EFFECTIVENESS OF DIFFERENT EXERCISE INTENSITY ON MUSCLE STRENGTH, BALANCE, AND MOBILITY OF ELDERLY WOMEN

By

KAMRAN HOSSEINZADEH GHASEMABAD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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October 2023

Chair : Roxana Dev Omar Dev, PhD
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This study aimed to investigate the effectiveness of different exercise intensities on muscle strength, dynamic–static balance as well as functional mobility of elderly women in different time periods. Participants in this study were chosen using simple random sampling from Malaysian older women (N=60) aged >65 years old who were randomly divided to the high-intensity training (HIT; n=15) (Mean age of 69.60 ± 3.68); moderate-intensity training (MIT; n=15) (Mean age of 69.27 ± 3.41); low-intensity training (LIT; n=15) (Mean age of 69.27 ± 1.94); and control group (CG; n=15) (Mean age of 68.67 ± 2.38). Experimental research designs were used in the present study. The experimental groups underwent a specific lower body training including leg press, leg extension, leg curl and seated calf raises for 12 weeks, but each group had different intensity. The HIT group did 80-90% of 1RM for 4 to 6 reps, The MIT group did 65-75% for 8-10 reps, and the LIT group did 50-60% for 12-14 reps, and the control group did not do any physical activity. In this study, seven tests were used for measurement: 5 times sit to stand (5STS) for strength, tandem stand test (TST) and one leg stand (OLS) for static balance, forward reach test (FRT) and lateral reach test (LRT) for dynamic balance, and timed up and go test (TUG) and 6-minute walking test (6MWT) for functional mobility were administered to all participants to measure their changes at week 4, 8, and 12. There were no statistically significant differences in the distributions of all assessments scores for the dependent variables between the treatment groups and control group prior to the intervention. The post-intervention measurements using two-way repeated measures ANCOVA showed significant improvements in lower extremity muscle strength (HIT=19.28%, MIT=10.87%, LIT=6.86%, [p<0.001]), dynamic balance ability by FRT (HIT=36.6%, MIT=22.1%, LIT=12.3%, [p<0.001]), and LRT (HIT=64.4%, MIT=36.3%, LIT=23.3% p < 0.001), static balance by OLS (HIT=18.7%, MIT=14.4%, LIT=6.3%, [p<0.001]), and TST (HIT=76.2%, MIT=44.65%, LIT=30.95%, [p<0.001], and functional mobility by TUG (HIT=23.71%, MIT=18.33%, LIT=9.68%, [p<0.001]), and 6MWT

(HIT=13.98%, MIT=11.57%, LIT=6.58%, [p<0.001]). This analysis showed that there was a statistical difference in the means of all the variables between groups (p<0.001) and in the means of all variables in different time points (except on 5STS and OLS tests). Moreover, a statistically significant connection between the intervention and time on all the variables (p<0.001) was also observed. Besides that, the multivariate analysis concluded a significant improvement in static–dynamic balance, and functional mobility. The results suggest that all three different training intensities are beneficial for improving muscle strength, static–dynamic balance, and functional mobility. In addition, HIT is most effective in improving muscle strength, static balance, dynamic balance, and functional mobility after 12 weeks of interventions.

Keywords: Elderly Women, Exercise Intensities, Functional Mobility, Muscle Strength, Static-Dynamic Balance

SDG: Goal 3, Good Health and Well Being

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KEBERKESANAN SENAMAN YANG BERBEZA INTENSITI TERHADAP KEKUATAN OTOT, KESEIMBANGAN, DAN MOBILITI WANITA WARGA EMAS

