocols highlight the clinical potential of dual-task resistance training for mitigating age-related functional decline (38). This perspective is supported by research from Cadore et al. (2014) and other studies that have emphasized the value of even minor improvements in this population (39). Cadore et al. (2014) specifically demonstrated that 12 weeks of high-speed resistance training enhanced muscle power, strength, and functional outcomes in frail older adults. This suggests that a longer training duration might have yielded statistically significant differences between our groups, a point that should be explored in future research. Conversely, our findings differ from those of Vieira et al. (2021), who reported greater gains with traditional slower-speed training. This discrepancy could be attributed to variations in participant baseline characteristics and the specific nuances of the dual-task training protocols employed in each study (40).

The specific adaptations resulting from high-velocity versus low-velocity training movements are a key point of discussion in the literature. At the same time, the latter is often associated with increases in maximal force production, high-velocity protocols linked to an improved rate of force development (RDF). It is important to note, however, that both modalities have been shown to increase maximal force. For instance, Magtouf et al. (2024) reported that slow resistance training led to a 21% improvement in maximal plantar flexor force, while fast training resulted in a 16% improvement (41). These studies underscore the distinct neuromuscular adaptations that different training speeds can induce. Potential neuromuscular mechanisms for the observed lower extremity power gains, though not directly measured in this study, likely include enhanced protein synthesis, increased muscle cross-sectional area, and improved motor unit recruitment (41, 42). Kryger et al. (2007) reported a 22% increase in type IIa muscle fibers in older adults' knee extensors following resistance training, which was directly linked to improved maximal force production (43). These neuromuscular changes are further translated into functional gains in the work of Cadore et al. (2014), who demonstrated that multi-component programs incorporating muscle power training significantly enhance muscle cross-sectional area and functional performance, such as the ability to rise from a chair and dual-task gait velocity, even in the oldest old (39). High-velocity training, in particular, may stimulate the fast-twitch motor units, which are more susceptible to atrophy with age, thus leading to greater neuromuscular improvements, a hypothesis supported by Magtouf et al. (2024) and others (41, 44). This is particularly relevant given that daily activities like standing from a chair depend more on muscular power, the ability to generate force quickly, than on absolute strength, a point emphasized by Pau et al. (2014) and Tocco et al. (2016) (43, 44). Our study's non-significant but better results in the high-velocity group align with this premise.

A unique aspect of our study is the simultaneous comparison of two resistance training velocities with a dual-task component. While Nascimento et al. (2023) showed that dual-task training improved lower extremity strength in older women, their protocol was different from ours, making direct comparison difficult (44). While our findings contribute to a growing body of literature, they must be contextualized alongside recent investigations into dual-task resistance training. Our work builds upon trials such as those by Baek et al. (2024), who explored the utility of DTRT in cognitively impaired older adults (45). However, direct comparisons remain difficult due to variations in equipment and methodologies. Notably, our study specifically isolates the variable of movement velocity within this framework. By utilizing standardized functional tests to evaluate the difference between HVDRT and LVDRT, we provide a more granular look at how contraction speed influences lower extremity power using a Senior Fitness Test. Our study also found that high-velocity resistance training with dual tasks led to a significantly greater improvement in upper extremity strength compared to the low-velocity group. Strength gains were assessed via a 30-second dumbbell bicep curl test, a method that aligns with the training stimulus and supports the principle of specificity. These findings are consistent with prior research by Cho et al. (2024) and a meta-analysis by Wilk (2021), which emphasize that training adaptations are most pronounced when the assessment method mirrors the training modality (46). Núñez-Cortés et al. (2025) found that both traditional and dual-task resistance training improved elbow strength, with the dual-task group experiencing even greater gains and reduced fear of movement. This suggests that the dual-task component may act as a distraction technique, lowering perceived exertion and leading to higher strength gains (47). However, the exact impact of movement speed on strength gains remains debated, as highlighted by Davies et al. (2017) and others, with inconsistent findings across studies (48, 49). Our novel approach, using the same training load (70-75% of 1RM) for both speed groups, allowed for a more accurate comparison than many previous studies where load varied with speed. The specific training tempo—the fastest possible concentric phase combined with a 2.5-second eccentric phase—provides novel data that contrasts with the results of some prior studies, which found no significant difference in strength gains between varying tempos. This suggests that the effect of speed on strength may be highly dependent on the specific training protocol and that fast-speed training offers a superior neuromuscular stimulus, an observation consistent with ACSM recommendations for strength development (50). Both training programs led to a significant improvement in aerobic capacity, a notable finding given that this benefit is often exclusively attributed to traditional aerobic exercise (51). Although no significant difference was observed between the two training speeds, the improvements, a 4.42% increase in the fast group and a 3.56% increase in the slow group, are clinically significant. This is particularly important because aerobic capacity declines with age, and even a 1 $mL \cdot kg^{-1} \cdot min^{-1}$ increase in VO2max can substantially reduce the risk of cardiovascular events (52). Our results are consistent with previous studies by Todde et al. (2016) and Cho et al. (2024), which also found that resistance training alone can enhance aerobic capacity (52, 53). The present study's innovative approach lies in its focus on dual-task resistance training, a method that has been less explored for enhancing aerobic capacity compared to combined or multi-component training programs. The improvements observed in both groups suggest that the intensity of resistance training, rather than the movement tempo, is the primary driver of the cardiovascular and pulmonary adaptations that enhance aerobic capacity. This conclusion is supported by the work of Keeler et al. (2001), who also found no difference in aerobic capacity gains between slow and very slow resistance training (54). While our use of the 6-Minute Walk Test (6MWT) as a predictive measure of VO2max is a limitation compared to direct measurements, it is a clinically valid and functional assessment for this population (r=0.71). The fact that both training speeds yielded similar improvements in aerobic capacity suggests that practitioners and older adults can choose either protocol to achieve meaningful enhancements in aerobic capacity, supporting overall health and functional independence in daily living.

