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THE EFFECTS OF DIFFERENT EXERCISE INTENSITIES ON THE STATIC AND DYNAMIC BALANCE OF OLDER ADULTS: A RANDOMISED CONTROLLED TRIAL

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Abstract This study aims to find the effectiveness of different exercise intensities (high-, moderate-, and low-intensity) on the dynamic and static balance of elderly women. A single-blinded factorial design study was conducted in healthy older adults (>65 years) in 12 weeks. The authors have assessed the Forward Reach Test (FRT), Lateral Reach Test (LRT), One Leg Stand (OLS), Tandem Stand Test (TST) in 60 healthy older women at a gym centre, Fit House located in Bukit Rimau, Kuala Lumpur, Malaysia. Participants were randomly assigned to a High-Intensity Training (HIT) group; (n=15) (Mean age 69.60 ± 3.68) who performed four exercises [Leg Press (LP), Leg Extension (LE), Leg Curl (LC), and Calf Raises (CR)] at 80 to 90% of One-Repetition Maximum (1RM); Moderate-Intensity Training (MIT) group (n=15) (Mean age 69.27 ± 3.41) performed at 65 to 75% of 1RM; Low-Intensity Training (LIT) group (n=15) (Mean age 69.27 ± 1.94) performed at 50 to 60% of 1 RM; and a Control Group (CG) (n = 15) (Mean age 68.67 ± 2.38) with no training. Data was collected at pre-test, 4th, 8th, and 12th weeks of intervention. 60 participants were analysed and the main effect of time showed a statistically significant difference in the mean of all variables (all $p < 0.001$), and also there was a statistically significant interaction between intervention and time on all variables (all $p < 0.001$). Different levels of intensity on only the lower extremities muscles had a significant effect on the dynamic balance and static balance of the elderly population. After four weeks of training HIT, MIT, and LIT illustrated significant improvement in dynamic balance, as well as static balance.

Keywords elderly, resistance training, high-intensity training, moderate-intensity training, low-intensity training, static balance, dynamic balance

Introduction

Ageing contributes to a reduction in static balance and dynamic balance. There is evidence that muscular weakness is highly associated with impaired balance and poses an increased risk of falls. Moreover, lower extremity muscle weakness has been identified as the dominant intrinsic fall-risk factor with a five-fold increase in the risk of falling (Rubenstein, 2006). This downward cycle can lead to reduced muscle quality, fatigability, hypertension, heightened disability, increased risk of developing cardiovascular disease, premature mortality, respiratory failure, and an increased risk of fall (Ghaffari et al., 2016; Jaul, Barron, 2017; Park et al., 2020; Wu, Ouyang, 2017). The lack of productivity also increases the chance of low muscle strength which becomes greater at the age of 70 years and above (Tournadre, Vial, Capel, Soubrier, Spine, 2019). Physical inactivity is estimated to be the primary cause of approximately 21 to 25% of breast and colon cancers, 27% of diabetes, and approximately 30% of heart disease worldwide (WHO, 2019).

In this regard, Resistance training (RT) programmes have been widely supported as a major countermeasure to the age-related declines mentioned above. Many studies have emphasised the safety and efficacy of strength training in older people, it is considered as a safe type of exercise for older adults, with hardly any related injuries or any report of adverse events (Aartolahti, Lönnroos, Hartikainen, Häkkinen, 2020; Lichtenberg, Von Stengel, Sieber, Kemmler, 2019; Müller et al., 2020; Sahin et al., 2018; Watson et al., 2015). (Moro et al., 2017; Müller et al., 2020; Sahin et al., 2018) suggest that high-intensity RT can be safely performed by older individuals, and it is also emerging as a safe and effective means to combat chronic diseases (Keating, Johnson, Mielke, Coombes, 2020). When addressing safety in an ageing population, it is always important to note that the intensity of RT (high, moderate, or low) is relative to the participant's level of fitness (Keating et al., 2020).

During the past several years, some organisations have released recommendations concerning RT programmes to provide a framework for training prescription guidelines for individuals of different trainability status, especially for older adults (Fragala et al., 2019; Nascimento, Ingles, Salvador-Pascual, Cominetti, Gomez-Cabrera, Viña, 2019). There have been recommendations that address effective RT to gain muscle strength and mass. RT can produce benefits in strength and balance performance, According to World Health Organization, older adults should participate in moderate intensity activities for minimum 150 minutes in a week and also, they should be involved in a strength resistance activities 2 or more days in a week (WHO, 2010). The Positive effects of RT has been reported by (Amarante et al., 2020) even after detraining the older women can regain the RT program benefits and (Marques, Figueiredo, Harris, Wanderley, Carvalho, 2017) reported that there was a significant improvement after RT training in old women. But the distribution of the training intensities must be carefully investigated and planned. However, there is a lack of information about what type of intensity can help the elderly to improve stability factors such as dynamic and static balance, to be faster and more effective (Cobbold, 2018; Marcos-Pardo et al., 2019). There have only been a few studies related to RT intensity so therefore this question has yet to be solved regarding the effectiveness of different intensities. Therefore, this current study is aimed at comparing the effects of 12-week different exercise intensities on balance factors of healthy older women. The hypothesis was that higher intensity training would be more effective in the 4th, 8th, and 12th weeks of intervention.