Oleh

KAMRAN HOSSEINZADEH GHASEMABAD

Oktober 2023

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Kajian ini bertujuan untuk meneliti keberkesanan intensiti senaman yang berbeza pada kekuatan otot, keseimbangan dinamik-statik, dan mobiliti berfungsi wanita warga emas dalam tempoh masa yang berbeza. Peserta dalam kajian ini dipilih menggunakan pensampelan rawak mudah daripada wanita warga emas Malaysia (N = 60) berumur > 65 tahun yang dibahagikan secara rawak kepada tiga kumpulan: latihan intensiti tinggi (HIT; n = 15) (purata umur 69.60 ± 3.68); latihan intensiti sederhana (MIT; n = 15) (purata umur 69.27 ± 3.41); latihan intensiti rendah (LIT; n = 15) (purata umur 69.27 ± 1.94); dan kumpulan kawalan (CG; n = 15) (purata umur 68.67 ± 2.38). Reka bentuk eksperimen telah digunakan dalam kajian ini. Kumpulan eksperimen menjalani latihan badan bawah badan, termasuk *leg press*, *leg extension*, *leg curl* dan *seated calf raises* selama 12 minggu mengikut intensiti yang diberikan. Kumpulan HIT melakukan 80–90% daripada 1RM untuk 4 hingga 6 ulangan; kumpulan MIT melakukan 65–75% untuk 8–10 ulangan; kumpulan LIT melakukan 50–60% untuk 12–14 ulangan; dan kumpulan kawalan tidak melakukan sebarang aktiviti fizikal. Dalam kajian ini, tujuh ujian telah digunakan untuk pengukuran: *5 times sit to stand* (5 STS) untuk kekuatan; *tandem stand test* (TST) dan *one leg stand* (OLS) untuk keseimbangan statik, *forward reach test* (FRT) dan *lateral reach test* (LRT) untuk keseimbangan dinamik, *timed up and go test* (TUG), dan *6-minute walking test* (6MWT) untuk mobiliti berfungsi diberikan kepada semua peserta untuk mengukur perubahan mereka pada minggu ke-4, 8, dan 12. Tiada perbezaan signifikan secara statistik dalam pengagihan semua markah penilaian untuk pemboleh ubah bergantung antara kumpulan rawatan dan kumpulan kawalan sebelum intervensi. Pengukuran selepas intervensi menggunakan Two-Way Repeated Measures ANCOVA menunjukkan peningkatan ketara dalam kekuatan otot bahagian bawah (HIT = 19.28%, MIT = 0.87%, LIT = 6.86%, [$p < 0.001$]), keupayaan keseimbangan

dinamik oleh FRT (HIT = 36.6%, MIT = 22.1%, LIT = 12.3%, [p < 0.001]), dan LRT (HIT = 64.4%, MIT = 36.3%, LIT = 23.3%, [p < 0.001]), imbangan statik mengikut OLS (HIT = 18.7%, MIT = 14.4%, LIT = 6.3%, [p < 0.001]), dan TST (HIT = 76.2%, MIT = 44.65%, LIT = 30.95%, [p < 0.001]), dan mobiliti berfungsi oleh TUG (HIT = 23.71%, MIT = 18.33%, LIT = 9.68%, [p < 0.001]), dan 6MWT (HIT = 13.98%, MIT = 11.57%, LIT = 6.58%, [p < 0.001]). Analisis ini menunjukkan bahawa terdapat perbezaan statistik yang signifikan dalam min semua pemboleh ubah antara kumpulan (p < 0.001) dan dalam cara semua pemboleh ubah pada titik masa yang berbeza (kecuali pada ujian 5STS dan OLS). Dalam pada itu, hubungan yang signifikan secara statistik antara intervensi dan masa pada semua pemboleh ubah (p < 0.001) juga diperhatikan. Selain itu, analisis multivariate menyimpulkan bahawa terdapat peningkatan yang ketara dalam keseimbangan statik-dinamik dan mobiliti berfungsi. Keputusan menunjukkan bahawa ketiga-tiga intensiti latihan yang berbeza adalah bermanfaat untuk meningkatkan kekuatan otot, keseimbangan statik-dinamik, dan mobiliti berfungsi. Di samping itu, HIT adalah yang paling berkesan dalam meningkatkan kekuatan otot, keseimbangan statik, keseimbangan dinamik, dan mobiliti fungsi selepas 12 minggu latihan intervensi.

