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The Role of High-, Moderate-, and Low-Intensity Training in Enhancing Functional Mobility and Muscle Strength of Aged Female: A Randomized Controlled Trial

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ABSTRACT

Resistance training provides many benefits to the older population, and it is considered one of the most effective ways to counter-attack age-related sarcopenia and dynapenia disorders. This article evaluates the impacts of high, moderate, and low training intensities on muscle strength and functional mobility of older adults. A single-blinded factorial design for 12 weeks was conducted among 60 healthy older Malaysian women (>65 years). The authors assessed the Five times Sit to Stand (5STS), the Timed Up and Go test (TUG), and the 6 Minutes Walking Test (6MWT). The participants were randomly divided to the High-Intensity Group (HIT; n=15) (69.60 ± 3.68); Moderate-Intensity Group (MIT; n=15) (69.27 ± 3.41); Low-Intensity Training (LIT; n=15) (69.27 ± 1.94); and Control Group (CG; n=15) (68.67 ± 2.38). In terms of time, there is a statistically noticeable difference in the means of all the variables (p< .001). Moreover, a statistically significant connection between the intervention and time was seen on all the variables (p< .001). However, there was a statistically significant difference between the means of 5STS (P< .001) and TUG (P= .025) in the intervention groups, there was no statistically significant difference observed in 6MWT (P= .90). The results suggested that all of these intensities training are beneficial for improving muscle strength and functional mobility. In addition, the HIT

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is more effective in improving the 5STS, TUG, and 6MWT, as compared to the MIT, LIT, and CG. These findings revealed that HIT tends to result in greater improvement of muscle strength and mobility.

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Keywords: High-intensity training, low-intensity training, moderate-intensity training, older adults, resistance training

INTRODUCTION

The world's population is currently projecting an upward growing old (United Nations, 2019). The aging population is defined as the increased number of citizens above 65 years old in absolute terms. Thus, the aging population is one of the most noteworthy demographic transitions and hence is contributing to the social changes of the twenty-first century (Reynaud & Miccoli, 2019). In addition, these changes have become a huge trouble for both the developed and developing countries due to the prompt conversion in the number of senior people that creates critical concern, especially regarding the health of senior citizens (Lyons et al., 2018). A report in 2018 revealed that the figure of individuals matured 65 or above had surpassed the number of kids under five worldwide. Meanwhile, the population with +80 years is predicted to triple, from 143 to 426 million people between 2019 and 2050 (United Nations, 2019).

Aging has a pivotal role in reducing and disfunction of strength and functional mobility in humans (Delmonico et al., 2009). Some studies have shown that muscular weakness is greatly related to mobility reduction and is causing an increased risk of falls. In addition, muscle weakness was labeled as one of the main contributing factors to fall, which causes a five-fold upturn in the risk of falling (Rubenstein, 2006). This descending muscle strength issue is causing various health consequences, such as decreased muscle quality, fatigability, hypertension, heightened disability, increased risk of developing cardiovascular disease, premature mortality, and respiratory failure (Cruz-Jentoft et al., 2019; Ghaffari et al., 2016; Jaul & Barron, 2017; M. J. Park et al., 2020; Wu & Ouyang, 2017). Non-productivity during the older age also boosted the chances of developing low muscle strength, as this issue tends to be higher in the 7th decade and above (Tournadre et al., 2019). Physical inactivity is a potential cause of colon and breast cancers (approximately 21-25%), heart disease (approximately 30%), and diabetes (27%) from all around the world (World Health Organization, 2019).

In the context of Malaysia, population aging is also rapidly growing as a result of increasing life expectancy, declining fertility, and mortality rates (Zamzamy Sormin et al., 2019). Malaysia is expected to transform into an aging population by 2030, estimating that 15% of the total population is categorized as elderly (Kenayathulla et al., 2016). One key issue raised by this dramatic demographic transformation is how healthy aging can be promoted in older adults (Chetty et al., 2016). Many Malaysian elders suffer from multiple chronic noncommunicable disorders. Therefore, by growing Malaysian older people, their health status seems to be a concern (Iddrisu et al., 2020).

As such, Resistance Training (RT) programs have been broadly supported as the main counteraction to the age-related deficits mentioned above. Many of the prior studies put emphasis on the safety and usefulness of strength training in senior people in order to consider and develop safer types of exercises for older adults with no related injuries or any reported adverse events (Aartolahti et al., 2020; Lichtenberg et al., 2019; Müller et al., 2020; Sahin et al., 2018; Watson et al., 2015). Moro et al. (2017), Müller et al. (2020), and Sahin et al. (2018) suggested that high-intensity RT can be performed safely even by older individuals and further stated that RT is a safe and effective means to fight against contracting chronic diseases (Keating et al., 2020). When addressing the safety issue of training in an aging population, it is vital to consider the intensity of RT (i.e., high, moderate, or low) to suit the fitness level of each participant so that the participants do not experience any extra pressures (Keating et al., 2020).