In contrast to our hypothesis, neither high-velocity (HVDRT) nor low-velocity (LVDRT) protocols had a significant effect on lower or upper extremity flexibility. This contradicts some studies that report flexibility improvements with resistance training, especially when performed through a full range of motion (55). A comprehensive meta-analysis by Alizadeh et al. (2023) confirmed that resistance training can improve joint range of motion, but other factors like training intensity and duration play a crucial role. Our study's duration (eight weeks) may have been too short to induce the necessary structural changes in muscle and connective tissues. Noronha et al. (2022), for instance, found flexibility improvements after 14 weeks of training (14). The principle of training specificity may also be a factor, as resistance training does not directly replicate dedicated stretching.

Furthermore, the use of the Senior Fitness Test (SFT) for flexibility, while functional, may not be as sensitive as tools like goniometers, potentially limiting our ability to detect small changes. Conceptually, this lack of improvement may also be explained by the distinction between exercise modes; as Netz (2019) characterizes, resistance training is a physical/metabolic activity, whereas flexibility is classified as a motor activity involving different neuromuscular demands (8) because our intervention did not include dedicated motor-stretching components, the mechanical loading of the RT likely served as an indirect stimulus that failed to exceed the functional muscle length already maintained by daily activities (56). This highlights the importance of incorporating targeted stretching into exercise programs alongside resistance training.

Both HVDRT and LVDRT resulted in a significant improvement in agility and dynamic balance, measured by the 8-Foot Up-and-Go test, compared to the control group. This improvement was 29% for the high-velocity group and 26% for the low-velocity group, with no significant difference between the two. These findings are consistent with Romero-Arenas et al. (2022), who also demonstrated the effectiveness of resistance training in improving TUG test performance in older women (57), and with Hess et al. (2005), who reported a 15.7% improvement in TUG time in older adults following high-intensity training (58). The improvements in agility and balance can likely be attributed to enhanced neuromuscular mechanisms such as improved force production and spatiotemporal awareness, which are crucial for maintaining balance and mobility during daily tasks. The observed reduction in TUG time, a strong predictor of fall risk (59), suggests that this type of training can play a critical role in preventing falls. Given that fall risk is a major health concern for older adults (60), the significant improvements in agility and balance in both training groups underscore the clinical utility of these exercises. Like any research, the present study is not without its limitations. First, the relatively small sample size (n=45) may limit the broader application of the results.

