ORIGINAL RESEARCH

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The Effect of Suspension Training vs. Traditional Resistance Training in Older Adults: Randomized Controlled Trial

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Abstract

Objective: The objective of this study is to compare the effects of traditional resistance training (RT) vs. suspension training (ST) on functional performance, body composition, and cognitive functions in older adults.

Materials and Methods: Participants were categorized into three groups: the ST group (ST, n=8, age: 71), the traditional RT group (RT, n=8, age: 70), and the control group [(C), n=7, age: 70]. All measurements, assessments, and test evaluations were performed at the baseline, the sixth week, and the twelfth week. The training programs were conducted two days per week. The ST group was included in a program consisting of exercises with the suspension apparatus, whereas the RT focused on RT with body weight and free weights. The C was not included in the training program.

Results: The arm strength was greater in the ST group than in the C group (p=0.007). Muscle mass (p=0.029), basal metabolic rate (BMR) (p=0.034), agility and dynamic balance (p=0.012), leg strength (p=0.005), arm strength (p=0.002), and cognitive function (p=0.006) were significantly different in the ST group compared to the C group (p<0.05). The balance (p=0.005) and BMR (p=0.030) were significantly improved in the ST group compared to the RT group (p<0.05).

Conclusion: Physical therapists and trainers may use a suspension method as an alternative to traditional methods for older adults. This method may provide trainers with the opportunity to improve strength, balance, and cognitive function with a single training method.

Keywords: Agility, aging, balance, cognition, resistance, suspension

Introduction

Resistance training (RT) is suggested as a beneficial treatment for sarcopenia and its effects (1-10). It also affects fat mass, balance, physical function, and muscle mass (11-19). However, some studies indicate that it does not significantly enhance physical function (20-23). Explosive RT with heavy loads is also recognized as more effective for muscle growth and strength in older adults (4, 24-26). However, many older adults engage in RT to maintain their daily activities and physical function rather than to increase muscle mass. For this reason, different approaches are needed to avoid excessive training loads and enhance functional performance more safely in older adults.

Suspension training (ST), also known as total resistance eXercise (TRX) (total RT), is more effective for core muscle activation (27-29) and has the potential to improve functional performance (27, 29-31). ST involves two straps that hang from a fixed point, with each strap's length adjustable for various exercises. Older adults can safely participate in this training method without any additional loads. Previous studies have highlighted that ST is an effective alternative method for RT (32,33). This method can potentially contribute to improving both physical function

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and body composition components (33,34). However, it is still uncertain whether ST is more effective than RT for older adults (30,32,34).

Cognitive functions naturally decline with age (35). This decline may be due to reduced muscle strength and alterations in brain structure and function (36). Additionally, cognition is linked to balance ability and muscle mass. Alzheimer's disease and cognitive impairment are also correlated with these factors (37,38). Although some research suggests that aerobic fitness is associated with changes in brain structure and cognitive function (39), RT is also known to have the potential to enhance cognition (40-44). However, studies have shown that some resistance exercises do not improve cognitive function (45,46).

Finally, RT is effective in improving some abilities and functions. However, lifting weights and gradually increasing resistance could pose risks, particularly for this age group. Furthermore, RT is not enough to improve balance and cognitive functions. Therefore, we hypothesized that ST might also influence cognition and balance without added loads. Thus, we aimed to provide data on ST for physiotherapists, physical trainers, and researchers working with the older population. The objective of this study is to compare the effects of RT vs. ST on functional performance, body composition, and cognitive functions in older adults.

Materials and Methods

Participants

All participants were reached by announcement at the Healthy and Active Aging Studies Research Center. They were aged 65-80 years, had no physical disabilities, did not use any assistive devices, reported participation in RT, had not undergone surgery in the past year, had trained for two years and had an Mini Mental State Examination Score of 23 or higher. Additionally, they do not use medication or supplements (protein, vitamin D/calcium, and vitamin B) that might contribute to increased strength were included in this study (Table 1). Participants used medications that might enhance muscle strength, had a physical disability, used an assistive device, had not trained for the past two years, had not reported participating in RT, had surgery within the last year, or used supplements such as protein, vitamin D/calcium, and vitamin B were excluded from the study.

Participants were randomly assigned to three groups. After randomization, the control group (C) was instructed to maintain their usual daily activities during the research. At baseline, 40 participants were included. However, some participants dropped out for various reasons, such as moving to another city, unexplained reasons, boredom, short-term illnesses, caring for grandchildren, or going on vacation (Figure 1). The participants were randomized into ST (n=8, female:6, male:2), RT (n=8, female:6, male:2), and C (n=7, female:4, male:3).