Over the last few years, some organizations have published suggestions regarding the RT programs aiming to establish a framework for training prescription guiding principles for individuals with different trainability statuses, especially for the older population (Fragala et al., 2019; Nascimento et al., 2019). Although suggestions to address effective RT training to gain more muscle strength and mass have been reported, very few studies have been carried out to determine the types of intense training that can lead the older adults population in improving their fitness factors, such as muscle strength, as well as to improve their mobility in the shortest time and with higher effectiveness (Cobbold, 2018; Marcos-Pardo et al., 2019). Therefore, this study aims to compare the impacts of various training intensities (specifically High, Moderate, and Low), performed in 12 weeks, on the muscle strength and mobility of healthy older women. The hypothesis is that the higher intensity training would be more effective in enhancing muscle strength and mobility, especially when measured in the 4th, 8th, and 12th weeks of interventions. To the best of our knowledge, the first study in Malaysia compares the effectiveness of different intensity training on muscle strength and functional mobility of aged people.

METHODS

Study Design

A single-blinded factorial design was conducted among the healthy older women population at a fitness center in Bukit Rimau, Petaling Jaya, Kuala Lumpur. Before participants sign the written consent form, they have informed about the study procedures and potential risks. The evaluation was done based on the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013) and was accepted by the University Putra Malaysia Interior Research Ethics Committee (JKEUPM-2018-333).

Moreover, this experiment was planned based on the CONSORT guidelines (https://www.consort-statement.org/).

Participants

The G*Power version 19 software was used to estimate the sample size. An effect size of 0.25 α level of 0.05 and a Power (1-β err prob) of 0.95 necessitates the use of at least 60 volunteers (15 participants per group). Participants were recruited using advertisements in public areas; as such, 96 participants were interested in participating in this study, the sample participants were primarily selected through interviews or clinical referrals. According to the inclusion criteria, the participants should be +65 years old, follow the simple training instructions and perform the exercises without any existing health problems, interfering with their safety or ability to complete high, moderate, and low intensities training. The health problems such as recent heart attack, the occurrence of myocardial infarction in the past six months, uncontrolled hypertension (Blood Pressure >166/96 mm Hg), diagnosed osteoporosis, the incidence of a broken leg in the past six months, and diagnosed stage three and four of heart failure were important in this regard. In addition, not participating in regular balance or lower body resistance training during the past three months and not taking any regular medications impair their balancing ability (Antidepressants, Neuroleptics, or Benzodiazepines) or muscle strength (Corticosteroids) were considered. In the end, 60 healthy aged Malaysian women (age range from 65 to 76 years old) were eligible to participate in this study (see Figure 1). The data was measured as Mean ± SD. The participants were randomly assigned to four groups: High-Intensity Training (HIT) (n=15), Moderate-Intensity Training (MIT; n=15), Low-Intensity Training (LIT; n=15), and CG (n=15) through a computerized random-number generator after an initial evaluation. A blinded researcher who was not affiliated with the study carried out the randomization process.

All the participants were blinded regarding their group allocation and throughout the completion of the entire study. If any participants could not join the scheduled training session, an alternative session was provided in the same week. All the training sessions were conducted in a fitness center in Bukit Rimau located in Petaling Jaya, Kuala Lumpur. The participant's demographic characteristics are displayed in Table 1.

Procedures

Anthropometry. Upon participants' arrival at the training location, they were asked to empty their bladders within 30 minutes before the anthropometric measurements. The body mass of each participant was calculated using an electronic scale (Omron Body Composition Monitor Weighing) to the closest 0.1 kg. The participants were advised to take off their shoes and preferably wear light attire. Then, their height was also measured by a stadiometer to the closest 0.1 cm. Next, their respective body mass index (BMI) is calculated by dividing kilograms on the square root of the height in meters.

Table 1
Demographic characteristics at baseline for HIT, MIT, LIT, and CG

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)	.85
Height (cm)	167.28 (3.50)	166.34 (5.24)	166.60 (3.20)	167.17 (3.85)	.91
Weight (kg)	77.86 (5.76)	75.60 (5.61)	75.68 (4.55)	75.26 (5.25)	.52
BMI (kg/m^2)	28.01 (1.23)	27.50 (1.94)	26.70 (2.15)	26.74 (1.47)	.12

Note. Data are presented as mean ± SD; *Obtained from the one-way analysis of variance (ANOVA)
Abbreviations: N = Number of participants; M = Mean; SD = Standard Deviation; HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; BMI= Body Mass Index

Muscle Strength. The 5 Times Sit to Stand (5STS) is a valid measurement to determine the lower extremities of muscle strength (De Melo et al., 2019). The participants were instructed to sit on the standard and cushioned arm-less chair (about 45 cm higher from the floor) and complete five times sit-to-stand actions as fast as possible. Adequate practice time and familiarization were provided to the participants to try out twice and have enough rest. The average time of two experiments was recorded in the analysis.