Materials and Methods

Study design

A single blinded factorial design randomised controlled trial has been conducted in healthy older adults at a gym centre, Fit House located in Bukit Rimau, Kuala Lumpur, Malaysia, from November 2019 till January 2020. All participants were informed about the experimental procedures and potential risks before they provided their written informed consent. The investigation was conducted according to the Declaration of Helsinki and was approved by the University Putra Malaysia Interior Research Ethics Committee (JKEUPM-2018-333), (Trial Registration: NCT04901520). In addition, this randomised clinical trial was designed according to CONSORT guidelines (https://www.consort-statement.org/).

Participants

Sample size estimation was conducted using G*Power version 19. An effect size of 0.25 level of 0.05 and a Power (1-β err prob) of 0.95 indicated that it would be necessary to include at least 52 volunteers (15 subjects per group). According to 15% possibility of dropout, according to 15% possibility dropout, 60 participants in this study were participated. The sample was primarily selected through interview or clinical referrals. The inclusion criteria were that subjects should be 65 years old and above, able to follow the simple instructions, and perform the exercises, without any health problems that would possibly interfere their safety or ability to complete High Intensity Training (HIT), Moderate Intensity Training (MIT) and Low Intensity Training (LIT).The exclusion criteria such as the occurrence of myocardial infarction in the past six months, recent heart attack, uncontrolled hypertension (Blood Pressure >166/96 mm Hg), broken leg in the past six months, diagnosed osteoporosis, and diagnosed stage three or four of heart failure, not participating in regular balance or lower body RT during the past three months and not taking regular medication that could impair balance ability (Antidepressants, Neuroleptics or Benzodiazepines) or muscle strength (Corticosteroids). Sixty healthy Malaysian elderly women (age range: 65 to 76 years old) were eligible to participate in this study. The data was measured as Mean ± *SD.* After an initial evaluation, the participants were randomly assigned to four groups: HIT (n = 15), MIT (n = 15), LIT (n = 15), and CG (n = 15) by a computerised random-number generator (See Figure 1). The process of randomisation was carried out by a blinded researcher who was not affiliated with the study.

Researcher obtained their signature for consent forms from all the participants. All the participants were blinded regarding their group allocation, and they completed the entire study. If any participants could not join the training session, then an alternative session in the same week was arranged for them and all the training sessions were conducted in the Fitness Centre in Atria Shopping Mall located in Petaling Jaya, Kuala Lumpur. The characteristics of the subjects are displayed in Table 1.

Table 1. Demographic Characteristics at baseline

Demographic Characteristics	HIT (N = 15)	MIT (N = 15)	LIT (N = 15)	CG (N = 15)	P-Value*
Age	69.60 (3.68)	69.27 (3.41)	69.27 (1.94)	68.67 (2.38)	0.85
Height (cm)	167.28 (3.50)	166.34 (5.24)	166.60 (3.20)	167.17 (3.85)	0.91
Weight (kg)	77.86 (5.76)	75.60 (5.61)	75.68 (4.55)	75.26 (5.25)	0.52
BMI (kg/m^2)	28.01 (1.23)	27.50 (1.94)	26.70 (2.15)	26.74 (1.47)	0.12

Data is presented as mean ± SD.

* Obtained from the one-way analysis of variance (ANOVA).

Abbreviations: N = Number of subjects; M = Mean; SD = Standard Deviation; HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; BMI= Body Mass Index; FM= Fat Mass; FFM= Fat Free Mass.

Measurements

Anthropometry: Upon arriving at the training location, the subjects were instructed to empty their bladders within 30 minutes of anthropometric measurements. Body mass was measured to the nearest 0.1 kg using a calibrated electronic scale (Omron Body Composition Monitor Weighing) (KYOTO, 617-0002 JAPAN) (Jensky-Squires, Dieli-Conwright, Rossuello, Erceg, McCauley, Schroeder, 2008), with the subjects wearing light workout clothing and no shoes. Height was measured to the nearest 0.1 cm with a stadiometer attached on the scale with subjects standing with no shoes. Body mass index (BMI) was calculated as body mass in kilograms divided by the square root of the height in metres.