Procedure

Participants were involved in all tests and measurements at baseline six weeks, and post-training. The Montreal Cognitive Assessment Scale (MoCA) Turkish version was used to evaluate cognition (47,48). The sit-to-stand test was used to assess leg functional strength (49). They were instructed to complete sit-stand cycles within 30 seconds. The arm curl test was used to evaluate functional strength. The participant was asked to

Table 1. Participants' demographic status

	n	%
Marital status		
Married	17	73.9
Others (single, divorce, death)	6	26.1
Job Retired	23	100
Education status		
< University degree	6	26.1
> University graduate	17	73.9
Income status		
<5000 TL	6	26.1
>5001 TL	17	73.9
Diseases		
None	10	43.5
Hypertension	9	39.1
Diabetes	2	8.7
Vertigo	2	8.7
Regular medicine use status		
Yes	8	34.8
None	15	65.2

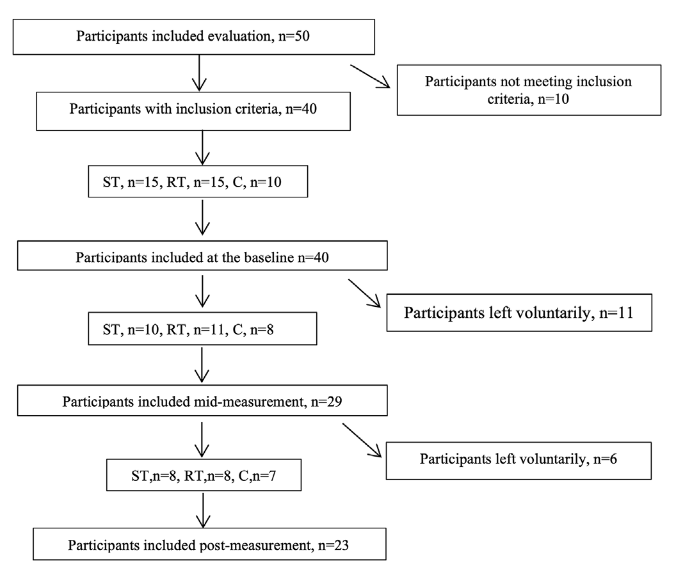

Figure 1. Participants diagram

RT: Resistance training, ST: Suspension training, C: Control group fully bend their arm while holding dumbbells. The total arm curls were recorded in 30 seconds (dumbbell: 1 kg for women, 2 kg for men). Agility was assessed using the get-up-and-go test, and the participants were instructed to rise from the chair, walk to the end of the 2.5 m distance, and then return to sit down (49). The Turkish version of the Berg Balance Scale (BBS) was used for balance assessment (50). Body mass index (BMI), basal metabolic rate (BMR), fat mass, muscle mass, body fat percentage, and free fat mass (FFM) were evaluated using the bioelectrical impedance method (InBody 270, Co., Ltd.). Participants were instructed to avoid heavy exercise the day before and to finish their nutritional routines at least two hours before the test. All training programs and measurements were conducted at the Çanakkale Onsekiz Mart University Healthy and Active Aging Studies Research Center, Healthy and Active Aging Studies Research Center. This study was approved by Çanakkale Onsekiz Mart University Faculty of Medicine, Clinical Research Ethics Committee (decision number: 2022-03, date: 02.02.2022). Participants signed a written consent form. All participants were informed about the study and potential risks.

Interventions

Suspension Training: The ST consisted of exercises performed with TRX brand training equipment. Each strap was adjusted to each participant for different exercises. In the first week, researchers explained to the participants how to use this equipment safely. The training included squats, leg curls, rowing, chest press, butterfly, and arm curl exercises with TRX (Table 2).

Traditional Resistance Training: The RT included wall squats or single-leg squats, chair squats, elastic band knee flexion and extension, butterfly and arm curls with dumbbells, and chest presses with dumbbells (Table 2). All RT was applied in groups.

All training programs were conducted two days/week and lasted 40 minutes (including a warm-up~10 minutes and relaxing exercises 5 minutes).

The Rate of Perceived Exertion (RPE) scale was used to adjust the training load. The RPE scale was increased from the 2-3 range to the 4-5 range during the training period. In the first week, the exercises started with two sets of six repetitions, and by week 12, the sets were increased from 4 to 12 reps. The training variables (frequency, intensity, volume, and rest period) for all methods are presented in Table 2.

Statistics

The Shapiro-Wilk test was used to analyze the conformity of the data to the normal distribution. Differences between parameters that did not show normal distribution (arm curl, get-up-and-go) were analyzed using the Kruskal-Wallis test. Age, body mass, height, muscle mass, fat mass, body fat %, BMR, FFM, BMI, sit to stand, BBS Score, and MoCA Score results were analyzed using one-way ANOVA. The post-hoc Tukey test was used for differences between groups for parameters that follow a normal distribution. Differences between groups for parameters that did not follow a normal distribution were analyzed using the Mann-Whitney-U test. The paired samples t-test and Wilcoxon signed-rank test were used to determine the significance of the difference between baseline and post-period data within the group. The effect size (ES) was calculated by Cohen ES (>0.2 a small, 0.5 moderate, >0.8 large) (51). The significance level was set at <0.05. The SPSS 26.0 software was used in all analyses.

