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ORIGINAL RESEARCH

Efficacy of an 8-Week Resistance Training Program in Older Adults: A Randomized Controlled Trial

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Older adults are challenged with aging-related declines in skeletal muscle mass and function. Although exercise interventions of longer duration typically yield larger changes, shorter-term interventions may kick-start positive effects, allowing participants to begin engaging in more activity. This study aimed to determine whether 8 weeks of a resistance training program (Stay Strong, Stay Healthy [SSSH]) improved dynamic muscle strength, balance, flexibility, and sleep. Inactive adults aged ≥60 years were randomized into SSSH ($n = 15$), walking (WALK; $n = 17$), or control (CON; $n = 14$) groups. The SSSH and WALK groups met 2 times per week for 60 min. The participants completed pre/post general health, activity, and sleep questionnaires; DXA scans; and functional tasks. One-way repeated-measures multivariate analysis of variance was used to determine interactions and decomposed using repeated-measures analysis of variance. SSSH improved sit-to-stand performance, back scratch distance, and sleep quality and reported more auxiliary physical activity than WALK or CON ($p < .05$). Resistance training interventions in sedentary older adults can improve physical function and encourage additional activity in 8 weeks.

Keywords: dynamic balance, elderly, muscle strength

The aging process, with and without the presence of chronic disease, is marked by a decline in the mass, quality, and overall function of skeletal muscle (Fragala et al., 2019). Interventions aimed at increasing the physical fitness of older adults should address factors such as physical inactivity, sarcopenia, dynapenia, dynamic balance and coordination, and impaired sleep quality. The National Strength and Conditioning Association's position statement supports the efficacy and safety of resistance training/strength training (RT) programs for combating physiological vulnerabilities associated with advanced aging (Fragala et al., 2019). RT programs tailored specifically for older adults can increase muscle mass and strength (Guizelini, de Aguiar, Denadai, Caputo, & Greco, 2018); improve bone density; reduce the risk of osteoporosis and related fractures (Foster & Armstrong, 2018; Giangregorio et al., 2014); improve diabetes, heart disease, arthritis, and obesity (Beavers et al., 2018); and increase self-confidence (Dionigi, 2007) and sleep quality (Singh et al., 2005; Yang, Ho, Chen, & Chien, 2012). Successful community exercise interventions must target these factors, with the primary aim of simultaneously improving as many outcomes as possible in the shortest period of time.

The frequency and duration of exercise sessions, as well as the minimum duration of the program, are important aspects to consider in exercise interventions in older adults. The ideal frequency for RT to combat muscle atrophy and improve muscle strength in older adults is 2–3 times per week (Fragala et al., 2019). The most beneficial program duration in weeks, however, can be difficult to characterize, as the rate of improvement is influenced by a variety of factors, such as previous activity levels, health status, and program adherence (Borde, Hortobágyi, & Granacher, 2015; Bray, Smart, Jakobi, & Jones, 2016). Many successful, progressive RT programs exist that target older adults, such as Growing Stronger (Seguin, Epping, Buchner, Bloch, & Nelson, 2002), Fit and Strong (Hughes et al., 2004), Geri-Fit (Goble, Hearn, & Baweja, 2017), and the StrongWomen program (Seguin et al., 2008). These 12-week programs often meet two times per week and have been shown to improve muscle strength (Nelson et al., 1994; Seguin et al., 2002) and balance (Goble et al., 2017) in adults over the age of 60 years (Goble et al., 2017). In 2005, the Stay Strong, Stay Healthy (SSSH) program expanded the StrongWomen RT curriculum to include both men and women and shortened it to 10 weeks. Despite being 2 weeks shorter, the SSSH program was shown to increase older adults' dynamic movement performance and flexibility (Ball et al., 2013) and their confidence in their physical strength and balance (Syed-Abdul, Peterson, Mills-Gray, Parks, & Ball, 2016). In an effort to provide the most beneficial results to older adults in the least amount of time, an 8-week, two-times-per-week SSSH program has recently been developed. Although other RT interventions lasting only 8 weeks in duration have reported less consistent results (Lee, Kim, Seo, Kim, & Yoon, 2015; Martins et al., 2015), the benefits of a shorter-duration program with the ability to kick-start a more active lifestyle for previously sedentary older adults is desirable.

The primary aim of this study was to determine whether, and to what extent, positive adaptations to older adults' lower body dynamic strength, coordination, balance, flexibility, and sleep quality would result from 8 weeks of SSSH participation and if these results differed from an exercise duration-matched control and a sedentary control (CON) group. We hypothesized that the SSSH group would experience a greater degree of improvement in lower body dynamic strength, coordination, balance, flexibility, and sleep quality measures compared with both the exercise duration-matched control and the CON group.