Dynamic Balance: Lateral Reach Test (LRT) and Forward Reach Test (FRT) tests were used to measure dynamic balance.

a) ***FRT*** *is taken as* the maximum length that a person might reach forward beyond arm's length while maintaining a stable standing position (Costarella, Monteleone, Steindler, Zuccaro, 2010). To measure this test, it is required to mount a measuring tape on the wall nearly at the shoulder height of the subject. The subject will stand next to, but not touching, the wall and elevate the arm that is nearer to the wall to 90 degrees shoulder flexion with a closed fist. After that, the subject should lean forward along the yardstick as far as possible without losing balance or taking a step. The distance will be measured in centimetres on the measuring tape. Each subject performed one practice and two trials that the longest score of two trials was recorded.

b) Older Adults often experience lateral falls. Therefore, it is necessary to test the lateral stability to identify fall risk (Takahashi et al., 2006). *To measure the* ***LRT***, the subject was asked to stand straight near and with the back against the wall. They were instructed to elevate the arm to 90 degrees shoulder and reach sideward as far as possible through the measuring tape mounted on the wall without losing balance, taking a step, or touching the wall with a dominant hand. The feet should remain completely in contact on the floor throughout the test. Each subject should maintain the maximal lateral reach position for three seconds before coming back to the initial position. Each subject performed one practice trial for familiarisation and two test trials. The best performance score of two trials was recorded.

Static Balance: To measure the static balance, Tandem Stand Test (TST) and One Leg Stand (OLS) was performed. The subjects performed one practice and two trials for each test, and the average time from the two trials was reported.

a) ***TST*** is an accepted clinical measurement of standing balance (Bergquist et al., 2019). To measure this test, the subject places the heel of one foot in front of and touching the big toe of the other foot in a straight line. The tester will demonstrate the tandem stance position and then instruct the participant to stay in this position and maintain it for a maximum of 30 seconds without losing balance or taking a step. The duration was measured by a stopwatch.

b) ***OLS*** is usually used for measuring postural stability in the elderly (Leirós-Rodríguez, Romo-Pérez, García-Soidán, 2017; Motalebi, Cheong, Iranagh, Mohammadi, 2018). The ability to stand on one leg needs to move the centre of mass towards the standing leg as well as preserving postural alignment in the space. This task demands control of body weight, the upright alignment of all the body parts and a sense of equilibrium. The OLS evaluates the static balance through the number of seconds when a person might preserve the one-leg position. It is assumed that people with higher postural steadiness can stand for a longer time on one leg. In the current study, the maximum OLS duration was 30 seconds based on Bohannon's ordinal balance assessment scale.

In this test, a subject should take the back of a chair and stand on the preferred leg and then take the hands off the chair and control their balance on one leg without any support for a maximum of 30 seconds. The time was measured by a digital stopwatch. Each subject performed one-time practice and two trials, and the average time for the two trials was reported.

Procedures

The total duration of the study was 14 weeks, of which the first 2 weeks (1 to 2 weeks) were used for familiarisation with the RT programme exercises and pre-training measures, and after 12 weeks of intervention a post-training measurement was performed. A supervised progressive RT programme was undertaken between weeks 2 to 14. Training was performed twice per week during the morning hours (8 to 9 AM). The protocol was based on RT recommendations for the older population to improve muscle endurance and muscular strength. All subjects were personally supervised by physical education professionals with substantial RT experience to ensure consistent and safe performance.