Results

There was no significantly different between ST, RT and C groups in age variable (ST =71.37±4.56, RT =70.87±3.97, C =70.00±3.21), height (ST =162.12±6.79, RT =161.62±5.52, C =164.00±6.58), and body weight (ST =72.25±8.20, RT =70.37±4.27, C =73.00±2.70) at the baseline (p>0.05). At the baseline, the age, body composition, physical and cognitive function scores were similar between the three groups (p>0.05, Table 3).

The BMI, BMR, FFM, fat mass, body fat %, muscle mass, and body mass were similar between baseline and week six in all groups (p>0.05, Table 3). Additionally, BBS, "get-up-and-go", and "sit to stand" were not different between groups (p>0.05, Table 3). However, there was a significant difference in the arm curl test, and MoCA scores from baseline to week six in all groups (p<0.05). The arm curl score was higher in both training groups compared to the C group. Furthermore, the cognitive function score was higher in the ST group than the C group (p<0.05, Table 3).

No significant differences were observed among the groups in body mass, BMI, fat mass, body fat %, and FFM (p>0.05, Table 4). However, we observed significant differences in muscle mass, BMR, MoCA, BBS, the sit to stand test, arm curl test, and get-up-and-go test scores of older individuals. We observed that the increase in muscle mass in the ST group was greater than that of the C group (ST =27.50 kg, C =23.00 kg). Additionally, the BMR in the ST group was higher than that in the RT and C groups (ST =1492.12 kcal, RT =1331.62 kcal, C =1329.71 kcal). BBS in the ST was higher than in the RT (ST =53.62, RT =51.00). Get-up-and-go test (ST =5.25 sec, C =6.28 sec), arm curl test (ST =19.50 reps, C =13.42 reps), sit to stand test (ST =17.50 reps, C =14.85 reps), and MoCA Score were higher than the C group (ST =29.87, C =28.71).

There was a significant difference in arm curl (ES =0.25), sit-to-stand (ES =0.60), BBS Score (ES =1.79), get-up-and-go (ES =0.76), and MoCA Score (ES =0.86) between groups (p<0.05). Muscle mass, BMR; get-up-and-go; sit to stand; arm curl, and MoCA Scores were significantly higher in the ST than in the C group (p<0.05, Table 4). The arm curl score was significantly better in the RT group than in the C group. The BBS score and

BMR were significantly higher in the ST than the RT group (p<0.05, Table 4).

Changes for the ST Over Time

We analyzed the data to assess differences between baseline and post-training periods. Significant improvements were observed in muscle mass (t=-4.339, p<0.05), fat mass (t=7.483, p<0.001), body fat % (t=9.000, p<0.001), FFM (t=-6.481, p<0.001), BMR (t=4.154, p<0.05), the get-up-and-go test (t=5.000, p<0.05), arm curl test (t=-3.454, p<0.05), and sit to stand test (t=-7.071, p<0.001). Additionally, there were notable improvements in the BBS Score (t=-3.476, p<0.05) and the MoCA Score (t=-4.583, p<0.05) when compared to other groups over time (Table 5).

Changes for the RT Over Time

In the RT Group, significant changes were noted in muscle mass (t=-2.497, p<0.05), body fat % (t=2.600, p<0.05), FFM (t=-3.100, p<0.05), BMR (t=-2.761, p<0.05), get-up-and-go test (t=4.583, p<0.05), arm curl test (t=-5.137, p≤0.001), and sit to stand test score (t=-5.400, p≤0.001) (Table 5).

Table 2. Suspension and resistance training programs

Weeks	Suspension training	Resistance training	RPE	Sets x rep	Rest between sets/rest between exercises (min.)
Weeks I -II	-Squat -Leg curl -Rowing -Chest press -Butterfly -Arm curl	-Chair squat -Knee curl (with band) -Leg extension (with band) -Butterfly (with dumbbell) -Arm curl (with dumbbell) -Bench press (with dumbbell)	2-3	1 x 6-8	1/3
Weeks I II-IV	-Squat -Leg curl -Rowing -Chest press -Butterfly -Arm curl	-Chair squat -Leg curl (with band) -Leg extension (with band) -Butterfly (with dumbbell) -Arm curl (with dumbbell) -Bench press (with dumbbell)	2-3	1 x 6-8	1/3
Weeks V-VI	-Squat -Leg curl -Rowing -Chest press -Butterfly -Arm curl	-Chair squat -Leg curl (with band) -Leg extension (with band) -Butterfly (with dumbbell) -Arm curl (with dumbbell) -Bench press (with dumbbell)	3-4	2 x 8-12	2/5
Tests II - all tests and evaluations					
Weeks VII-VIII	-One leg squat -Leg curl -Rowing -Chest press -Butterfly -Arm curl	-Wall squat -Leg curl (with band) -Leg extension (with band) -Butterfly (with dumbbell) -Arm curl (with dumbbell) -Bench press (with dumbbell)	4-5	2 x 8-12	2/5
Weeks IX-X	-One leg squat -Leg curl -Rowing -Chest press -Butterfly -Arm curl	-Wall squat -Leg curl (with band) -Leg extension (with band) -Butterfly (with dumbbell) -Arm curl (with dumbbell) -Bench press (with dumbbell)	4-5	3 x 8-12	2/5
Weeks XI-XII	-One leg squat -Leg curl -Rowing -Chest press -Butterfly -Arm curl	-Wall squat -One leg squat -Leg curl (with band) -Leg extension (with band) -Butterfly (with dumbbell) -Arm curl (with dumbbell) -Bench press (with dumbbell)	4-5	3 x 8-12	2/5
Test III - all tests and evaluations					