Functional Mobility. The functional mobility analysis in this study was assessed by The Timed Up and Go (TUG) and The 6 Minutes Walking Test (6MWT).

a) The TUG is a proper and commonly used trial to measure functional mobility in the older adult population (Sebastião et al., 2016). The TUG evaluates different segments of functional mobility, such as sit-to-stand ability, balance or stability, and turning while walking (Dubois et al., 2019; S. H. Park, 2018). To perform this test, the participant should stand up from the sitting position (armless chair 45 cm high) and walk toward a marked point located three meters away from the first point, turn back, and sit on the chair. A digital stopwatch was used to evaluate the time used to complete these actions, starting from rising until sitting on the chair for the second time. Similarly, this study employed the same procedures to obtain the functional mobility data from each participant. Additionally, the participants had a chance to familiarize themselves with the whole process by having enough resting periods before the two actual trials. The average time to complete the action from these two trials was then used in the data analysis.
b) The 6MWT examined the maximal distance walked by the participants for six minutes and is usually used for evaluating the physical functions and mobility (Kim et al.,

2016). In this study, the participants were asked to walk as fast as they could in a long hallway between two marked lines (30 meters) for six minutes. In this test, the participant was followed closely from behind by the tester. They were asked not to talk during the test. The tester informed the participants of the laps and the remaining time every two minutes.

Resistance Training Program. The RT training was designed for performing over 12 weeks during the morning period. Professional coaches guided all the participants with great experience training people to guarantee consistency and safety. The participants performed different intensities of RT by using correct exercising machines. The RT program was a lower extremity program with four exercises done in the following order: horizontal leg press, leg extension, leg curl, and seated calf raise. The HIT group performed three sets of 4 to 6 repetitions with between 80 to 90% of 1RM, the MIT group performed three sets of 8 to 10 repetitions with between 65 to 75% of 1RM, and the LIT group performed three sets of 12 to 14 repetitions with between 50 to 60 % of 1RM. In addition, the participants were trained to inhale in concentric muscle action and exhale in eccentric muscle action. Meanwhile, the movement velocity ratio was maintained at a 1:2 ratio (concentric and eccentric muscle actions, respectively). Then, they were allowed to rest two to three minutes between each exercise. The instructors regulated loads of each exercise based on the individual ability and improvements seen in exercise capacity during the study to make certain that they were exercising with as much resistance as possible while retaining suitable exercising executional techniques. RT intensities progression was planned if the participants could do full sets and reps, then the weight was gradually increased by around 5 to 10% in the next training session. During both of the RT phases, the instructors registered the load (in kilograms) and repetitions performed for each of the four exercises from all the participants during each session. Meanwhile, all the participants were asked to sustain their diet like before during the study.

Experimental Approach to the Problem

In total, the study was completed in 14 weeks. Firstly, participants were familiarized with the RT training and pre-training measurements (1-2 weeks). After that, a supervised progressive RT program was done between 2 to 14 (total 12 weeks). The training was done twice per week during the morning hours (from 8 AM to 9 AM).

In this study, the authors measure the RT intensity by an indirect method aimed at measuring one repetition maximum (1 RM). Accordingly, after two introductory sessions, the training load was measured using 3 to 6 repetitions (Bechshøft et al., 2017). A 3 to 6 RM test was chosen owing to the capability to measure the maximum strength of participants with little or without former resistance training experience

(Liguori et al., 2020). According to the strength test result, 1RMs were evaluated with the Brzycki formula: 1 RM (estimated) = load (kg) / [1.0278 − (0.0278 × number of repetitions)]. After calculating the 1 RM, the participants were randomly divided into their respective experimental groups according to the different intensities of RTs performed, while those assigned to the CG were allowed to continue undertaking their daily activities (without training). The participants in the experimental groups performed the RT program twice a week for 12 weeks. The HIT group trained with 80 to 90% of 1RM, while the MIT group trained with 65 to 75% of 1RM, followed by the LIT group that trained with 50 to 60% of 1RM. The RT was the same across the experimental groups and included Leg Press (LP), Leg Extension (LE), Leg Curl (LC), and Seated Calf Raises (CR) designed based on the recently published evidence.

All the participants were evaluated in one session. Before the testing session, the anthropometric was done. The participants performed the TUG, 5STS, and 6MWT during the testing session. During the two weeks preceding this study, four preliminary familiarization sessions were introduced to the participants to ensure that they could