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Methods

Research Design

This randomized controlled trial (NCT03990415) was conducted between June and October of 2019. This study was approved by the University of Missouri Institutional Review Board (IRB#2014256) and was conducted in accordance with the Declaration of Helsinki. The trial design, implementation, and reporting used CONSORT principles and guidelines (Schulz, Altman, Moher, & The CONSORT Group, 2010). The participants met with our research team twice prior to the intervention and once after the intervention for testing. During the first visit, all participants provided informed consent, completed initial questionnaires, and became familiarized with all testing techniques. The second and third visits marked the beginning and end of the 8-week intervention period and included a body composition assessment, additional questionnaires, and balance and physical performance testing. The participants were randomized into three groups, SSSH, walking (WALK), and sedentary control (CON), by the project director, using a computer-generated randomization stratified by sex. The rest of the research team was blinded to the participant group assignment throughout all testing procedures and statistical analyses. Trained SSSH program staff who were independent of the research study led both the SSSH and WALK classes. The inclusion criteria were being ≥60 years of age, sedentary (no strength training and <30 min per week of other structured exercise), independently ambulatory (canes and walkers permitted), and free from physical injury or illness preventing physical activity (PA). The exclusion criteria were answering yes to two or more questions on the PA Readiness Questionnaire (Thomas, Reading, & Shephard, 1992), female subjects who had not fully gone through menopause (self-reported), previous participation in the SSSH program, and having dementia/Alzheimer's or other cognitive impairments that would limit one's ability to safely follow directions.

Participants

A total of 126 older adults from Boone County, MO, were screened for participation (Figure 1). Sixty recruits met all inclusion and exclusion criteria. Of the 60 participants who consented, 14 were excluded for the following reasons: general voluntary termination ($n = 5$), voluntary termination due to CON group assignment ($n = 3$), underlying cognitive impairments ($n = 2$), unexpected surgical procedures ($n = 2$), engagement in structured RT ($n = 1$), and poor compliance ($n = 1$). A total of 46 participants were included in the analysis (SSSH: $n = 15$, WALK: $n = 17$, CON: $n = 14$; Figure 1). The sample of those who completed the study was 76% female, and the ages ranged from 60 to 86 years.

Intervention Arms

The SSSH group engaged in 8 weeks of strength training, which consisted of 16 sessions, meeting twice weekly for 60 min. Each session began with a warm-up period lasting as long as 9 min. Warm-ups included 3–5 min of aerobic exercises, such as marching, walking, sidesteps, and quarter squats, and 2–4 min of dynamic and static stretching of the major muscle groups in the lower and upper body. The warm-up was followed by four standing exercises and four seated exercises. The standing exercises were a wide-leg squat with dumbbells and leg curls, glute extension, and toe stand with ankle weights. The sitting exercises were biceps curl, overhead press, and bent-over seated row with dumbbells and knee

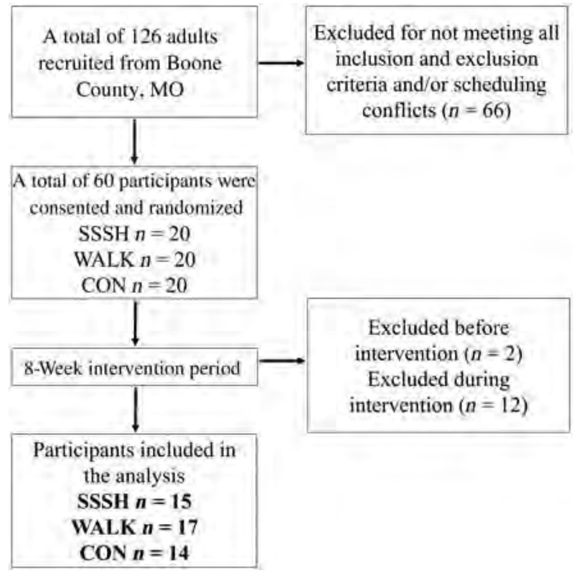

Figure 1 — Participant selection and assignment flow chart. SSSH = Stay Strong, Stay Healthy group; WALK = walking group; CON = control group.

extension with ankle weights. All exercises were performed using a 2:4-s tempo of concentric-to-eccentric muscle action. The classes ended with a 5-min cool-down period, including light stretching and breathing exercises. All classes were taught by trained SSSH instructors who provided progression and specificity for each participant over time. Since all participants had started the intervention sedentary, the first three classes did not utilize weights, and more time was spent on completing the movements safely, with proper technique, through a full range of motion. During these first classes 1×5, 2×5, and 2×6 sets and repetition ranges were utilized. Classes 4–6 aimed for completion of 2×6, 2×8, and 2×10 sets, and repetition ranges allowed for participants to begin using ankle and dumbbell weights, ranging from 0.2 to 1.5 kg and from 0.5 to 5.5 kg, respectively. Classes 7–16 focused on full range of motion, safe but challenging completion of all sets and repetitions, and progression of weights when deemed appropriate by instructors. To ensure progression, rest periods for side-specific exercises were reduced 50% by Class 11, 13, and 15 were marked with movement modifications to increase difficulty. For instance, when performing the wide-leg squat, the instructors might encourage the participants to not use assisted devices for balance, increases in dumbbell weight, and increased depth of the wide-leg squat. At 4 weeks, the average weight increase was 62% for lower body movements and 82% for upper body movements. By 8 weeks, the average weight increase was 102% for the lower body movements and 121% for the upper body movements. The SSSH participants were asked to refrain from any strength training or other forms of structured exercise outside of the designated SSSH classes.