RPE: Rate of Perceived Exertion, rep: Repetitions, Min.: Minimum

Changes for the C Over Time

The fat mass (t=-2.500) showed a significant change over time (p<0.05, Table 5).

Discussion

The main finding of the present study was that both training methods improved certain body composition components, cognition score, and physical function in older adults. Another finding is that ST had a more significant impact on the BBS, MoCA cognitive function, body composition, and physical function compared to other groups. Considering the ES, ST is more effective for balance (ES =1.79), cognitive function (ES =0.86), and agility (ES =0.76) (Table 4).

A significant increase in BBS was observed for the ST group (p<0.05, Tables 3 and 4). ST engages more muscle groups and

Table 3. Differences between the baseline and after six weeks

	Baseline				Week VI			
	ST	RT	C		ST	RT	C	
	Mean ± SD	Mean ± SD	Mean ± SD	p	Mean ± SD	Mean ± SD	Mean ± SD	p
Body mass (kg)	72.25±8.20	70.37±4.27	73.00±2.70	0.505	72.25±8.31	71.00±3.74	75.14±5.17	0.512
BMI (kg/cm²)	27.62±2.32	27.87±2.99	28.14±2.67	0.933	27.12±1.55	27.75±2.76	28.14±2.67	0.708
Muscle mass (kg)	24.12±3.18	24.37±2.55	24.00±2.70	0.966	26.12±3.52	24.75±2.60	24.00±2.44	0.374
Fat mass (kg)	25.50±4.92	26.25±4.94	26.28±4.53	0.936	24.37±5.39	25.62±4.56	26.85±4.45	0.619
Body fat %	37.00±4.84	38.37±5.31	36.28±4.27	0.700	33.75±5.67	38.00±4.78	35.00±5.25	0.275
FFM (kg)	45.50±6.00	45.50±2.77	46.71±2.98	0.821	45.75±5.77	45.62±2.55	47.85±4.33	0.566
BMR (kcal)	1347.00±161.24	1263.75±76.014	1365.57±45.08	0.171	1435.62±168.33	1308.3772.21	1363.42±48.98	0.098
MoCA (Score)	29.12±0.64	28.50±0..41	28.28±1.38	0.375	29.50±0.53	29.00±0.75	28.42±0.90	0.044**
BBS (Score)	49.50±3.58	50.37±1.99	50.57±2.07	0.709	50.37±2.13	50.75±1.75	51.71±1.25	0.346
Sit to stand (rep/30 s)	12.50±1.19	13.25±1.28	13.57±1.81	0.346	15.37±1.18	15.62±1.59	14.00±2.38	0.189
Arm curl (rep/30 s)*	16.75±2.81	15.62±2.66	14.71±3.03	0.222	18.00±2.00	18.62±1.76	13.85±2.67	0.004**
Get-up-and-go (s)*	6.50±0..75	6.37±0.51	6.42±0.53	0.792	5.62±0.74	5.75±0.46	6.14±0.69	0.286

*Non-parametric Kruskal Wallis test, **p<0.05
SD: Standard deviation, ST: Suspension training, RT: Resistance training, FFM: Free Fat mass, BMI: Body mass index, BMR: Basal metabolic rate, BBS: Borg Balance Score, MoCA: Montreal Cognitive Assessment Scale, s: Second, rep: Repetitions, C: Control group

Table 4. Comparisons of all groups following 12 weeks

	ST	RT	C		
	Mean ± SD	Mean ± SD	Mean ± SD	p	ES
Body mass (kg)	72.12±8.40	70.87±3.83	75.42±5.47	0.441	-
BMI (kg/cm²)	27.37±1.30	27.75±2.43	28.57±2.76	0.582	-
Muscle mass (kg)	27.50±3.58	26.12±3.18	23.0±2.38	0.034**	0.80
Fat mass (kg)	23.50±5.15	24.87±4.48	27.00±4.50	0.376	-
Body fat %	32.50±5.18	36.75±6.58	33.287.54	0.392	-
FFM (kg)	48.50±6.09	47.75±2.86	49.71±4.23	0.714	-
BMR (kcal)	1492.12±150.10	1331.62±75.47	1329.7±08.28	0.017**	0.25
MoCA (Score)	29.87±0.35	29.37±0.74	28.71±0.75	0.008**	0.86
BBS (Score)	53.62±1.30	51.0±1.60	51.85±1.46	0.006**	1.79
Sit to stand (rep/30 s)	17.50±1.19	16.62±1.68	14.85±1.34	0.006**	0.60
Arm curl (rep/30 s)*	19.50±1.19	19.12±1.72	13.4± 2.76	0.001·	0.25
Get-up-and-go (s)*	5.25±0.46	5.62±0.51	6.28±0.75	0.022**	0.76