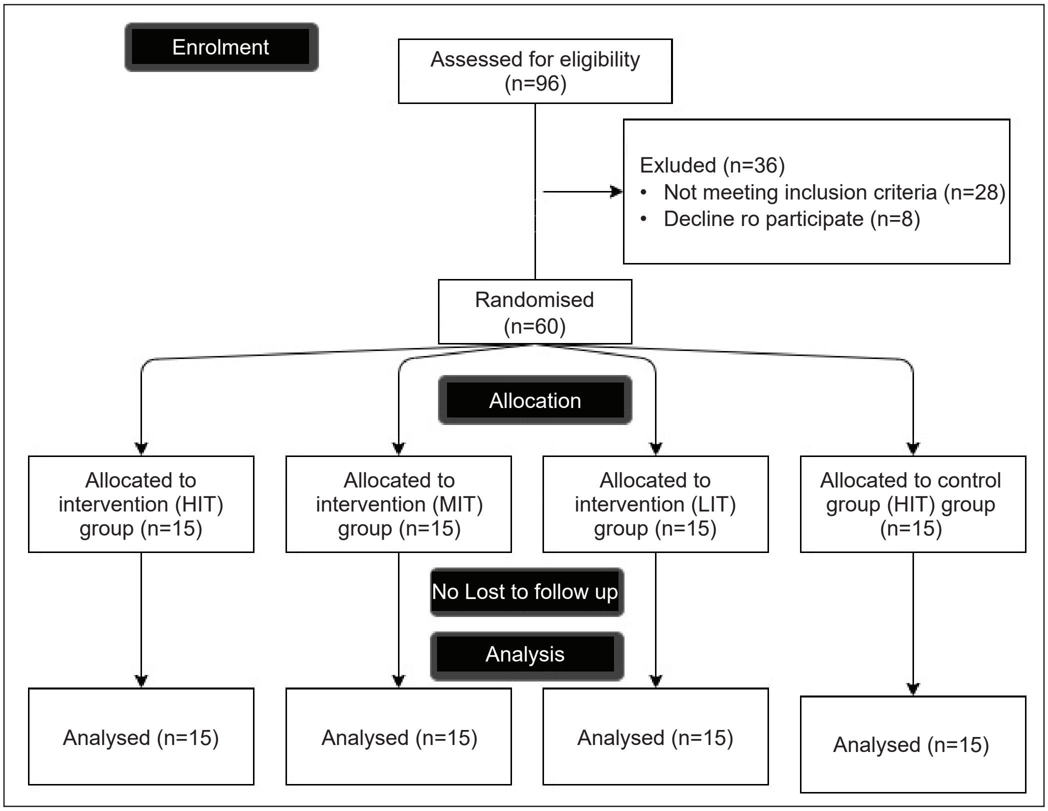

Figure 1. Study flow diagram
Note. n = Number; HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group

properly execute these techniques in all the exercises during the testing session. In order to evaluate the effectiveness of different intensity levels, the same tests were performed and repeated after the 4th, 8th, and 12th weeks of training with at least 48 hours of the recovery period. Meanwhile, the participants were asked to avoid regular exercise programs focusing on enhancing or retaining strength.

Statistical Analysis

The data normality test of the study was confirmed by using the Shapiro–Wilk test and Q-Q plots. A one-way analysis of variance (ANOVA) was used to examine possible group differences at baseline. A time (baseline, 4th, 8th, and 12 weeks) × group (HIT vs. MIT vs. LIT vs. CG) factorial ANOVA with repeated measures was done to evaluate the distinctions between the treatments, followed by the multivariate analysis of variance (ANOVA) that was performed to find the effects of two tests on one variable. A two-way analysis of covariance (ANCOVA) for repeated measures was done using the baseline scores as a covariate to omit any possible influences of initial score variances on the training results (Van Breukelen, 2006; Vickers & Altman, 2001). Data were presented for the main outcomes using the ANCOVA-adjusted results. It was followed by the appropriate Bonferroni and Tukey post hoc test when a noticeable treatment and treatment-by-time connection was shown. The variables that showed violated sphericity indicated by the Mauchly test were adjusted using a Greenhouse-Geisser correction. The effect size partial eta squared (η2) was used for effects comparisons in the study. The interpretation of effect sizes was carried out as follows: (1) small effect: $\eta2 = 0.01$, (2) medium effect: $\eta2 = 0.06$, and (3) large effect: $\eta2 = 0.14$. The statistical significance was set at $P < .05$. IBM SPSS (version 26, IBM) software was used to examine the collected data.

RESULTS

The overall compliance of participants to the RT program was 100%, a replacement session was planned if a participant could not attend any of the sessions. In addition, the baseline value comparison for age, body mass, height, BMI, 5STS, TUG, and 6MWT showed no significant differences between groups ($P > .05$). Accordingly, the anthropometric measurement and assessments were done at baseline, 4th, 8th, and 12th weeks of interventions, and the results are presented in Table 2. No adverse events were reported throughout the testing or training periods in all the groups. There were only some muscle soreness reports in the first couple of weeks.

Muscle Strength

The 5STS assessment was used to measure the lower extremity of muscular strength. The mean comparison between the groups at different time points is presented in Table 2. The effects of time in all the tested groups showed that all the pairwise comparisons between the intervention groups were statistically significant ($P<.05$).

Unlike the other groups, the pairwise comparisons of CG were found to be not statistically significant in the repeated times of CG (P>.05; see Figure 2). The effects of time at each treatment level illustrated a statistically significant difference between the times at each treatment level, except in the CG. The tests of treatment at each time point were performed. The results of pairwise comparisons indicated that the HIT compared with MIT at 4^{th} (p=.045), 8^{th} (p<.001), and 12^{th} weeks (p=.001) of intervention, the HIT compared with LIT at 8^{th} weeks (p=.001) and 12^{th} (p<.001) weeks of intervention, the HIT compared with CG at 4^{th} weeks (p=.012), at 8^{th} week (p<.001) and 12^{th} weeks (p<.001) of intervention were statistically significant. The MIT compared with LIT was not statistically significant at any time points. In contrast, the MIT compared with CG at 12^{th} weeks (p=0.015) of intervention was statistically significant (see Figure 1).