The participants in the exercise duration-matched WALK group met two times per week for 60 min and were asked to refrain from any strength training or other forms of structured exercise outside of the designated walking group. Each walking class was taught by trained instructors who led a 5-min light stretching period; 50 min of walking on level, firm ground, at a self-selected pace; and a 5-min cool-down period. The instructors for both the SSSH and WALK groups recorded participant attendance. The participants in the CON group were asked to refrain from any strength training or structured forms of exercise for the duration of the study.

Questionnaires and DXA

All participants completed questionnaires and dual-energy X-ray absorptiometry (DXA) scans pre- and postintervention. An in-house general health survey that included questions regarding health, medication use, PA habits, and falls was completed. PA habits were determined by assessing the reported minutes per week of structured strength, aerobic, flexibility, and balance exercises. Similarly, the minutes per week of the auxiliary activities, such as home chores, cleaning, gardening, running errands, or taking care of a spouse or pet were also characterized. These data were used to ensure the sedentary activity levels, defined as no strength training, and less than 30 min per week of structured aerobic, flexibility, or balance exercises in the past 3 months. The Pittsburgh Sleep Quality Index (PSQI) survey was administered, with scores ranging from 0 to 21 and scores greater than 5 indicating poor sleep quality (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The Self-Administered Gerocognitive Examination (SAGE) was also administered, with scores ranging from 0 to 22, and scores above 17 indicating normal cognitive abilities (Scharre et al., 2010). A total fear of falling score was calculated based on a participant's self-reported ratings of fear of falling during seven daily activities (e.g., taking a bath or shower, using the stairs).

The DXA (Hologic, Horizon A, Apex Software, version 5.6.0.5; Hologic Inc., Marlborough, MA) was used to measure whole-body composition. Measures of total fat mass (FM; in grams), percentage of fat mass (%FM), and bone-free lean body mass (LM; in grams) were obtained from the whole-body scan and used to calculate the LM to FM ratio (LM:FM). For the total body scan, the participants laid supine on the DXA table, centered within the scan field. The hands were placed on the sides of the legs, while the legs were straight and strapped together according to protocol. In our laboratory, the coefficient of variation percentage for all body composition variables ranges from 0.92% to 1.02%. The same qualified, trained technician performed all quality assurance tests, scans, and analyses for each DXA measurement.

Physical Performance and Balance

All participants completed seven physical performance and balance tests pre- and postintervention. The 10-m walk test (10MWT) was used to calculate preferred gait speed (in meters per second). The 8-ft timed up and go (TUG) was used as an overall dynamic assessment of balance, gait speed, and coordination. The mean grip strength (Jamar hand grip dynamometer; Patterson Instruments, Warrenville, IL), upper body flexibility using the back scratch test (BS), and lower body flexibility using the seated sit and reach (SnR) test were also tested. These tasks were completed three times and averaged. The same trained and qualified research team member administered all tests, and their interclass coefficient ranged from 0.948 to 0.967 over separate days of testing. Additionally, the 30-s sit-to-stand test (30STS), Center for Disease Control (CDC) four-stage balance test (STEADI: Stopping Elderly Accidents, Deaths, and Injuries, 2017), and a 10-s period of quiet standing were completed on two Pasco Force Platforms (PS-2141; Pasco, Roseville, CA) by the same research team member. To quantify balance, the mean magnitude of postural sway, in the form of total, medial/lateral, and anterior/posterior center of pressure mean velocity (in millimeters per second) during the quiet standing and each of the completed CDC stances were calculated. During the 30STS task, the total number of repetitions completed in 30 s, the time to complete each full stand/sit repetition (cycle), the time to rise (rise time), and the time to sit (sit time) for each cycle was determined from ground reaction forces. Furthermore, a fatigue index was calculated for both the rise time and sit time, using the following equations: fatigue index rise time = [(last repetition rise time – first repetition rise time) / first repetition rise time] × 100 and fatigue index sit time = [(last repetition sit time – first repetition sit time)/first repetition rise time] × 100.