*Non-parametric Kruskal Wallis test, **p<0.05, ·p£0.001
SD: Standard deviation, ST: Suspension training, RT: Resistance training, C: Control, FFM: Free fat mass, BMI: Body mass index, BMR: Basal metabolic rate, BBS: Borg Balance Score, MoCA: Montreal Cognitive Assessment Scale, s: Second, rep: Repetitions, ES: Effect size

creates an unstable environment. This feature may explain why ST is more effective for neuromuscular control and balance compared to RT. Yu et al. (52) found that resistance exercises did not affect the BBS of older adults. Previous research shows RT alone does not effectively improve balance performance (23). Due to reduced balance, although force production declines in unstable conditions, RT on unstable surfaces is crucial for maintaining joint stability in the limb and trunk muscles. The relatively unstable position of ST significantly contributes to balance development and strength gains (33,53). Thus, the impact of ST on balance scores can be attributed to the unique characteristics of this training method. We hypothesized that ST could produce different results due to its nature (Table 5). We recognize that our sample size is relatively small and requires validation through future studies with larger samples. However, we emphasize that our results have the potential to introduce new methods and practical applications in geriatric sciences.

Exercise is known to increase cell proliferation in the hippocampus (54) and to support cerebral blood flow, thereby enhancing neurogenesis and learning (55). Previous research has shown that RT is effective for cognitive function (56). In this study, a relatively small improvement was observed in the cognitive function scores of older adults in both training groups ($p<0.05$, Table 3). However, the results of this study showed that the scores of older adults in the ST group were higher than those in the other groups. Unlike the basic movement components, ST is performed in a suspended position. While this feature contributes to the physical functioning of older adults, it may also affect cognitive processes by causing strain on neural and learning pathways. Exercise activates more neurons, and a stimulating environment provides greater benefits for the brain (57).

Table 5. Differences between the baseline and after 12 weeks for each group

	ST group	RT group	C group
Body mass (kg)	0.826	0.227	0.080
BMI (kg/cm²)	0.685	0.802	0.078
Muscle mass (kg)	0.003**	0.041**	0.529
Fat mass (kg)	0.000·	0.083	0.047**
Body fat %	0.000·	0.035**	0.126
FFM (kg)	0.000·	0.017**	0.075
BMR (kcal)	0.004**	0.028**	0.310
MoCA (Score)	0.003**	0.111	0.200
BBS (Score)	0.010**	0.217	0.136
Sit to stand (rep/30 s)	0.000·	0.001··	0.093
Arm curl (rep/30 s)*	0.011**	0.001··	0.063
Get-up-and-go (s)*	0.002**	0.003**	0.736

*Non-parametric Mann Whitney U test, **p<0.05, ·p<0.001, ··p£0.001.
ST: Suspension training, RT: Resistance training, C: Control group, FFM: Free fat mass, BMI: Body mass index, BMR: Basal metabolic rate, MoCA: Montreal Cognitive Assessment Scale, BBS: Borg Balance Score, s: Second, rep: Repetitions

Cognitive function is based on learning, repetition, memory, and the coordination of these processes. When cognitive stimulation is insufficient, no further neuron formation occurs (54). It is thought that ST may have encouraged learning and increased scores due to its unusual, somewhat complex, and relatively challenging structure. Interestingly, a notable increase in cognitive function was observed in the sixth week of the study (Table 3). However, there is no clear data on the correlation between exercise duration and cognitive function (58). We believe that this early development, indirectly influences the score due to exercise-induced neural adaptation (learning). MoCA is a simple and independent cognitive screening tool that is known for its superior sensitivity (47). Although the participants have a healthy cognitive state in this study, this difference suggests it may have a more significant impact on those with cognitive decline.

These results are consistent with previous studies that observed significant improvements after three months (59), twelve months (60), and six months (61). Although a longer exercise program does not result in greater cognitive benefits (62), future studies are necessary to identify the mechanisms that affect cognitive function in the older population.

The arm strength, leg strength, muscle mass, and agility improved significantly in two training groups (Table 3). However, a more significant difference was observed in older adults when ST was compared with the C group. Additionally, arm strength was identified as a second parameter that showed improvement after the sixth week ($p<0.05$, Table 3). It is believed that the early increase in arm strength may result from older adults' limited training of their arm muscles. Similar to our research, Soligon et al. (32) found that both training methods had comparable effects on muscle mass, strength, and functional performance. The ST method can significantly enhance functional performance as it promotes greater activation of core muscles compared to RT (28). Jiménez-García et al. (31) reported that TRX training was effective in improving BMI, hand grip strength, and walking speed in older adults.