Functional Mobility

TUG. The mean comparisons between the groups at different time points are as represented in Table 2. The effects of time at each treatment level illustrated that there was a statistically significant difference between the times at each treatment level (P<.05), except in the control group (P>.05; see Figure 2). The effects of time in all the groups showed that all the pairwise comparisons between the intervention groups were statistically significant. In contrast, the pairwise comparisons analyses of the other groups were not statistically significant in the repeated times of the CG. The tests of treatment at each time point were performed, and the results of pairwise comparisons indicated that the HIT compared with LIT at 12th weeks (p=.040) of intervention, the HIT compared with CG at 8th weeks (p=.006) and 12th weeks (p<.001) of intervention were statistically significant. Similarly, the MIT compared with the CG group at the 8th week (p<.001) and the 12th weeks (p=.003) of intervention, as well as the LIT compared with CG at the 12th weeks (p=.039) of intervention, were statistically significant.

6MWT. The mean comparisons between the groups at different time points are as shown in Table 2. The effects of time at each treatment level illustrated that there was a statistically significant difference between the times at each treatment level (P<.05), except at the time of four weeks after the intervention, as compared to the 8th week of intervention in the CG (P>.05; see Figure 2). The effects of time in all the groups showed that all the pairwise comparisons for intervention groups were statistically significant. In contrast, the pairwise comparisons analyses of the other groups detected no statistical significance in the repeated times of the CG. The tests of treatment at each time point were performed, and the results of pairwise comparisons indicated that the HIT compared with LIT group at 12th weeks (p=.004) of intervention, the HIT compared with CG group at 8th weeks (p=.009) and 12th weeks (p<.001) of after intervention were statistically significant. The MIT

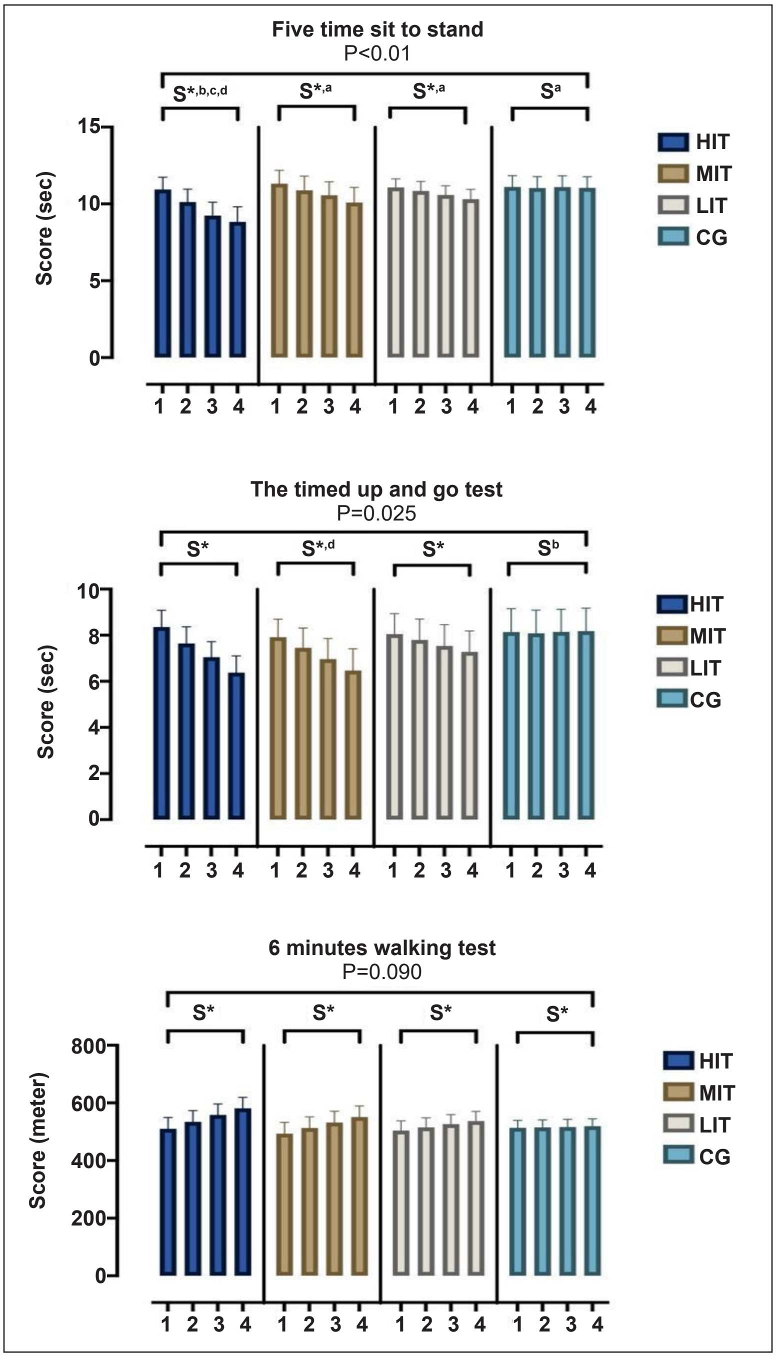

Figure 2. Comparison between groups at baseline, 4th, 8th, and 12th weeks of intervention
Note. 1= Baseline; 2= 4th week; 3= 8th week; 4= 12th week
Abbreviations: HIT= High-Intensity Training; MIT= Moderate-Intensity Training; LIT= Low-Intensity Training; CG= Control Group.
S* Significant from Baseline to 12th week; S[a] Significant compared with the HIT; S[b] Significant compared with the MIT; S[c] Significant compared with the LIT; S[d] Significant compared with the CG