Kata kunci: Wanita warga emas, Intensiti semaman, Mobiliti berfungsi, Kekuatan otot, Keseimbangan statik-dinamik

SDG: Matlamat 3, kesihatan dan kesejahteraan yang baik

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

5STS	Five Timed Sit to Stand
6MWT	Six-minute Walking Test
CG	Control Group
FRT	Forward Reach Test
HIT	High Intensity Training
LIT	Low Intensity Training
LRT	Lateral Reach Test
MIT	Moderate Intensity Training
OLS	One Leg Stand
PRT	Progressive Resistance Training
RT	Resistance Training
TST	Tandem Stand Test
TUG	The Timed Up and Go Test

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The world's population is growing fast towards ageing (United Nations, 2019a). Population ageing, defined as the increase in the population above the age of 65 in absolute terms, is one of the most significant demographic changes—and hence, the social transformations of the 21st century (Reynaud & Miccoli, 2019a). Developed and developing countries are struggling with population ageing. It has become an enormous challenge because the high speed of conversions among aged people creates a significant concern, specifically regarding seniors' health (Lyons et al., 2018). By 2050, one in six people in the world will be over age 65 (16%), up from one in 11 in 2019 (9%). Regions where the share of the population aged 65 years or over is projected to double between 2019 and 2050 include Northern Africa, Western Asia, Central and Southern Asia, Eastern and Southeastern Asia, Latin America and the Caribbean. In 2018, persons aged 65 or above outnumbered children under five globally for the first time in history. The number of persons over 80 years old is projected to triple, from 143 million in 2019 to 426 million in 2050 (United Nations, 2019b).

In Malaysia, population ageing is also promptly developing because of the higher life expectancy, and decreasing fertility and mortality rates (Zamzamy Sormin et al., 2019). According to the recent data in Malaysia, a new-born girl is expected to live longer, up to 77.3 years, while a new-born boy is expected to live until 72.2 years in 2019. Therefore, males and females who reach the age of 65 years in 2019 are expected to live a further 14.8 years and 17.1 years, respectively, reaching 79.8 and 82.1 years old, respectively. At the same time, the total fertility rate has dropped from 6.5 children per woman in 1960 to 1.97 in 2020, and the mortality rate has fallen dramatically (Malaysia, 2019). Malaysia is expected to transform into an ageing population by 2030, with older adults making up 15% of the total population (Kenayathulla et al., 2016).

Ageing is linked with a decline in both physiological and psychological function (Scott et al., 2015). The degenerative loss of skeletal muscle mass, known as sarcopenia and loss of muscle strength, known as dynapenia (Tournadre et al., 2019a), are the main physiological problems encountered by the ageing population (Mair et al., 2019). Moreover, ageing are associated with a declining functional ability, which is necessary for an individual to maintain posture, respond to voluntary movements, and react to external perturbations (Osoba et al., 2019a). Health problems arise more frequently with increasing age, which is the main reason for the functional drop, and the incapability of the elderly to maintain modest activities of everyday living. In a recent study, the association between active ageing and subjective health promotion indicators showed that

active seniors were likelier to have positive perceived health status and health responsibility (Loke et al., 2020).

Functional ability is an individual's actual or potential capacity to perform the activities and tasks that can be normally expected. In other words, the practical ability is about having the capabilities that enable people to be and do what they have reason to value. This includes a person's ability to meet basic needs, learn, grow, make decisions, be mobile, build and maintain relationships, and contribute to society (Beard et al., 2016). Functional ability is also an essential factor that decreases dramatically in old age (Mair et al., 2019). Significant factors causing the loss of functional ability are sarcopenia and dynapenia (Bravo-José et al., 2018). Poor nutrition, atrophy and ageing are the main reasons for sarcopenia. Sarcopenia also has been recognized as a core reason for incapacity and loss of independence in the older population (Aibar-Almazán et al., 2018a). Besides that, it is a highly prevalent condition among older adults (Yamamoto et al., 2016a). Sarcopenia becomes noticeable at 45 (Landi et al., 2017), and people lose 0.5% of their lean mass yearly. This annual rate of decline accelerates to 1% after 75 (Alajlouni et al., 2020).

The most crucial question upraised by this intense demographic transformation is how health providers can promote healthy ageing in this population (Chetty et al., 2016a). According to a recent study, aged Malaysian people suffer from several chronic non-communicable disorders. Hence, with the increasing senior population in Malaysia, health conditions can be a significant concern (Iddrisu et al., 2020).