Statistical Analysis

An a priori power analysis using three previously published studies was performed to determine the sample size (Ball et al., 2013; Crowe & Ball, 2015; Syed-Abdul et al., 2016). For the 30STS, DXA body fat percentage, and SAGE effect size (*ES*) of 0.8, a minimum sample size ranging from 9 to 12 participants per group was required. All data were normally distributed based on the Shapiro–Wilk's test and reported as unadjusted mean (*SD*). One-way analysis of variance (ANOVA) was used to test for group differences in baseline physical characteristics. For measures taken pre- and postintervention, one-way repeated-measures multivariate ANOVA (RM-MANOVA) were conducted for four sets of variables: questionnaire data (PSQI and SAGE scores, and auxiliary PA); dynamic performance tasks (30STS, TUG, and gait speed); static performance tasks (CDC composite score, grip strength, BS, and SnR); and DXA measures (total body areal bone mineral density, bone-free lean body mass, and body fat percentage). Two-way RM-ANOVA was used to decompose the model with Bonferroni post hoc by determining group (SSSH, WALK, and CON) and time (pre and post) main effects and Group × Time interactions. Reported auxiliary PA (in minutes per week) was used as a covariate for two-way repeated-measures ANCOVAs. When significant interactional effects were found from the post hoc

Table 1 Baseline Participant Characteristics

Variable	SSSH (*n* = 15)	WALK (*n* = 17)	CON (*n* = 14)
Age (years)	68.2 (6.7)	68.6 (8.7)	67.6 (6.9)
Height (m)	1.69 (0.08)	1.64 (0.07)	1.66 (0.11)
Body mass (kg)	95.4 (17.7)	83.4 (26.1)	87.1 (29.5)
BMI (kg/m^2)	33.5 (6.7)	30.6 (7.8)	31.2 (8.4)
LM:FM	1.38 (0.56)	1.26 (0.34)	1.35 (0.26)
% Fat mass	42.6 (7.7)	44.5 (6.6)	41.9 (5.0)
aBMD T-score[a]	–1.5 (1.3)	–1.7 (1.6)	–1.6 (1.9)
30STS (reps)	9.8 (4.5)	9.1 (2.6)	9.2 (3.5)
CDC balance (0–4)	3.2 (0.8)	3.4 (0.7)	3.4 (0.8)
TUG (s)	8.19 (1.89)	8.8 (2.84)	9.46 (3.91)
Gait speed (m/s)	1.6 (0.3)	1.7 (0.3)	1.6 (0.4)
Mean hand grip (kg)	30.1 (9.9)	26.5 (8.8)	28.3 (12.0)
Mean BS (cm)	–15.6 (12.5)	–12.1 (13.4)	–19.0 (13.2)
Mean SnR (cm)	3.4 (11.7)	–1.8 (11.2)	– 6.5 (13.0)
SAGE score	18.5 (1.9)	18.2 (2.5)	18.6 (2.2)
PSQI score	5.0 (2.7)	5.8 (3.4)	5.9 (3.0)
Falls in past year	0.7 (1.6)	0.6 (0.9)	2.0 (2.4)

Note. SSSH = Stay Strong, Stay Healthy group; WALK = walking group; CON = control group; BMI = body mass index; LM:FM = lean mass to fat mass ratio; aBMD = areal bone mineral density; 30STS = 30-second sit-to-stand; TUG = 8-ft timed up and go; BS = back scratch; SnR = sit and reach; SAGE = self-administered gerocognitive exam; PSQI = Pittsburgh Sleep Quality Index; CDC = Center for Disease Control. Values are presented as mean (*SD*).
[a]aBMD T-score excluded participants with orthopedic implants.

analyses, the model was further decomposed using additional paired *t* tests within each group. The ES were calculated as described by Cohen, with the ES being defined as small (0.2), medium (0.5), and large (0.8; Cohen, 1988). Percentage changes (%Δ) were calculated for all performance variables and were analyzed using one-way ANOVAs using the following equation: $\%\Delta = [(\text{post} - \text{pre}) / |\text{pre}|] \times 100$. All statistical procedures were performed using SPSS (version 25.0; IBM Corp., Armonk, NY), and significance was set at $\alpha = .05$.

Results

Baseline Characteristics

Compliance was 93.3% for the SSSH classes and 90.1% for the WALK group, with no differences between groups ($p = .378$). At the baseline, no significant differences were found among the three groups for anthropometrics, body composition, physical or cognitive performance, number of falls, or sleep quality (all $p > .058$; Table 1). BMI was not different between groups ($p = .341$). All enrolled adults reported that they had not engaged in any structured exercise or RT (sedentary classification). Self-reported activity such as gardening, mowing the lawn, walking during grocery shopping, and/or cleaning was considered auxiliary PA, and each group averaged 49 min per week. Auxiliary PA was not different among groups (all $ps = .456$). No differences were found in the baseline measures between those who completed the study and those who did not complete the study (all $p > .097$).