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

Test	Int	Baseline	4^{th} week	8^{th} week	12^{th} week	Change	P-value* (partial eta square)		
							Time	Group	Time*group
5STS (Sec)							<.001 (.82)	<.001 (.29)	<.001 (.73)
	HIT	10.94 (0.79)	10.11 (0.84)	9.23 (0.87)	8.83 (0.98)	-2.10 (0.74)[b,c,d]			
	MIT	11.31 (0.87)	10.89 (0.92)	10.56 (0.87)	10.08 (0.98)	-1.22 (0.34)[a]			
	LIT	11.07 (0.55)	10.84 (0.61)	10.57 (0.60)	10.31 (0.63)	-.75 (0.26)[a]			
	CG	11.10 (0.73)	11.03 (0.73)	11.09 (0.72)	11.04 (0.72)	-.05 (0.03)[a]			
TUG (Sec)							<.001 (.91)	.025 (.15)	<0.001 (.85)
	HIT	8.35 ± 0.72	7.64 ± 0.72	7.04 ± 0.66	6.37 ± 0.72	-1.97 (0.40)			
	MIT	7.91 ± 0.78	7.45 ± 0.85	6.96 ± 0.89	6.46 ± 0.94	-1.44 (0.30)[d]			
	LIT	8.05 ± 0.88	7.79 ± 0.90	7.53 ± 0.92	7.27 ± 0.90	-0.77 (0.16)			
	CG	8.13 ± 1.01	8.08 ± 1.00	8.14 ± 0.98	8.17 ± 0.99	0.04 (0.04)[b]			
6MWT (Cm)							<.001 (.97)	.090 (.10)	<.001 (.93)
	HIT	510.07 ± 39.20	534.20 ± 38.86	558.00 ± 38.02	581.40 ± 38.00	71.33 (6.24)			
	MIT	493.53 ± 39.15	512.67 ± 38.71	531.93 ± 39.32	550.67 ± 38.87	57.13 (4.85)			
	LIT	503.80 ± 33.91	514.93 ± 32.99	526.47 ± 32.96	537.00 ± 33.58	33.20 (3.27)			
	CG	513.60 ± 25.37	514.93 ± 25.74	516.27 ± 26.77	519.27 ± 25.58	5.66 (7.23)			

Note. *Obtain from the two-way (mixed) repeated measures (ANOVA)
Abbreviations: Int = Intervention groups; HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; 5STS = Five Time Sit to Stand Test; TUG = The Timed Up and Go Test; 6MWT = 6 Minutes Walking Test.
[a] Significant compared to HIT
[b] Significant compared to MIT
[c] Significant compared to LIT
[d] Significant compared to CG

compared with LIT at 4th weeks, 8th weeks, and 12th weeks of intervention were not statistically significant. Similarly, the MIT and LIT compared with CG at 4th weeks, 8th weeks, and 12th weeks of intervention were also not statistically significant.

The multivariate analysis of variance (MANOVA) was performed to understand the overall impacts of TUG and 6MWT on the functional mobility of healthy aged women. The results are presented in Table 3. The findings observed a significant effect from the different intensities training on dynamic balance ($P<.001$, $\eta^2p=.817$) and also when the baseline values outcomes were adjusted ($P<.001$, $\eta^2p=.824$).

DISCUSSION

Muscle Strength

This 5STS approach is one of the most appropriate ways to find out about the lower body strength and draw inferences for the muscle strength in the aged population. In this study, the comparison among the groups in terms of muscle strength demonstrated

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

Variables	Adjustment	Test	HIT	MIT	LIT	CG	P Value	Partial eta square
Muscle Strength *	Crude							
		5STS	-2.10 ± 0.74	-1.22 ± 0.34	-0.75 ± 0.26	-0.05 ± 0.03	<.001	.761
	Adjusted [b]							
		5STS	-2.11 ± 0.11	-1.21 ± 0.11	-0.76 ± 0.11	-0.05 ± 0.11	<.001	.761
Functional Mobility **	Crude						<.001	.817
		TUG	-1.97 ± 0.40	-1.44 ± 0.30	-0.77 ± 0.16	0.04 ± 0.04	<.001	.897
		6MWT	71.33 ± 6.24	57.13 ± 4.85	33.20 ± 3.27	5.66 ± 7.23	<.001	.955
	Adjusted [b]						<.001	.824
		TUG	-1.99 ± 0.06	-1.42 ± 0.06	-0.77 ± 0.06	0.02 ± 0.06	<.001	.902
		6MWT	71.29 ± 1.46	56.96 ± 1.47	33.20 ± 1.44	5.86 ± 1.45	<.001	.956

Note. Data are 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)
[b] Adjustment for baseline values
Abbreviations: HIT = High -Intensity Training; MIT = Moderate-Intensity Training; LIT = Low-Intensity Training; CG = Control Group;
5STS = Five Time Sit to Stand Test; TUG = The Timed Up and Go Test; 6MWT = 6 Minutes Walking Test

that the HIT was more effective than all the other groups at all the different time points tested (except on the 4th week in which the LIT showed better results). Meanwhile, the other groups showed no statistically significant difference compared to each other in all the intervals tested (except on the MIT, as compared to CG at the 12th week). The mean difference comparison between the groups showed that the MIT is showing more effects statistically than LIT, CG, and LIT (see Table 3).