Study Limitations

This research has a few limitations. First, the sample size was relatively small. However, some studies demonstrate that ST can improve physical strength, balance, and overall quality of life among participants in a small sample size (32,63). Second, participants' dietary habits were not controlled in this study. They were only informed about supplements as part of the inclusion criteria and advised to maintain their usual dietary habits. Lastly, the effects of exercise on body composition can vary significantly between genders. However, due to an inadequate gender distribution in the sample group, a comparison between genders could not be conducted. Therefore, future studies should consider dietary habits and gender factors in older populations.

Conclusion

ST recommended as a safe method to improve physical function for adults aged 65 to 80 who prefer to avoid traditional RT. Physical therapists and trainers may use ST as an alternative to traditional methods for older adults. This method gives trainers the opportunity to improve strength, balance, and cognitive function. However, further studies are needed to evaluate the sustainability of training effects in the older population.

Ethics

Ethics Committee Approval: This study was approved by Çanakkale Onsekiz Mart University Faculty of Medicine, Clinical Research Ethics Committee (decision number: 2022-03, date: 02.02.2022).

Informed Consent: All participants were informed about the study and potential risks.

Footnotes

Authorship Contributions

Concept: F.Ç., G.Ş., Design: F.Ç., G.Ş., Data Collection or Processing: F.Ç., Analysis or Interpretation: G.Ş., Literature Search: F.Ç., G.Ş., Writing: G.Ş.

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References

1. Frontera WR, Hughes VA, Lutz KJ, Evans WJ. A cross-sectional study of muscle strength and mass in 45- to 78-yr-old men and women. J Appl Physiol (1985). 1991;71:644-650.
2. Lynch NA, Metter EJ, Lindle RS, Fozard JL, Tobin JD, Roy TA, Fleg JL, Hurley BF. Muscle quality. I. Age-associated differences between arm and leg muscle groups. J Appl Physiol (1985). 1999;86:188-194.
3. Cruz-Jentoft AJ, Sayer AA. Sarcopenia. Lancet. 2019;393:2636-2646.
4. Frontera WR, Meredith CN, O'Reilly KP, Knuttgen HG, Evans WJ. Strength conditioning in older men: skeletal muscle hypertrophy and improved function. J Appl Physiol (1985). 1988;64:1038-1044.
5. Fragala MS, Cadore EL, Dorgo S, Izquierdo M, Kraemer WJ, Peterson MD, Ryan ED. Resistance training for older adults: position statement from the national strength and conditioning association. J Strength Cond Res. 2019;33:2019-2052.
6. Hunter GR, McCarthy JP, Bamman MM. Effects of resistance training on older adults. Sports Med. 2004;34:329-348.
7. Visser M, Goodpaster BH, Kritchevsky SB, Newman AB, Nevitt M, Rubin SM, Simonsick EM, Harris TB. Muscle mass, muscle strength, and muscle fat infiltration as predictors of incident mobility limitations in well-functioning older persons. J Gerontol A Biol Sci Med Sci. 2005;60:324-333.
8. Lord SR, Murray SM, Chapman K, Munro B, Tiedemann A. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J Gerontol A Biol Sci Med Sci. 2002;57:M539-M543.
9. Bean JF, Kiely DK, Herman S, Leveille SG, Mizer K, Frontera WR, Fielding RA. The relationship between leg power and physical performance in mobility-limited older people. J Am Geriatr Soc. 2002;50:461-467.
10. Galvão DA, Taaffe DR. Resistance exercise dosage in older adults: single-versus multiset effects on physical performance and body composition. J Am Geriatr Soc. 2005;53:2090-2097.
11. Henwood TR, Taaffe DR. Improved physical performance in older adults undertaking a short-term programme of high-velocity resistance training. Gerontology. 2005;51:108-115.
12. Campbell WW, Crim MC, Young VR, Evans WJ. Increased energy requirements and changes in body composition with resistance training in older adults. Am J Clin Nutr. 1994;60:167-175.
13. Treuth MS, Ryan AS, Pratley RE, Rubin MA, Miller JP, Nicklas BJ, Sorkin J, Harman SM, Goldberg AP, Hurley BF. Effects of strength training on total and regional body composition in older men. J Appl Physiol (1985). 1994;77:614-620.
14. Hunter GR, Bryan DR, Wetzstein CJ, Zuckerman PA, Bamman MM. Resistance training and intra-abdominal adipose tissue in older men and women. Med Sci Sports Exerc. 2002;34:1023-1028.
15. Visser M, Deeg DJ, Lips P, Harris TB, Bouter LM. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. J Am Geriatr Soc. 2000;48:381-386.
16. Anderson K, Behm DG. The impact of instability resistance training on balance and stability. Sports Med. 2005;35:43-53.
17. Lee IH, Park SY. Balance improvement by strength training for the elderly. J Phys Ther Sci. 2013;25:1591-1593.
18. Joshua AM, D'Souza V, Unnikrishnan B, Mithra P, Kamath A, Acharya V, Venugopal A. Effectiveness of progressive resistance strength training versus traditional balance exercise in improving balance among the elderly - a randomised controlled trial. J Clin Diagn Res. 2014;8:98-102.
19. American College of Sports Medicine; Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, Skinner JS. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc. 2009;41:1510-1530.
20. Schlicht J, Camaione DN, Owen SV. Effect of intense strength training on standing balance, walking speed, and sit-to-stand performance in older adults. J Gerontol A Biol Sci Med Sci. 2001;56:M281-M286.
21. Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in community-dwelling older adults. J Gerontol A Biol Sci Med Sci. 2003;58:171-175.
22. DeBolt LS, McCubbin JA. The effects of home-based resistance exercise on balance, power, and mobility in adults with multiple sclerosis. Arch Phys Med Rehabil. 2004;85:290-297.
23. Orr R, Raymond J, Fiatarone Singh M. Efficacy of progressive resistance training on balance performance in older adults: a systematic review of randomized controlled trials. Sports Med. 2008;38:317-343.
24. Fiatarone MA, Marks EC, Ryan ND, Meredith CN, Lipsitz LA, Evans WJ. High-intensity strength training in nonagenarians. Effects on skeletal muscle. JAMA. 1990;263:3029-3034.
25. Taaffe DR, Duret C, Wheeler S, Marcus R. Once-weekly resistance exercise improves muscle strength and neuromuscular performance in older adults. J Am Geriatr Soc. 1999;47:1208-1214.