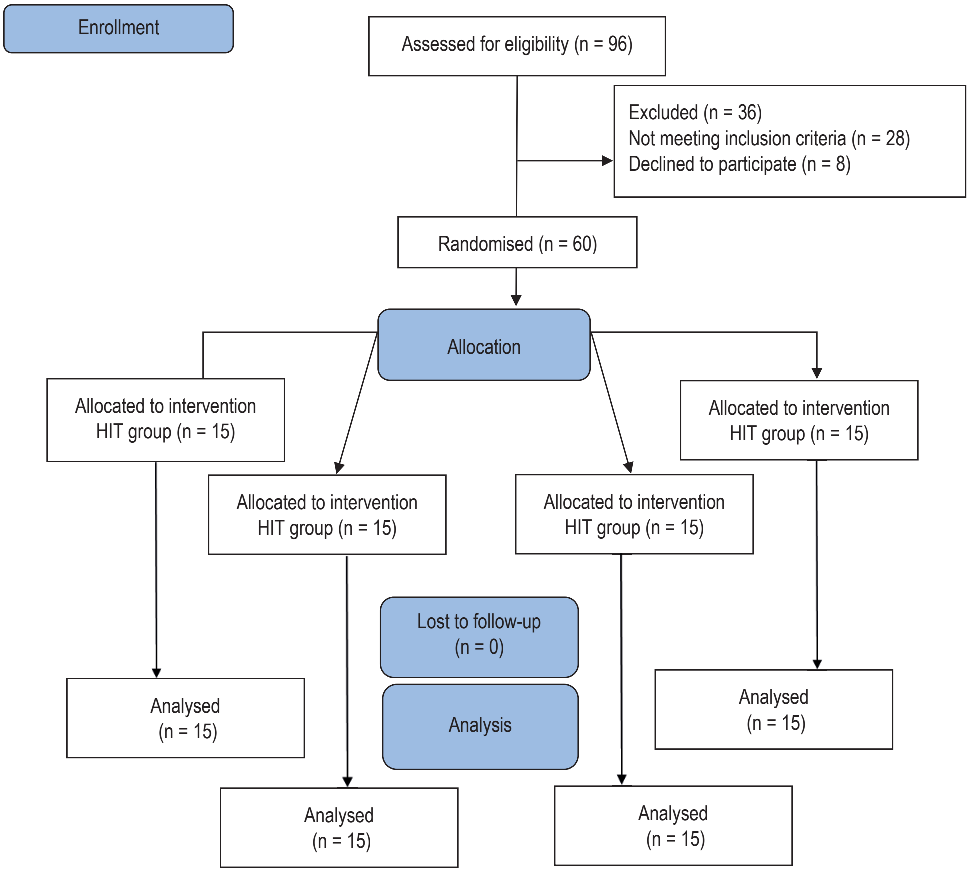
Subjects performed different intensities RT using machines. The RT programme was a lower extremity programme with four exercises performed in the following order: Leg Press (LP), Leg Extension (LE), Leg Curl (LC), and Calf Raises (CR). The intensity of the strength training in this study was determined individually by an indirect method to evaluate One Repetition Maximum (1 RM): after a couple of introductory training sessions, the prediction of training load was evaluated using 3 to 6 repetitions (Bechshøft et al., 2017). A 3 to 6 RM test was chosen because it was suitable to test maximal strength in subjects with little or no previous resistance training experience (Liguori et al., 2020), and this technique has been shown to have a high reproducibility (r = 0.99) in the laboratory (Paoli et al., 2013). Using the results of the strength testing, 1RMs were estimated with the Brzycki formula: 1 RM (estimated) = load (kg) / [1.0278 − (0.0278 × number of repetitions)].

After calculating the 1 RM, participants were randomly assigned to the experimental groups performing different intensity RTs, while those assigned to the Control Group (CG) merely undertook daily-life activities (without training). All experimental groups performed the RT programme twice a week for 12 weeks. HIT group trained with 80 to 90% of their 1RM, the MIT group 65 to 75% of their 1RM and the LIT group (50 to 60% of their 1RM). RT was the same across the experimental groups, consisting of LP, LE, LC, and CR which was designed based on recent pieces of evidence.

All subjects were evaluated in one session. Before the testing session, the anthropometric measurement had been taken. During the testing session, the participants performed the following: FRT, LRT, OLS, TST. During the two weeks preceding this study, four preliminary familiarisation sessions were undertaken to ensure a properly executed technique in all exercises by all participants. To evaluate the effectiveness of different intensities, the same tests were performed after the 4th, 8th, and 12th weeks of training. Throughout this period, the participants were asked to refrain from participating in regular exercise programmes outside the study aimed at developing or maintaining strength.

Subjects were instructed to inhale during the eccentric muscle action and exhale during the concentric muscle action while maintaining a constant velocity of movement at a ratio of 1 : 2 (concentric and eccentric muscle actions, respectively). Subjects were afforded a 2 to 3-minute rest between each exercise. The instructors adjusted the loads of each exercise according to the ability of the subjects and improvements in exercise capacity throughout the study to ensure that they were exercising with as much resistance as possible while maintaining proper exercise execution technique. Progression was planned if the subject could perform full sets and repetitions such that the weight was increased 5 to 10% in the next training session. During both RT phases, instructors registered the load (in kilograms) and repetitions performed for each of the four exercises from all subjects during each session. All subjects were asked to maintain their normal diet throughout the study period.