The frequency of age-related illnesses has largely improved over time (Belikov, 2019). As such, most patients registered in the healthcare centers, such as hospitals, are aged people, and 66% have two or more chronic diseases (Fernandes et al., 2015). Additionally, healthcare costs escalate by increasing chronic conditions amongst the older population (Koris et al., 2019a). Therefore, the Malaysian aged population's health status seems to be a subject of worry (Koris et al., 2019a).

Lower-body muscle strength is crucial for upholding functional ability, balance, and mobility. Dynapenia in lower-body muscles were recognized to be a significant predictor of balance damage in older adults (Vries et al., 2020). Balance ability is linked not only to accurate sensory (Osoba et al., 2019a) and neurological systems (Porras et al., 2019), but also to good muscle strength, which can be affected by sarcopenia (Tournadre et al., 2019a). Hence, the remaining muscle can be affected by dynapenia, which might cause weaker muscle strength and an inability to create sufficient power to keep balance (Hamed et al., 2018). Good muscle strength and mass are crucial for the independence and safety of daily living activities (Wang et al., 2020). Another essential factor for maintaining physical abilities and lower-body muscles is mobility and flexible joints, which have notable roles in physical performance.

Yamamoto et al. (2016a) mentioned that impaired physical mobility was an important characteristic associated with ageing. Therefore, impaired physical mobility usually includes impairments in daily life activities, such as walking short distances, climbing stairs, and showering (Asp et al., 2017).

The fast-increasing older population has emphasized the need for practical interventions for prevention and improving age-related health care, and its costs (Steffl et al., 2017).

1.2 Problem Statement

Natural ageing and inactivity consequences in physiological changes result in to decrease in muscle mass, “sarcopenia” and muscle strength, “dynapenia” (Larsson et al., 2019a). The absence of productivity increases the possibility of dynapenia, which develops more after 70 years (Tournadre et al., 2019a). The prime reason for around 21–25% of breast and colon cancers, 27% of diabetes, and about 30% of heart disease around the world is physical inactivity (*World Health Organization (WHO)*, 2019). Related to Malaysia, a study (Kaur et al., 2015) investigated the level of physical inactivity among the Malaysian elderly population. They interviewed 4831 subjects and found that more than four-fifths of the respondents were physically inactive, irrespective of the monthly household income level (almost 88%). Earlier studies illustrated that sarcopenia caused 18.5 billion dollars annually in healthcare costs (Janssen et al., 2004). These costs will continue to rise as societies increase. The earlier analysis calculated that a 10% decrease in sarcopenia will drop healthcare costs by 1.1 billion dollars (Janssen et al., 2004). Thus, significant medical charges can be protected yearly by successfully stopping or reversing sarcopenia. The multiple adverse health outcomes associated with sarcopenia, such as fractures and falls (Balogun et al., 2017; Hars & Trombetti, 2017; Scott et al., 2018; Sornay-Rendu et al., 2017; Stevens & Lee, 2018), insulin resistance and the risk of prediabetes (Hirasawa et al., 2019), cardiovascular diseases (Uematsu et al., 2012), cognitive impairment (Gariballa & Alessa, 2018), depression (Beaudart et al., 2018) and others (Santos et al., 2017a; Prado et al., 2018) influence a person’s life by the loss of independence, reduced quality of life (Beaudart et al., 2018; Locquet, et al., 2018; Tsekoura et al., 2017) and earlier necessary admission to nursing homes (Santos et al., 2017a; Kojima, 2018), making the necessity for interventions critical. There is a crucial necessity to regulate practical plans to stop or diminish these losses to uphold the health and quality of senior citizens’ life, particularly in Malaysia, given the predictable drops in muscle mass and strength with higher age.

Consistent physical activity and exercise are effective in the health development, the functional abilities in activities of daily living, slowing ageing process, delaying development of premature ageing in the older adults (Andrieieva et al., 2019), upholding psychological health, growing physical performance, and increasing quality of life (Vancampfort et al., 2017). Regular physical exercise is

crucial for healthy ageing to support positive mental health. It can help delay, prevent, or manage many costly and challenging chronic diseases older adults face. It can also reduce the risks of moderate or severe functional limitations in older adults and the risk of premature death (Mora & Valencia, 2018).