Changes Over Time

Significant changes occurred between the baseline and the 8-week follow-up for questionnaire responses. The effect was significant, as shown by the one-way RM-MANOVA test for self-reported auxiliary PA, PSQI scores, and SAGE cognition scores, Wilks' lambda = 0.567, $F(6, 82) = 4.487$, $p = .001$. Subsequent RM-ANOVAs demonstrate SSSH increased reported auxiliary PA by more than 60 min per week ($p = .049$, ES = 0.75), while the PA did not change for WALK or CON (both $p > .080$). This 148.3% increase in SSSH was significantly greater than both WALK (–27.1%) and CON (–41.2%; post hoc *t* tests $p < .043$) (Figure 2). As auxiliary PA could be a confounding factor not evident at the baseline, a subsequent repeated-measures ANCOVA was performed with auxiliary PA as a covariate. This additional analysis did not change any results. The PSQI scores significantly decreased (improved) by 1.3 points in the SSSH participants ($p = .009$, ES = 0.56), did not

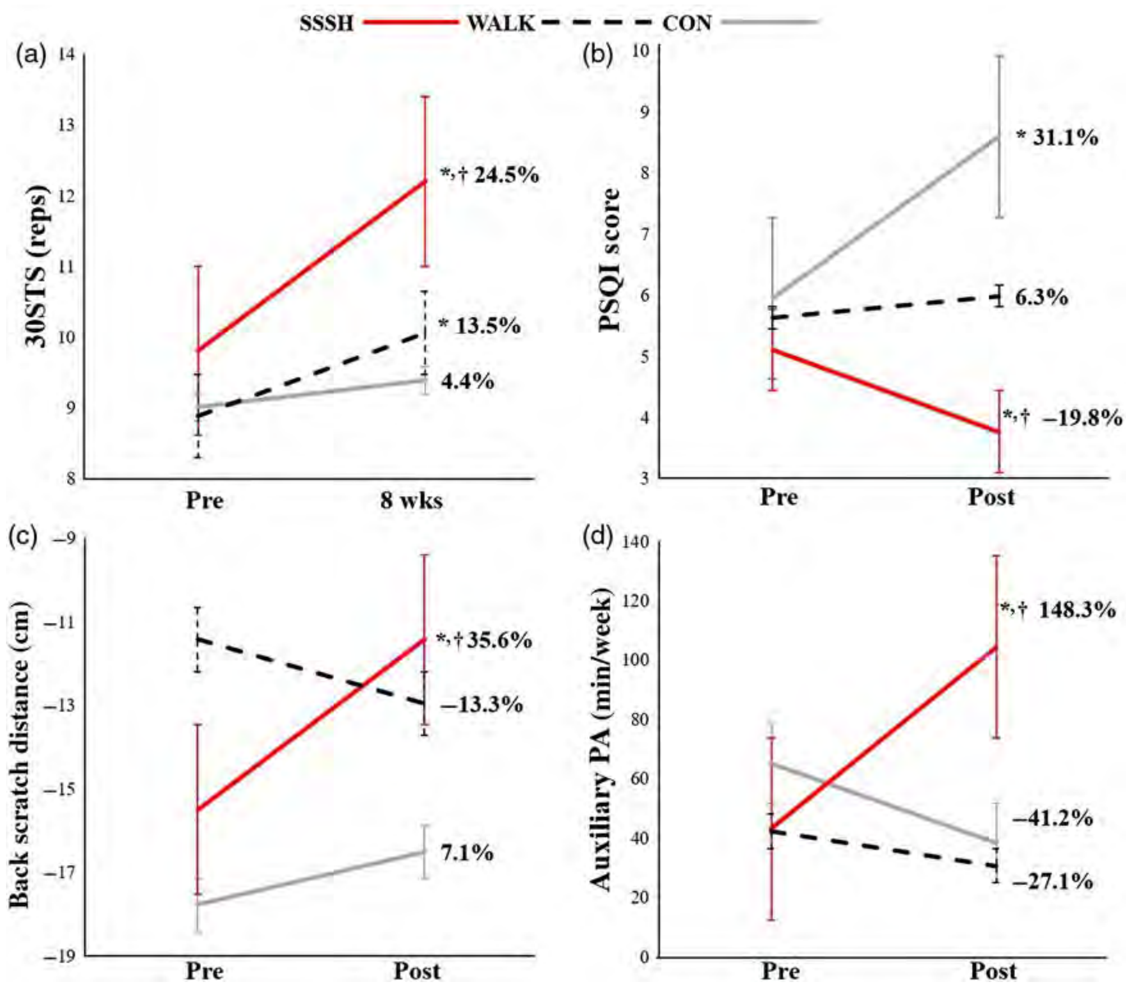

Figure 2 — Significant interactions for (a) 30STS, (b) PSQI, (c) back scratch flexibility, and (d) auxiliary physical activity. SSSH indicates Stay Strong, Stay Healthy group; WALK = walking group; PSQI = Pittsburgh Sleep Quality Index; 30STS = 30-s sit-to-stand test; PA = physical activity; CON = control group.*Significant within-group difference from pre values ($p \leq .05$). †Significant magnitude of change greater than WALK or CON, respectively ($p \leq .05$).

change in the WALK participants, and increased (worsened) by 2.6 points in the CON participants ($p = .040$, ES = 0.59). The %Δ in PSQI was also significantly improved in SSSH (−19.8%) over both WALK (6.3%) and CON (31.1%) (post hoc t tests $p < .016$) (Figure 2). The SAGE cognition scores and fear of falling scores did not change over time (both $p > .561$). Additionally, no changes were observed for anthropometrics or DXA-derived measures of bone, muscle, or fat, Wilks' lambda = 0.871, $F(6, 82) = 0.976$, $p = .447$.