A few previous types of the research reported no difference in muscle strength following various intensity levels of resistance training (Ribeiro et al., 2020; Sahin et al., 2018). However, the results of strength improvement in this study were in line with the majority of previous studies and reports on similar resistance exercise interventions in more mature people (Borde et al., 2015; Fragala et al., 2019; Liu et al., 2017; Miller et al., 2021; Peterson et al., 2010; Silva et al., 2014; Steib et al., 2010).

The findings of Ribeiro et al. (2020) surprisingly suggested that lower-intensity (3 sets*15 reps) and moderate-intensity (3 sets* 10 reps) are equally applicable for the enhancements of knee extension 1RM chest press and preacher curl in healthy older women. In addition, unexpected results were reported by Sahin et al. (2018) that showed that LI and HI exercises were equally effective for most of the factors tested in the study, such as muscle strength and daily life activity. However, the study also observed that the HI only performed better in the physical performance, as compared to LI. Furthermore, CG was shown to maintain muscle strength in eight weeks but had lower physical performance.

In line with our study, Steib et al. (2010) concluded that high intensity reached a more substantial improvement on strength outcome than moderate or low-intensity. Moreover, Moderate had more impacts on the strength than low-intensity level. Furthermore, a randomized clinical trials meta-analysis analyzed a wider intensity range (from between 50% 1RM to 90% 1RM) and resistance training impacts in sedentary aged people, and these studies found the similarly same results as our study. The results demonstrated that the intensity levels between 70 to 79% 1RM contributed to greater strength (Borde et al., 2015).

A recent study by Miller et al. (2021) examined the effects of 40 weeks of HI and LI training (two or three times per week) on the upper- and lower-body strengths of healthy older adults. In the study, the HI group performed 80% 1RM (3*8 reps), and the LI group performed: 40% 1RM (3*16 reps). The authors concluded that HI is more effective than LI in improving the upper- and lower-body strengths, especially when training was done at least twice a week. However, there was no significant difference between HI and LI when training was carried out three times per week. Peterson et al. (2010) and Silva et al. (2014) made a comparison of the studies reporting on the RT intensity levels between 40 to 85% of 1RM. Both confirmed that substantial development in muscle strength was achieved with higher intensity training.

Moreover, in a report, Fragala et al. (2019) concluded that healthy adults who are 60 years or older showed optimal strength gains when performing the 1RM resistance training intensity of between 70 to 85%.

The results of our study support the previous findings (Borde et al., 2015; Fragala et al., 2019; Miller et al., 2021; Peterson et al., 2010; Silva et al., 2014; Steib et al., 2010). In conclusion, HIT is more effective than MIT, LIT, and CG. Subsequently, MIT is more effective than LIT and CG, followed by LIT more useful than CG in healthy older women.

Functional Mobility

The overall changes in functional mobility were induced and determined through TUG and 6MWT assessments. These approaches have been reported to address functional mobility in aged people completely. In this study, the assessments between the groups were compared one by one and also entirely. The comparisons between groups in TUG illustrated that the differences between HIT and MIT were significant after the 8th and 12th weeks of intervention compared to the differences between CG and LIT that were significant only at the 12th week of intervention. It is worth mentioning that the adjusted mean difference comparison between the groups showed that the HIT had more effects statistically than MIT, LIT, and CG. Similarly, the MIT had more effects statistically than LIT and CG, while the LIT had more effects than CG (see Table 3).

Regarding the 6MWT, the comparisons between the groups showed that the HIT at the 12th week of intervention was statistically significant compared to LIT. Moreover, the HIT was significant with CG at the 8th and 12th weeks of interventions. The adjusted mean difference comparison between the groups showed that the HIT had more effects statistically than MIT, LIT, and CG, followed by the MIT that had more effects statistically than LIT and CG, while LIT had more effects than CG (see Table 3).

Resistance training specifically diminishes older interconnected transformations in functional mobility (Papa et al., 2017). Previous studies had reported the effects of different RT variables on functional mobility. In most of the studies, the different varieties of RTs are shown to be impressive to enhance functional mobility in senior people (Alfieri et al., 2012; Bavaresco Gambassi et al., 2020; Buckinx et al., 2018; Granacher et al., 2013; Idland et al., 2014; Lustosa et al., 2011; Moro et al., 2017; Müller et al., 2020; Nicholson et al., 2015; Nicklas et al., 2015; Sahin et al., 2018; Sylliaas et al., 2011; Watson et al., 2015; Yamada et al., 2011). In addition, some of the systematic reviews, reports, and positional statements also reported improvements in functional ability after different RT variations (Fragala et al., 2019; Lai et al., 2018; Papa et al., 2017; Steib et al., 2010). However, a few studies report no improvement in functional mobility in older adults (Coetsee & Terblanche, 2015; Liu et al., 2017).