Figure 1. Study Flow Diagram



Statistical Analysis

The normality of the data from the study was confirmed using the Shapiro–Wilk test and Q-Q plots. Possible group differences at the baseline were examined using a one-way analysis of variance (ANOVA). A time (baseline, 4th, 8th, and 12th weeks) × group (HIT vs. MIT vs. LIT vs. CG) factorial ANOVA with repeated measures was performed to determine differences between the treatments and also the multivariate analysis of variance (ANOVA) was performed to find the effect of two tests on one variable. A two-way analysis of covariance (ANCOVA) for repeated measures was performed with the baseline scores used as a covariate to eliminate any possible influence of initial score variances on training outcomes (Van Breukelen, 2006; Vickers, Altman, 2001). While the raw unadjusted and ANCOVA-adjusted data for main outcomes was presented, statistical interpretations were made from the ANCOVA-adjusted results. This was followed by the appropriate Bonferroni and Tukey post hoc test when a significant treatment and treatment-by-time interaction was revealed. In variables where the sphericity was violated as indicated by the Mauchly test, the analyses were adjusted using a Greenhouse-Geisser correction. The effect size partial eta squared ($\eta 2$) was used for comparisons of effects within the study. Statistical significance was set at $P < 0.05$. IBM SPSS (version 26, IBM) was used to analyse the data.

Results

Overall compliance of subjects to the RT programme was 100% as a replacement session was arranged if a subject could make any of the sessions and also there were no dropouts during the study. There were no significant differences between groups for age, body mass, height, BMI, FRT, LRT, OLS, and TST, at baseline ($P > 0.05$). Assessments were done at baseline, 4th, 8th, and 12th weeks of interventions, and the results presented in Table 2. No adverse events were reported during testing or training in all groups. There were only a few reports regarding muscle soreness in the first two weeks of training.

Dynamic Balance:

FRT: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each treatment level illustrated that there was a statistically significant difference between times at each treatment level except for the CG. The effect of time in all groups showed that all pairwise comparisons for the intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that, HIT compared with LIT at 12th week ($P < 0.001$) of intervention, HIT compared with CG at 8th week ($P < 0.001$) and 12th week ($P < 0.001$) of intervention was statistically significant. MIT compared with CG at 8th week ($P = 0.007$), 12th week ($P < 0.001$) of intervention was statistically significant. LIT compared with CG at 12th week ($P = 0.005$) of intervention was statistically significant. (See Figure 1).

LRT: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each treatment level illustrated that there was a statistical significance between times at each treatment level except for the CG. The effect of time in all groups showed that all pairwise comparisons for intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that HIT compared with MIT at 12th week ($P < 0.001$) of intervention, HIT compared with LIT at 8th week ($P = 0.001$) and 12th week ($P < 0.001$) of intervention, HIT compared with CG at 4th week ($P < 0.001$), 8th week ($P < 0.001$), and 12th week ($P < 0.001$) of intervention was statistically significant. MIT compared with LIT at 4th week, 8th weeks, 12th week of intervention was not statistically significant. MIT compared with CG at 4th week ($P = 0.004$), 8th week ($P < 0.001$), 12th week ($P < 0.001$) of intervention was statistically significant. Also, LIT compared with CG at 4th week ($P = 0.011$), 8th week ($P < 0.001$), 12th week ($P < 0.001$) of intervention was statistically significant (See Figure 1).

The authors attempted to understand the overall effects of FRT, and LRT on dynamic balance, as such the multivariate analysis of variance (ANOVA) was undertaken for both test and the results presented in Table 3. The authors found there was a significant effect of different intensity training on dynamic balance ($P < 0.001$, = 0.847) and also when the baseline value outcomes were adjusted ($P < 0.001$, = 0.848).

Static Balance:

OLS: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each treatment level illustrated that there was a statistical significance between times at each treatment level except for the CG. The effect of time in all groups showed that all pairwise comparisons for the intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that only HIT compared with CG at 12th week ($P = 0.021$) of intervention was statistically significant. MIT compared with LIT at 4th week, 8th week and 12th week of intervention were not statistically significant. MIT compared with CG at 12th week ($P = 0.038$) of intervention, LIT compared with CG at 12th ($P = 0.047$) week of intervention was statistically significant. (See Figure 1).

TST: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each intensity level illustrated that there was a statistically significant difference between the times at each treatment level except the CG. The effect of time in all groups showed that all pairwise comparisons for intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that HIT compared with CG at 8th week ($P = 0.007$) and 12th week ($P < 0.001$) of intervention is statistically significant. MIT compared with LIT at 4th week, 8th week, and 12th week of intervention was not statistically significant. MIT with CG 8th week ($P = 0.007$), and 12th week ($P < 0.001$) of intervention, LIT compared with CG at 8th week ($P = 0.023$), and 12th week ($P = 0.002$) of intervention was statistically significant (See Figure 1).

The authors attempted to understand the overall effects of OLS, and TST on static balance, as such the multivariate analysis of variance (ANOVA) was performed for both test and the result as presented in Table 3. It was found that there was a significant effect of different intensity training on dynamic balance ($P < 0.001$, = .765) and when the baseline value outcomes were adjusted ($P < 0.001$, = .766).