Significant changes occurred between the baseline and the 8-week follow-up for dynamic and static physical performance assessments. The effect was significant, as shown by the one-way RM-MANOVA for the dynamic performance tasks, that is, the 30STS, TUG, and 10MWT, Wilks' lambda = 0.709, $F(6, 80) = 2.500$, $p = .029$, but not for the static performance tasks, that is, the CDC total scores, grip strength, and BS and SnR flexibility, Wilks' lambda = 0.813, $F(8, 74) = 1.007$, $p = .438$. Subsequent analysis demonstrates that the SSSH and WALK participants significantly improved in the 30STS by two repetitions ($p < .001$, ES = 0.55) and one repetition ($p = .008$, ES = 0.52), respectively, while the CON participants did not improve ($p = .468$). When these 30STS data are represented as %Δ, SSSH, WALK, and CON improved 24.5%, 13.5%, and 4.4%, respectively, and the SSSH improvement was significantly greater than the CON (post hoc $p = .030$). The average BS distance reached for WALK (−1.8 cm, $p = .063$) or CON (3.8 cm, $p = .084$) did not change, but the SSSH participants improved by 4.3 cm ($p = .039$, ES = 1.35). When upper body flexibility is presented as %Δ, SSSH (35.6%) improved significantly more than CON (7.1%) or WALK (−13.3%) and CON improved more than WALK (both post hoc $p < .038$). Significant time effects were found, as all three groups improved in gait speed, 10MWT, TUG times, and SnR distance (all $p < .001$, ES ranged from 0.39 to 0.55; Figure 3). When these changes were analyzed as %Δ, no significant group differences were found. No significant interactions or main effects for group or time were found for CDC balance tasks or grip strength (all $p > .099$). For static balance tasks (10 s of quiet standing and the CDC four-stage balance task on the force plates), a significant time effect was found, as the CDC single-foot task magnitude of postural sway significantly decreased ($p = .011$, ES = 1.09). For the dynamic 30STS task, time per complete sit/stand cycle, rise time, and sit time significantly decreased in all groups (all $p < .014$, ES ranged from 0.26 to 0.61). No significant interactions, group effects, or percentage changes were found for the remaining force plate data (Table 2).

Discussion

As the U.S. population continues to age, the importance of successful evidence-based community exercise interventions targeting older adults increases. Although specific improvements in muscle size and power increase with longer durations of total exercise intervention (Fragala et al., 2019), older adults may benefit significantly from as