In contrast, the sample size was calculated based on a medium effect size for the primary outcomes; we acknowledge that the study may lack sufficient statistical power for robust subgroup analyses or to detect subtle differences between the two training interventions. Second, the quasi-experimental design of the study, despite our efforts to control for variables, may introduce potential selection or assignment biases that could affect the internal validity. Third, this study was conducted exclusively on older adult males; therefore, the findings may not be fully generalizable to older women due to physiological and hormonal differences. Third, although the Senior Fitness Test (SFT) is a clinically valid and functional tool, it may lack the sensitivity of laboratory-based instruments, such as goniometers for flexibility or automated metabolic carts for precise cardiopulmonary assessment, to detect minor physiological changes. Finally, the eight-week duration of the intervention, while sufficient for initial neuromuscular adaptations, might have been too short to induce significant structural changes in connective tissues or show clear differences between training velocities in all functional parameters. Future multi-center studies with larger, mixed-gender cohorts and longer follow-up periods are recommended to elucidate these effects further.

CONCLUSION

Overall, the integration of dual-task challenges into resistance training, regardless of movement velocity, provides a practical strategy for enhancing the functional fitness of older adults. While both modalities effectively improved physical fitness parameters, the observed trends suggest that high-velocity training may elicit more favorable functional adaptations. However, the negligible impact of either modality on flexibility suggests that stretching remains a necessary component of comprehensive senior fitness programs. These findings emphasize the clinical value of multi-component training regimens, though further longitudinal investigations are required to understand the underlying mechanisms and optimize these interventions for the aging population.

APPLICABLE REMARKS

- Velocity-Specific Programming: Coaches and clinicians should consider high-velocity dual-task resistance training (HVDRT) as a potentially more effective modality for specifically targeting upper-body strength compared to traditional slow-velocity methods in older adults.
- Time-Efficient Multimodal Benefits: Both high- and low-velocity dual-task resistance training can be effectively used to improve aerobic capacity and dynamic balance. This allows practitioners to design time-efficient programs that address cardiovascular health and fall prevention simultaneously without needing separate aerobic sessions.
- Fall Risk Mitigation: Integrating dual-task elements (combining cognitive challenges with resistance exercise) is highly recommended for improving performance in mobility tasks such as the 8-Foot Up-and-Go test. This is a critical practical consideration for therapists focused on enhancing spatiotemporal awareness and reducing fall risk in the elderly population.

- Prescription for Power: To address the age-related decline in Type II muscle fibers and lower extremity power, trainers should emphasize the fastest possible concentric phase during dual-task resistance exercises. Even when statistical significance is not reached, this approach may offer meaningful clinical advantages for essential activities of daily living, such as rising from a chair.
- Need for Supplemental Flexibility: As dual-task resistance training at varying velocities did not significantly improve upper or lower body flexibility, it is essential to prescribe targeted stretching protocols alongside these programs to ensure a comprehensive improvement in overall functional fitness.
- Clinical Implementation: Healthcare providers can utilize dual-task resistance training as a "distraction technique" to potentially lower perceived exertion and fear of movement in older adults, thereby increasing adherence to high-intensity strength protocols (70-75% 1RM).

AUTHORS' CONTRIBUTIONS

Study concept and design: J. Harati; H. Daneshmandi. Acquisition of data: J. Harati. Analysis and interpretation of data: J. Harati; H. Daneshmandi. Drafting of the manuscript: J. Harati. Critical revision of the manuscript for important intellectual content: J. Harati; H. Daneshmandi. Statistical analysis: J. Harati; H. Daneshmandi. Administrative, technical, and material support: J. Harati. Study supervision: H. Daneshmandi.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to this research.

FINANCIAL DISCLOSURE

All authors confirm that they have no financial relationships with any commercial entity that could potentially bias the results of this study.

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ETHICAL CONSIDERATION

The study received ethical approval from the Human Research Ethics Committee of the University of Guilan, Iran (Approval Code: IR.GUILAN.REC.1403.144; Date: 2024-10-21). All procedures strictly adhered to the ethical principles of the Declaration of Helsinki.

ROLE OF THE SPONSOR

As no external funding was received, no sponsor had any role in the study design, data collection, analysis, interpretation of data, writing of the report, or the decision to submit the paper for publication.

ARTIFICIAL INTELLIGENCE (AI) USE

The authors declare that no artificial intelligence (AI) tools were used in the creation of this research or the preparation of the manuscript.

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