Resistance training (RT) has been documented as essential for stabilizing independence among aged people and reducing sarcopenia (Guizelini et al., 2018a). Previous research recommended RT as an effective plan to counteract age-related declines and advance muscular strength and physical activity in older adults (Choi et al., 2017; Fragala et al., 2019a; Lavin et al., 2019; McLeod et al., 2019).

RT has been shown as the safest and most operative procedure for growing and upholding muscle mass and strength in the old population (Chan et al., 2018). A review stated noticeable results of RT in older people (Guizelini et al., 2018a). Nonetheless, RT must be studied more carefully and strictly by considering various variables, such as exercise mode, intensity, volume, and progression (Gentil et al., 2017; Suchomel et al., 2018). A standardized treatment method that can be used for a wide variety of older people and contains an authenticated training procedure has yet to be defined. The drill should be time-efficient, bearing in mind that one of the reasons for nonparticipation from the suggested training quantities has been the time limit and low enthusiasm (Rodrigues et al., 2017), and cost-effectiveness in the face of the high and growing prevalence of sarcopenia (Shafiee et al., 2017).

There is a lack of studies exploring the effects of different intensities of RT on muscle strength, balance, and mobility in elderly subjects. However, many researchers believe that different-intensity training is suitable for the elderly as it is easy to perform and safe, and has good results (Cobbold, 2018a; Marcos-Pardo et al., 2019; Sahin et al., 2018a). A meta-analysis suggests that intensity from 51% to 79% of 1 RM is effective to increase muscle mass in healthy older adults (Borde et al., 2015a). However, the effectiveness of this intensive training is still unclear. There is a gap in the literature comparing high-intensity training (HIT), moderate-intensity training (MIT), low-intensity training (LIT), and control group (CG) at different time points.

Resistance training is crucial for the health of older adults, offering benefits like improved muscle strength, balance, and mobility. Past studies have looked at how different intensities of resistance training affect older individuals. Some suggest that higher intensities lead to faster and more effective improvements (Bechshøft et al., 2017a; Bezerra et al., 2018; Carneiro et al., 2018; Cobbold, 2018b; Schranz et al., 2018; Yang et al., 2017), while others propose that, for active seniors, the specific intensity might matter less (Ribeiro et al., 2020a; Sahin et al., 2018b). Yet, there is a gap in the research when it comes to systematically control and adjust resistance training intensities. This study aims to fill that gap, carefully examining how different intensities impact muscle

strength, balance, and mobility in older adults.

Previous research also mentioned the importance of clarifying the most effective intensity and studying different variables of RT. Roie et al. (2013a) believed further research should additionally investigate the underlying mechanisms accounting for variations in the effectiveness of high- and low-resistance training protocols. Hurst et al. (2019a) suggested that additional work was required to evaluate the potential efficacy of high-intensity training functioning in elderly population groups. A recent study (Miller et al., 2021a) believed that upcoming studies were needed to develop the variation of RT and other features of training intensity that might contribute to resistance training outcomes in older adults. A study by Keating et al. (2020a) mentioned that research was needed to determine if there were additional exercise modalities that could be used and if one was better than another in differing populations. Lopez et al. (2021a) commented that the results supported the design of future exercise trials comparing low and high doses of RT to test responsiveness to this type of training and the beneficial effects on clinical outcomes of interest. Grgic et al. (2020a) suggested that finding ways to promote further participation and adherence to muscle-strengthening activities in the aged population group was of considerable public health interest.

The goal of the scientist interested in the avoidance of sarcopenia and associated functional limitations should be creating a training procedure that is sufficiently doable to keep aged people train consistently, but sufficiently intense to encourage muscle strength, balance and functional mobility (Moro et al., 2017a). Hence, a study is required to find the fastest and safest way to gain muscle strength for the elderly.

To the best of author knowledge, the effects of RT with different training intensities performed in older women are still unclear. This is the first study to examine the effectiveness of varying intensity exercises to improve muscle strength, balance, and functional mobility among older Malaysian women community dwellers.