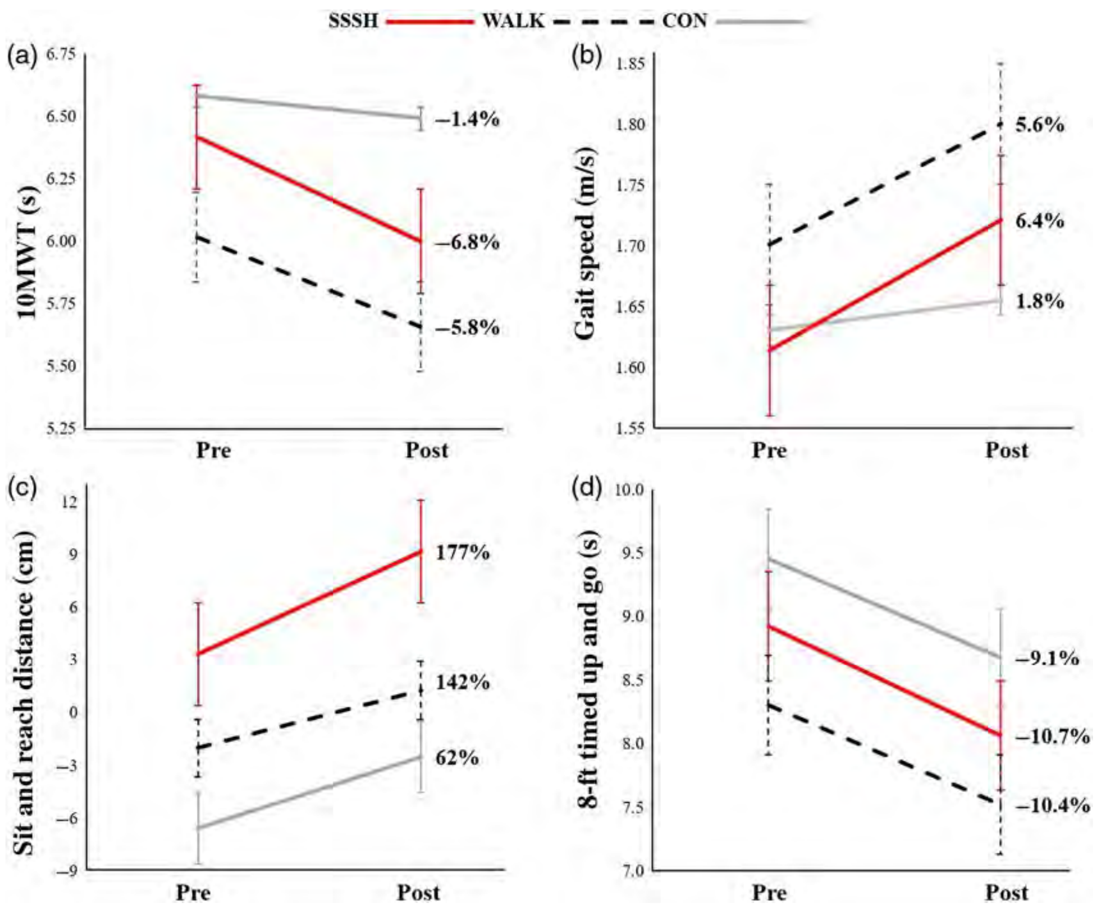

Figure 3 — Significant time effects for (a) 10MWT, (b) gait speed, (c) sit and reach flexibility, and (d) timed up and go. Percentage changes are included for reference and are not statistically significant. SSSH indicates Stay Strong, Stay Healthy group; 10MWT = 10-m walk test; WALK = walking group; CON = control group.

little as 8 weeks of RT. The present study showed that 8 weeks of the SSSH RT program induces positive changes in muscle function/flexibility, balance, and sleep quality. Prior work with former SSSH participants has shown that program-related improvements in lower body strength, dynamic balance, and coordination are linked with reductions in fall risk (Ball et al., 2013; Crowe & Ball, 2015; Syed-Abdul et al., 2016) and increases in longevity of independent living, quality of life, and survivability by others (Applebaum et al., 2017; Herman, Giladi, & Hausdorff, 2011; Lipsitz et al., 2018; Slaughter et al., 2015; Studenski et al., 2011).

Dynamic tasks like the 30STS and TUG are indicators of lower body strength, balance, and coordination and are often used to assess fall risk (Applebaum et al., 2017; Chow et al., 2019; Reynaud et al., 2019). In the present study, the SSSH participants significantly improved their 30STS (compared with WALK and CON) and TUG (compared with pretraining) performance, but had little change in static balance tasks. Given that dynamic tasks have been shown to be stronger predictors of fall risk than static balance tasks alone (Desai, Goodman, Kapadia, Shay, & Szturm, 2010; Dunsky, Zeev, & Netz, 2017), the SSSH RT program may aid in participants' decreasing their overall fall risk. The distinctions between static and dynamic balance for risk of falls is further supported by Desai et al. (2010), who reported that dynamic but not static balance task performance distinguished fallers from non-fallers in 72 community-dwelling older adults who were equivalent for gait speed and other physical parameters of health. Since the majority of falls in older adults occur during dynamic movement tasks, dynamic balance assessments may be a more comprehensive assessment and a stronger determinant of fall risk than static balance tasks for this population (Dunsky et al., 2017; Gusi et al., 2012; Zhao & Chung, 2016). In addition to muscle strength and balance, flexibility is another factor associated with fall risk (Emilio, Hita-Contreras, Jiménez-Lara, Latorre-Román, & Martínez-Amat, 2014; Stathokostas, Little, Vandervoort, & Paterson, 2012). Thus, the physical performance improvements associated with SSSH participation, including upper and lower body flexibility, may indirectly mitigate fall risk in older adults.

The interrelatedness of PA and sleep quality and their concomitant associations with healthy aging and reduced fall risk makes each of these key targets for intervention outcomes

Table 2 Group Comparison of Force Plate Data During the 30STS Task Over Time

Task	Stance	Variable	Group	Baseline	%Δ
Quiet standing (10 s)		Postural sway (mm/s)	SSSH	13.52 (3.34)	2.25 (14.74)
			WALK	14.95 (4.90)	−1.29 (25.53)
			CON	14.56 (5.27)	−7.77 (31.08)
CDC balance tasks 1–4 (10 s)		Task 1 postural sway (mm/s)	SSSH	19.36 (4.41)	−1.05 (21.80)
			WALK	19.91 (5.76)	4.35 (36.09)
			CON	20.97 (6.04)	−8.17 (28.14)
		Task 2 postural sway (mm/s)	SSSH	23.28 (7.32)	0.63 (30.71)
			WALK	24.55 (7.99)	6.06 (29.34)
			CON	20.53 (4.88)	1.19 (33.83)
		Task 3 postural sway (mm/s)	SSSH	56.09 (14.92)	−23.09 (47.23)
			WALK	57.04 (23.26)	−12.73 (48.49)
			CON	43.08 (13.27)	−10.20 (38.75)
		Task 4 postural sway (mm/s)*	SSSH	64.93 (5.69)	−9.26 (14.39)
			WALK	62.69 (21/36)	−7.70 (25.03)
			CON	69.55 (22.58)	−36.77 (35.33)
30STS task		Cycle time (s)**	SSSH	2.13 (0.52)	−15.32 (20.52)
			WALK	2.26 (0.63)	−10.29 (15.47)
			CON	2.04 (0.54)	−11.21 (15.34)
		Rise time (s)*	SSSH	0.79 (0.15)	−5.76 (14.70)
			WALK	0.83 (0.21)	−18.02 (34.52)
			CON	0.74 (0.19)	−4.68 (11.74)
		Sit time (s)**	SSSH	0.73 (0.18)	−11.53 (19.68)
			WALK	0.77 (0.27)	−6.23 (16.73)
			CON	0.73 (0.20)	−14.70 (9.52)
		Rise fatigue index (% time)*	SSSH	9.42 (12.91)	83.70 (114.24)
			WALK	0.95 (10.07)	86.90 (114.35)
			CON	7.06 (10.67)	−60.25 (340.66)
		Sit fatigue index (% time)	SSSH	0.07 (22.07)	118.42 (138.06)
			WALK	−3.85 (15.75)	−46.61 (789.68)
			CON	−5.83 (17.01)	119.44 (324.22)