The results of our study are comparable with most research that measures the efficacy of RT on the aged population. Some of the studies stated a significant improvement in participants' TUG and functional mobility after 12 and 26 weeks of full-body RT (Idland et al., 2014; Nicholson et al., 2015). Interestingly, the study by Nicholson et al. (2015) tested very low intensity (between 10 to 30% of 1RM) but with high repetitions (between 70 to 100 reps). In addition, Bavaresco Gambassi et al. (2020) reported the effectiveness of RT in improving the functional factors in older adults. Regarding the different exercise intensities, Seynnes et al. (2004) made a comparison of the high-intensity and low-intensity in an infirm population, and the study reported that the functional enhancement was vital for both high and low intensities training groups, and the high-intensity was noticeably more beneficial for the walking test but not in stair climbing or chair rise. Moreover, Watson et al. (2015) measured the impacts of high-intensity progressive RT with low-intensity home-based exercise for eight months on the functional mobility of aged females with low bone mass. The findings of this study showed a consequential improvement in the TUG in the high-intensity group. Sahin et al. (2018) believe that although high and low-intensity training improves physical performance, higher-intensity is sufficient.

In contrast, Coetsee and Terblanche (2015) did not find any positive mutation in the functional mobility of senior citizens after 4, 8, and 12 weeks of training. However, they found significant changes after 16 weeks of training in the TUG. The improvements reported may be due to different reasons, for example, the lack of improvement in functional mobility because of a shorter period of training time (less than 12 weeks). Firstly, they used lower body and upper body exercises compared to the other studies that only work on the lower body muscles. Secondly, they might not work until the failure occurs in the first two sets of each exercise. The study used a different intensity for each set of RT group, 50%, 75%, and 100% of 10 RM respectively for the first, second, and third set. Their results contrast with the findings of some studies that showed noticeable changes in the physical function marked after a smaller time duration. For instance, Pinto et al. (2014) found that muscle strength and physical function increase in mature females when they trained lower body for six weeks.

The meta-analysis conducted by Steib et al. (2010) made a comparison of various training intensity levels of PRT to enhance physical performance. However, they found no substantial group differences for the functional tests conducted in the studies. They concluded that RT is effective in enhancing the participant's performances in the functional activities. Although a higher intensity level is more effective than moderate or low intensity on muscle strength, this does not apply to functional performance. Previously, various research had proposed that the lower limb strength can be improved by higher training intensities (between 70 to 89% of 1RM). Meanwhile, the functional performance is likely to be improved by moderate intensity (between 50 to 69% of 1RM) or even low intensity (less than 50% of 1RM; Raymond et al., 2013). Several possible explanations can explore the lack of functional improvement after varying the RT training intensities. There is a close relationship between strength enhancement, especially for the functional performance (e.g., stair climbing and walking) and the muscles of lower extremities of aged people (Barry & Carson, 2004; Latham et al., 2003). As mentioned above, LI and MI resulted in noticeable strength improvements. In contrast with our results, a meta-analysis published by Liu et al. (2017) found that multimodal exercise and PRT play an outstanding role in enhancing the strength of the lower extremity muscle. However, these exercises did not result in a positive effect and did not improve the functional mobility outcomes.

Limitations and Strengths

The current study consists of several strengths—first, a clear comparison between three different RT intensity prescriptions and no training. Secondly, the different time points were added and tested to confirm that the intensity levels have a faster impact on muscle strength. Thirdly, this study has a control group, which can be considered an advantage due to the ability to focus on the impacts of the determined, different RT intensities on muscle strength and functional mobility. Despite these strengths, this study also has some limitations that need to be addressed. Although the current study worked on the female participants owing to their potential to struggle with sarcopenia (Gyasi & Phillips, 2018), the findings could be more conclusive if the male participants were added. An additional limitation is the lack of dietary surveillance throughout the study. In addition, the volume of training was a bit higher in the LIT group compared to MIT and HIT because the authors of this study compared three intensities, and it was not easy to control the volume in all groups. For future studies, authors can adjust the intensities to a level that the training volume will be the same for all groups. Finally, the reported results were specified just to untrained aged females and may not be extrapolated to the other groups of society.

CONCLUSIONS

The current results provide full supporting evidence that even though all the different intensity levels were important in enhancing muscle strength and functional mobility, the HIT demonstrated much more effectiveness than MIT and LIT. In terms of clinical importance, each training instruction led to the improvement in muscular strength. Thus, the authors suggested that any of the different intensities can be useful for enhancing muscular strength, as well as functional mobility in more mature women. However, more study is necessary to explore further on these observations, in addition, to including further details on various potential influences, like sex and training frequency, that may lead to the resistance training results in the aged population. According to the benefits of RT training for aged people (Fragala et al., 2019; Lavin et al., 2019; McLeod et al., 2019; Tavoian et al., 2020), it is important to state that our study did not expose any detrimental incident. This observation confirmed the previous findings by demonstrating that high, moderate, and low intensities strength training is safe to perform and conceivable for older people.

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