1.3 Objective of Study

1.3.1 General Objective

The primary purpose of this study was to find the effectiveness of 4, 8, and 12 weeks of high, moderate, and low-intensity training on muscle strength, balance, and functional mobility of older women.

1.3.2 Specific Objectives

1. To compare the effectiveness of HIT, MIT, LIT, and no training on muscle strength of Malaysian elderly in the 4th, 8th, and 12th weeks of intervention.
2. To compare the effectiveness of HIT, MIT, LIT and no training on static balance of Malaysian elderly in the 4th, 8th, and 12th weeks of intervention.
3. To compare the effectiveness of HIT, MIT, LIT, and no training on dynamic balance of Malaysian elderly in the 4th, 8th, and 12th weeks of intervention.
4. To compare the effectiveness of HIT, MIT, LIT, and no training on functional mobility of Malaysian elderly in the 4th, 8th, and 12th weeks of intervention.

1.4 Research Questions

1) Is HIT more effective than MIT, MIT than LIT, and LIT than no training in muscle strength of older women in the 4th, 8th, and 12th weeks of intervention?
2) Is HIT more effective than MIT, MIT than LIT and LIT than no training in dynamic balance of older women in the 4th, 8th, and 12th weeks of intervention?
3) Is HIT more effective than MIT, MIT than LIT, and LIT than no training in static balance of older women in the 4th, 8th, and 12th weeks of intervention?
4) Is HIT more effective than MIT, MIT than LIT, and LIT than no training in improving functional mobility of older women in the 4th, 8th, and 12th weeks of intervention?

1.5 Research Hypothesis

The hypotheses for the present study include the following:

1. HIT is more effective than MIT, LIT, and no training in improving muscle strength among older women in Malaysia in the 4th, 8th, and 12th weeks of intervention. Same as the above, MIT is more effective than LIT, and LIT is more effective than no training.
2. HIT is more effective than MIT, LIT, and no training in improving dynamic balance among older women in Malaysia, in the 4th, 8th, and 12th weeks of intervention. Same as the above, MIT is more effective than LIT, and LIT is more effective than no training.
3. HIT is more effective than MIT, LIT, and no training in improving static balance among older women in Malaysia, in the 4th, 8th, and 12th weeks of intervention. Same as the above, MIT is more effective than LIT, and

LIT is more effective than no training.

4. HIT is more effective than MIT, LIT, and no training in improving mobility among older women in Malaysia in the 4th, 8th, and 12th weeks of intervention. Same as the above, MIT is more effective than LIT, and LIT is more effective than no training.

1.6 Significance of the Study

In Malaysia, the rapid increase of aged population and the higher life expectancy increase the total number of seniors. A higher percentage of the elderly population will result in significant social and economic changes, such as increased dependency ratios (Tobi et al., 2017). Ismail et al. (2019) stated that while the Malaysian senior elderly generations preferred to age in place and live independently for as long as possible, finding the proper training for the aged population could help them to live independently for a more extended time.

This phenomenon is alarming as the elderly population is multiplying. Evidence suggests that the Malaysian people's median age will increase from 26 years in 2010 to 37 years in 2040 (Cheah, 2018). The rise in the number of elderly is likely to cause a massive spike in health expenditure as more funds will be allocated for senior health care (Cheah, 2018).

Different intensity training shows different results in elderly functional parameters. Some recent studies (Fragala et al., 2019a; Levin et al., 2017; Lopez et al., 2021a; Turpela et al., 2017) have described the valuable outcomes of different resistance exercises intensity for senior people while some find no difference between different intensities (Csapo & Alegre, 2016a; Ribeiro et al., 2020b).

From the previous research, the authors concluded that the finding was still unclear. Despite this finding, insufficient studies have been undertaken to evaluate the effectiveness of high, moderate, and low-intensity training in different periods. As such, the researchers cannot make pure assumptions regarding the efficacy of different intensity trainings on functional capacity in senior adults. This research has been planned to deliver crucial and helpful data about the significance of a practical exercise program, including high, moderate, and low-intensity training programs to develop the physical function and quality of life among senior adults, and the results of the current study can contribute to designing effective interventions for women elderly population.