Figure 2. Comparison between HIT, MIT, LIT and CG at baseline, 4th, 8th, and 12th week of intervention

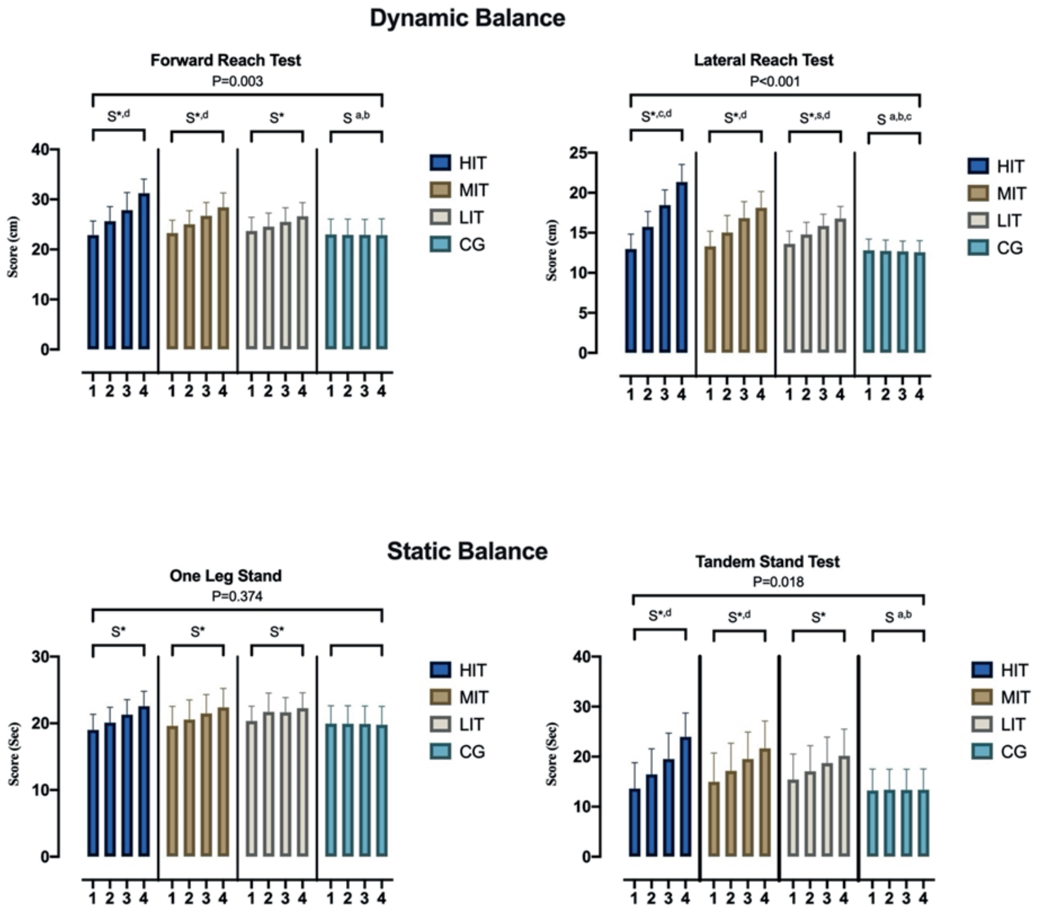


Table 2. The effect of different intensity training on different variables among study participants after 4th, 8th, and 12th week of intervention