26. de Vos NJ, Singh NA, Ross DA, Stavrinos TM, Orr R, Fiatarone Singh MA. Optimal load for increasing muscle power during explosive resistance training in older adults. J Gerontol A Biol Sci Med Sci. 2005;60:638-647.

27. Harris S, Ruffin E, Brewer W, Ortiz A. Muscle activation patterns during suspension training exercises. Int J Sports Phys Ther. 2017;12:42-52.

28. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, Fábrega-Cuadros R, Aibar-Almazán A, Cruz-Díaz D, Martínez-Amat A. Risk of falls in healthy older adults: benefits of high-intensity interval training using lower body suspension exercises. J Aging Phys Act. 2019;27:325-333.

29. Jordan SL, Brinkman B, Harris S, Cole T, Ortiz A. Core musculature co-contraction during suspension training exercises. J Bodyw Mov Ther. 2022;30:82-88.

30. Campa F, Silva AM, Toselli S. changes in phase angle and handgrip strength induced by suspension training in older women. Int J Sports Med. 2018;39:442-449.

31. Jiménez-García JD, Martínez-Amat A, De la Torre-Cruz MJ, Fábrega-Cuadros R, Cruz-Díaz D, Aibar-Almazán A, Achalandabaso-Ochoa A, Hita-Contreras F. Suspension training HIIT improves gait speed, strength and quality of life in older adults. Int J Sports Med. 2019;40:116-124.

32. Soligon SD, da Silva DG, Bergamasco JGA, Angleri V, Júnior RAM, Dias NF, Nóbrega SR, Cesar MC, Libardi CA. Suspension training vs. traditional resistance training: effects on muscle mass, strength and functional performance in older adults. Eur J Appl Physiol. 2020;120:2223-2232.

33. Angleri V, Soligon SD, da Silva DG, Bergamasco JGA, Libardi CA. Suspension training: a new approach to improve muscle strength, mass, and functional performances in older adults? Front Physiol. 2020;10:1576.

34. Gaedtke A, Morat T. TRX Suspension training: a new functional training approach for older adults - development, training control and feasibility. Int J Exerc Sci. 2015;8:224-233.

35. Baltes PB, Lindenberger U. Emergence of a powerful connection between sensory and cognitive functions across the adult life span: a new window to the study of cognitive aging? Psychol Aging. 1997;12:12-21.

36. Raz N, Lindenberger U, Rodrigue KM, Kennedy KM, Head D, Williamson A, Dahle C, Gerstorf D, Acker JD. Regional brain changes in aging healthy adults: general trends, individual differences and modifiers. Cereb Cortex. 2005;15:1676-1689.

37. Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA. Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. Arch Neurol. 2009;66:1339-1344.

38. Tangen GG, Engedal K, Bergland A, Moger TA, Mengshoel AM. Relationships between balance and cognition in patients with subjective cognitive impairment, mild cognitive impairment, and Alzheimer disease. Phys Ther. 2014;94:1123-1134.

39. Bherer L, Erickson KI, Liu-Ambrose T. A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. J Aging Res. 2013;2013:657508.

40. Ozkaya GY, Aydin H, Toraman FN, Kizilay F, Ozdemir O, Cetinkaya V. Effect of strength and endurance training on cognition in older people. J Sports Sci Med. 2005;4:300-313.