Note. SSSH = Stay Strong, Stay Healthy group; WALK = walking group; CON = control group; 30STS = 30-s sit-to-stand task; CDC = Center for Disease Control. Values are presented as mean (*SD*).
$^*p < .05$ and $^{**}p < .01$ indicates a significant time effect.

(Freburger, Callahan, Shreffler, & Mielenz, 2009; Holfeld & Ruthig, 2014; Reid et al., 2010). Nearly 50% of men and 75% of women above the age of 75 years do not engage in PA (Office of Disease Prevention and Health Promotion, 2008), and 50% of older adults report chronic sleep disturbances (Reid et al., 2010). The SSSH participants significantly improved both PA volume and sleep quality compared with WALK and CON. These findings lend additional evidence to the relationship between PA and sleep, as well as the benefits of short-term RT on each of these outcomes. The PSQI score improvement of the SSSH group (from poor sleeper to normal sleeper) is similar in magnitude to the observed positive effects of a 25-week Tai Chi intervention, despite SSSH lasting only 8 weeks (Irwin, Olmstead, & Motivala, 2008). These rapid improvements in PA levels and sleep quality suggest that SSSH participation may improve quality of life in older adults (Latimer Hill, Cumming, Lewis, Carrington, & Le Couteur, 2007; Stone et al., 2014; Stone, Ensrud, & Ancoli-Israel, 2008).

The greatest strength of the SSSH program is its ability to kick-start sedentary older adults into more active lifestyles in as little as 8 weeks. Simple activities of daily living can be difficult for older adults due to actual and/or perceived lack of strength and coordination. This study and others have shown that RT programs, as opposed to other forms of exercise, are an excellent modality for increasing baseline strength, coordination, and dynamic balance in detrained individuals (Fragala et al., 2019) and oftentimes result in an increase in reported activity outside of the structured exercise program (Syed-Abdul et al., 2016; Seguin et al., 2002). Authors suggest the large increase in reported auxiliary PA in the SSSH group as opposed to the WALK or CON groups resulted from improved physical function and increased participant confidence in their physical abilities, allowing the participants to reengage in activity. This increase in auxiliary PA is beneficial to older adults engaging in SSSH, as it will concomitantly improve sleep quality (Holfeld & Ruthig, 2014), body composition (Lee et al., 2015), depression scores (Singh et al., 2005), and quality of life (Reid et al., 2010). Furthermore, participants in the SSSH program are encouraged to continue to remain active outside of classes and progress through the multilevel SSSH program. More advanced levels include increasingly challenging exercises and nutrition, home safety, and fall prevention instructional material.

A primary strength of this study is the inclusion of both sedentary and active control groups. An active control population allows differentiation of the effects of exercise in general versus the effects of the specific exercise intervention (SSSH). Considering that many barriers exist for older adults to maintain regular participation in community exercise interventions (Hong, Hughes, & Prohaska, 2008), the participants within the 8-week SSSH program had excellent compliance. The average attendance was 15 of the 16 classes, suggesting that the program is well-tolerated and that benefits from consistent participation could compound over time. An important limitation of the present study is that, despite inclusive recruitment strategies, the sample was fairly homogenous; all of the participants were White, and nearly 80% were female, reducing the generalizability of the findings. Additionally, the limited duration of the intervention constrained possible effects of RT on body composition and bone density. Because these systems change at a slower pace than our focal phenotypes of muscle strength and balance, future studies investigating body composition or bone as a primary outcome will need to explore extended durations. Lastly, because this was not a nutritional intervention, the intertwined effects of exercise and diet cannot be discussed, as no dietary information was collected during this study.

Conclusion

Twice-weekly participation in 8 weeks of the SSSH RT program significantly improved lower body strength/coordination, dynamic balance, sleep quality, and engagement in auxiliary PA to a greater extent than an exercise duration-matched walking group. These positive adaptations suggest that community-based exercise programs, such as SSSH, may reduce their duration to only 8 weeks and still afford participants' significant improvements in physical well-being.

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