		Baseline	4th week	8th week	12th week	Change	P-Value* (partial eta square)		
							Time	Group	Time*group
FRT							<0.001 (.85)	0.003 (.22)	<0.001 (.76)
	HIT	22.83 (2.81)	25.65 (2.89)	27.86 (3.51)	31.23 (2.83)	8.38 (.64)[d]			
	MIT	23.28 (2.56)	25.04 (2.71)	26.70 (2.69)	28.42 (2.87)	5.14 (1.02)[d]			
	LIT	23.70 (2.71)	24.56 (2.71)	22.52 (2.80)	26.63 (2.73)	2.93 (.47)			
	CG	22.99 (3.08)	22.91 (3.15)	22.90 (3.10)	22.85 (3.25)	–0.14 (.53)[a,b]			
LRT							<0.001 (.96)	<0.001 (.48)	<0.001 (.94)
	HIT	12.69 ±1.87	15.75 ±1.91	18.46 ±1.90	21.34 ±2.18	8.38 (.72)[c,d]			
	MIT	13.30 ±1.88	15.04 ±2.12	16.82 ±2.07	18.13 ±2.04	4.83 (.63)[d]			
	LIT	13.61 ±1.59	14.79 ±1.51	15.84 ±1.48	16.78 ±1.50	3.17 (.43)[a,d]			
	CG	12.81 ±1.40	12.72 ±1.36	12.67 ±1.29	12.57 ±1.44	–0.24 (.49)[a,b,c]			
OLS							<0.001 (.63)	0.374 (.05)	<0.001 (.47)
	HIT	19.00 ±2.35	20.10 ±2.30	21.28 ±2.28	22.56 ±2.21	3.56 (.32)			
	MIT	19.58 ±2.94	20.53 ±2.95	21.44 ±2.84	22.35 ±2.86	2.76 (.30)			
	LIT	20.34 ±2.21	21.71 ±2.81	21.64 ±2.22	22.28 ±2.30	1.93 (.30)			
	CG	19.94 ±2.69	19.92 ±2.71	19.90 ±2.68	19.78 ±2.75	–0.15 (.64)			
TST							<0.001 (.85)	0.018 (.16)	<0.001 (.73)
	HIT	13.60 ±5.19	16.44 ±5.11	19.53 ±5.15	23.94 ±4.78	10.34 (3.75)[d]			
	MIT	14.96 ±5.75	17.15 ±5.53	19.51 ±5.39	21.64 ±5.48	6.68 (.82)[d]			
	LIT	15.41 ±5.12	17.06 ±5.15	18.72 ±5.17	20.18 ±5.33	4.76 (.48)			
	CG	13.24 ±4.27	13.36 ±4.12	13.35 ±4.12	13.37 ±4.18	0.12 (0.56)[a,b]			

[a] Significant compared to HIT.
[b] Significant compared to MIT.
[c] Significant compared to LIT.
[d] Significant compared to CG.
*Obtained from the two-way (mixed) repeated measures (ANOVA).
Abbreviations: HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; FRT = Forward Reach Test; LRT = Lateral Reach Test; OLS = One Leg Stand Test; TST = Tandem Stand Test.

Table 3. Crude mean changes of outcome variables throughout the trial in the HIT, MIT, LIT, and CG

			HIT	MIT	LIT	CG	P-Value	Partial eta square
1	2	3	4	5	6	7	8	9
Dynamic Balance**								
	Crude						<0.001	0.847
		FRT	8.38 ±0.64[b,c,d]	5.14 ±1.02[a,c,d]	2.93 ±0.47[a,b,d]	–0.14 ±0.53[a,b,c]	<0.001	0.955
		LRT	8.38 ±0.72[b,c,d]	4.83 ±0.63[a,c,d]	3.17 ±0.43[a,b,d]	–0.24 ±0.49[a,b,c]	<0.001	0.968
	Adjusted[b]						<0.001	0.848
		FRT	8.39 ±0.18[b,c,d]	5.13 ±0.18[a,c,d]	2.90 ±0.18[a,b,d]	–0.11 ±0.18[a,b,c]	<0.001	0.955

1	2	3	4	5	6	7	8	9
		LRT	8.37 ±0.15[b,c,d]	4.83 ±0.15[a,c,d]	3.17 ±0.15[a,b,d]	–0.23 ±0.15[a,b,c]	<0.001	0.968
Static Balance **								
	Crude						<0.001	0.765
		OLS	3.56 ±0.32[b,c,d]	2.76 ±0.30[a,c,d]	1.93 ±0.30[a,b,d]	–0.15 ±0.64[a,b,c]	<0.001	0.921
		TST	10.34 ±3.75[b,c,d]	6.68 ±0.82[a,d]	4.76 ±0.48[a,d]	0.12 ±0.56[a,b,c]	<0.001	0.791
	Adjusted[e]						<0.001	0.766
		OLS	3.54 ±0.11[b,c,d]	2.76 ±0.11[a,c,d]	1.95 ±0.11[a,b,d]	–0.15 ±0.11[a,b,c]	<0.001	0.920
		TST	10.28 ±0.50[b,c,d]	6.74 ±0.49[a,d]	4.87 ±0.50[a,d]	0.01 ±0.50[a,b,c]	<0.001	0.801

Data is presented as mean ± SE.
Changes obtained through this formula: Final – Baseline.
* Obtained from the Univariate Analysis of Variance (ANOVA).
** Obtained from Multivariate Analysis of Variance (ANOVA).
[a] Significant compared to HIT.
[b] Significant compared to MIT.
[c] Significant compared to LIT.
[d] Significant compared to CG.
[e] Adjust for baseline values.
Abbreviations: HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; FRT = Forward Reach Test; LRT = Lateral Reach Test; OLS = One Leg Stand Test; TST = Tandem Stand Test.