41. Liu-Ambrose T, Nagamatsu LS, Graf P, Beattie BL, Ashe MC, Handy TC. Resistance training and executive functions: a 12-month randomized controlled trial. Arch Intern Med. 2010;170:170-178.

42. Chang YK, Pan CY, Chen FT, Tsai CL, Huang CC. Effect of resistance-exercise training on cognitive function in healthy older adults: a review. J Aging Phys Act. 2012;20:497-517.

43. Peterson MD, Rhea MR, Sen A, Gordon PM. Resistance exercise for muscular strength in older adults: a meta-analysis. Ageing Res Rev. 2010;9:226-237.

44. Liu-Ambrose T, Nagamatsu LS, Voss MW, Khan KM, Handy TC. Resistance training and functional plasticity of the aging brain: a 12-month randomized controlled trial. Neurobiol Aging. 2012;33:1690-1698.

45. Smolarek Ade C, Ferreira LH, Mascarenhas LP, McAnulty SR, Varela KD, Dangui MC, de Barros MP, Utter AC, Souza-Junior TP. The effects of strength training on cognitive performance in elderly women. Clin Interv Aging. 2016;11:749-754.

46. Ikudome S, Mori S, Unenaka S, Kawanishi M, Kitamura T, Nakamoto H. Effect of long-term body-mass-based resistance exercise on cognitive function in elderly people. J Appl Gerontol. 2017;36:1519-1533.

47. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, Cummings JL, Chertkow H. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53:695-699.

48. Selekler K, Cangoz B, Uluc S. Power of discrimination of Montreal Cognitive Assessment (MOCA) Scale in Turkish patients with mild cognitive impairment and Alzheimer's disease. Turk J Geriatr. 2010;13:166-171.

49. Rikli RE, Jones CJ. Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years. Gerontologist. 2013;53:255-267.

50. Sahin F, Yilmaz F, Ozmaden A, Kotevolu N, Sahin T, Kuran B. Reliability and validity of the Turkish version of the Berg Balance Scale. J Geriatr Phys Ther. 2008;31:32-37.

51. Cohen J. Statistical power analyses for the behavioral sciences (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.1998.

52. Yu W, An C, Kang H. Effects of resistance exercise using thera-band on balance of elderly adults: a randomized controlled trial. J Phys Ther Sci. 2013;25:1471-1473.

53. Aguilera-Castells J, Buscà B, Fort-Vanmeerhaeghe A, Montalvo AM, Peña J. Muscle activation in suspension training: a systematic review. Sports Biomech. 2020;19:55-75.

54. Kronenberg G, Bick-Sander A, Bunk E, Wolf C, Ehninger D, Kempermann G. Physical exercise prevents age-related decline in precursor cell activity in the mouse dentate gyrus. Neurobiol Aging. 2006;27:1505-1513.

55. van Praag H, Shubert T, Zhao C, Gage FH. Exercise enhances learning and hippocampal neurogenesis in aged mice. J Neurosci. 2005;25:8680-8685.

56. Coelho-Junior H, Marzetti E, Calvani R, Picca A, Arai H, Uchida M. Resistance training improves cognitive function in older adults with different cognitive status: a systematic review and Meta-analysis. Aging Ment Health. 2022;26:213-224.

57. Olson AK, Eadie BD, Ernst C, Christie BR. Environmental enrichment and voluntary exercise massively increase neurogenesis in the adult hippocampus via dissociable pathways. Hippocampus. 2006;16:250-260.

58. Sanders LMJ, Hortobágyi T, la Bastide-van Gemert S, van der Zee EA, van Heuvelen MJG. Dose-response relationship between exercise and cognitive function in older adults with and without cognitive impairment: a systematic review and meta-analysis. PLoS One. 2019;14:e0210036.

59. Langlois F, Vu TT, Chassé K, Dupuis G, Kergoat MJ, Bherer L. Benefits of physical exercise training on cognition and quality of life in frail older adults. J Gerontol B Psychol Sci Soc Sci. 2013;68:400-404.

60. Liu-Ambrose T, Nagamatsu LS, Graf P, Beattie BL, Ashe MC, Handy TC. Resistance training and executive functions: a 12-month randomized controlled trial. Arch Intern Med. 2010;170:170-178.

61. Cassilhas RC, Viana VA, Grassmann V, Santos RT, Santos RF, Tufik S, Mello MT. The impact of resistance exercise on the cognitive function of the elderly. Med Sci Sports Exerc. 2007;39:1401-1407.

62. Northey JM, Cherbuin N, Pumpa KL, Smee DJ, Rattray B. Exercise interventions for cognitive function in adults older than 50: a systematic review with meta-analysis. Br J Sports Med. 2018;52:154-160.

63. Pierle C, McDaniel AT, Schroeder LH, Heijnen MJH, Tseh W. Efficacy of a 6-week suspension training exercise program on fitness components in older adults. Int J Exerc Sci. 2022;15:1168-1178.