Discussion

Although there have been some studies where an experiment was conducted to determine the effect of different intensity RT on static and dynamic balance, to the best of our knowledge the present experiment is the first study to assess HIT, MIT, LIT and CG at the same time to find their exact effect and also to have a better understanding of their role in the body at different time points.

The main study objective was to compare the effects of different RT intensities on dynamic balance, and static balance of elderly women. The data was collected at the 4th, 8th, and 12th week of intervention. All experimental groups showed improvements in the assessed variables, specifically the FRT, LRT, OLS, and TST. Furthermore, HIT (80 to 90% 1RM) seemed to be more effective than MIT (65 to 75% 1RM), LIT (50 to 60% 1RM) and CG (no training) for improvement in FRT, LRT, and TST at different time points, but there was no difference between groups in OLS. These findings reveal that although all the RT intensities resulted in improvements, the HIT tended to result in higher gains after the 4th, 8th, and 12th week of training.

Previous studies reported the effects of different RT variables on dynamic and static balance. Progressive RT (Cancela Carral, Rodríguez, Cardalda, Gonçalves Bezerra, 2019; Marques et al., 2011; Martins et al., 2011), home-based training (Sparrow, Gottlieb, Demolles, Fielding, 2011) and also different intensity training (Marques et al., 2011; Nicklas, Chmelo, Delbono, Carr, Lyles, Marsh, 2015; Ramirez-Campillo et al., 2018; Shiotsu, Yanagita, 2018; Sparrow et al., 2011) have been shown to be effective to improve balance in elderly and even in home-dwelling hip fracture patients (Sylliaas, Brovold, Wyller, Bergland, 2011; Berg, Stutzer, Hoff, Wang, 2021).

The result of this study is in line with many previous studies that examined the effects of RT on the elderly population. In a study by Shiotsu, Yanagita (2018) those authors found greater dynamic balance improvement in a group who combined aerobic training with moderate intensity RT compared to aerobic and low-intensity RT. In addition, Ramirez-Campillo et al. (2018) concluded that two and three training sessions per week of RT with 75%

1RM were effective for improving balance in older women. In a 32-week study by Marques et al. (2011), the intensity of the training after two weeks was adjusted to 75 % to 80 % of 1 RM at a working range of six to eight repetitions for two sets and those authors found that 8 months RT could elicit significant gains in balance with moderate to high intensity compared to aerobic training and no training. Significant improvement in balance was found in the patients with hip fracture after three months of high-intensity RT (Sylliaas et al., 2011). In that study the authors studied the patients for 12 weeks and subjects trained three times per week with 70% (first three weeks) and 80% (for rest of the study) intensity and repetition dropped from 12 to 8. Those authors found a significant improvement in balance compared to the CG in the study. Along with different intensity training, some studies reported that RT generally could be effective to improve dynamic and static balance. Also Nicklas et al. (2015) looked to find balance improvements in RT with and without calorie restriction. They studied overweight and obese elderly and the subjects participated in the intervention for 20 weeks and three times per week with an intensity of 70% 1RM. Both RT and RT with calorie restriction improved balance significantly, which suggested that even with calorie restriction RT can be effective to improve balance.

As the current authors expected in this study, the result supported the previous studies that examined the different RT intensities concerning balance. It is worth noting that different studies have linked an increase in muscle strength to an increase in the ability to balance in the elderly (Lacroix et al., 2016; Lee, Park, 2013; Marques et al., 2017). This was likely due to the intrinsic factors associated with ageing, such as degenerative processes in the nervous and muscular systems that lead to muscle weakness and gait instability (Rubenstein, 2006). Hence also in this study an improvement in muscle strength as well as static and dynamic balance was observed which can support the previously mentioned studies.

Conclusion

Different levels of intensity on only lower extremities muscles have a significant effect on dynamic balance and static balance of the elderly population. After 4 weeks of training HIT, MIT, and LIT illustrated significant improvement in dynamic balance, as well as static balance. This result showed that even short-term lower body muscle strength training can be effective in the older population to increase their balance ability. The result was repeated at 8 and 12 weeks of training. HIT was found to be more effective than MIT, and MIT was more effective than LIT. However, LIT was more effective than no training in all at the three different time points (4, 8, and 12 weeks). Given the importance of RT for older adults, it was promising to note that the current intervention did not report any adverse events. This confirms the previous findings that HIT, MIT and LIT is feasible and safe for older adults.

Practical Applications

The results suggested that performing different intensity training may be beneficial for balance development in healthy older women. Furthermore, choosing HIT can be more beneficial in these variables compared to MIT, LIT, and no training. These findings should be considered useful to design RT programmes for healthy elderly women to gain their functional factors faster in a shorter time.

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