This study was warranted in terms of the followings:

Contribution to Knowledge: To the best of the author's knowledge, there has

been no detailed research covering the effectiveness of different intensity training on senior people in Malaysia. Therefore, the outcomes of this research deliver extra awareness to the literature in connection to the usefulness of this training program on physical function in senior adults. This study also helps to determine the effects of different intensity training on muscle strength, balance control and functional mobility.

Contribution to Practice: The conclusions from this research can offer specific substantial and scientific evidence for health providers and therapists occupied with senior people to use different intensity training for other purposes in their program. Additionally, the authors anticipated that the information gained from this research might urge policymakers to increase finance on this community to uphold or improve the independence.

1.7 Operational Definitions

Resistance Training (RT)

Conceptual definition: Resistance training is a general term that includes different modes and methods of regular exercise. The modes of training can include both machines and free weights. Resistance training comprises training process that can be useful for injury prevention and rehabilitation, general fitness training, bodybuilding, and training for competitive sport (Stone et al., 2007).

Operation definition: In this study, resistance training refers to four lower extremity exercises, including leg press, leg extension, leg curl and seated calf raises.

High-intensity training (HIT): HIT in this study refers to 80% to 90% of 1RM of individual strength.

Moderate-intensity training (MIT): MIT in this study refers to 65% to 75% of 1RM of individual strength.

Low-intensity training (LIT): LIT in this study refers to 50% to 60% of 1RM of individual strength.

Muscle Strength

Conceptual definition: Muscular strength is defined as “the ability of the muscle or muscle group to exert a maximal external force” (Denton, 2003).

Operational definition: In this study, muscle strength is the score of the subjects in the five-time sit-to-stand test (5STS).

Dynamic Balance

Conceptual definition: Dynamic balance is the branch of mechanical principles that relates alignment and the body, which provides body balance while moving (Bozkurt et al., 2017).

Operational definition: In this study, dynamic balance is the score of the subjects in the front reach test (FRT) and lateral reach test (LRT).

Static Balance

Conceptual definition: Static Balance is maintaining the body in some fixed posture. Static balance maintains postural stability and orientation with the centre of mass in a specific place or position (Bozkurt et al., 2017).

Operational definition: In this study, static balance is the score of the subjects in the tandem stand test (TST) and one leg stand (OLS).

Functional Mobility

Conceptual definition: Functional mobility is a person's ability to move to accomplish activities of daily living, such as getting in and out of a chair, walking, and turning (Bouça-Machado et al., 2020).

Operational definition: In this study, functional mobility is the score of subjects in the timed up and go test (TUG) and 6-minute walking test (6MWT).

Elderly

Conceptual definition: There is no United Nations standard numerical criterion for being elderly, but the UN agreed that the cut-off age for the elderly is 60 years old and above to refer to the older population. The World Health Organization (WHO) uses categories starting at the age of 65 and 80 (World Health Organization, 2015).

Operational definition: In Malaysia, individuals aged 65 and above have been accepted as older people (Khanuja et al., 2018). In the study, older Malaysian aged 65 years to 80 were sampled.

1.8 Research Framework

This study was designed to apply different intensity training to improve muscle strength, balance, and mobility of the elderly in Malaysia.

Figure 1.1 shows the associations between the dependent variables, including muscle strength, dynamic and static balance, and functional mobility of the current study. As presented below, there are several internal and external elements subsidized to sarcopenia, especially in elderly population. Being inactive physically is the main adjustable risk factor which diminishes lower-extremity muscle strength and increases balance weakening in this population.

This can lead to higher chance of fall accidents, which can lead to minor and major injuries as well as fear of falling. In older population, these alterations are significant explanations for impaired mobility.

Commonly, the detection of imbalance (sensory modalities) and ability to improve muscle strength and muscle power are key to maintain balance in elderly population (Daubney & Culham, 1999). Therefore, maintaining body balance is highly related to increasing the lower-extremity muscle strength. Additionally, muscle strength in lower-extremities and balance capability are connected to functional mobility in this population (Hasselgren et al., 2011).

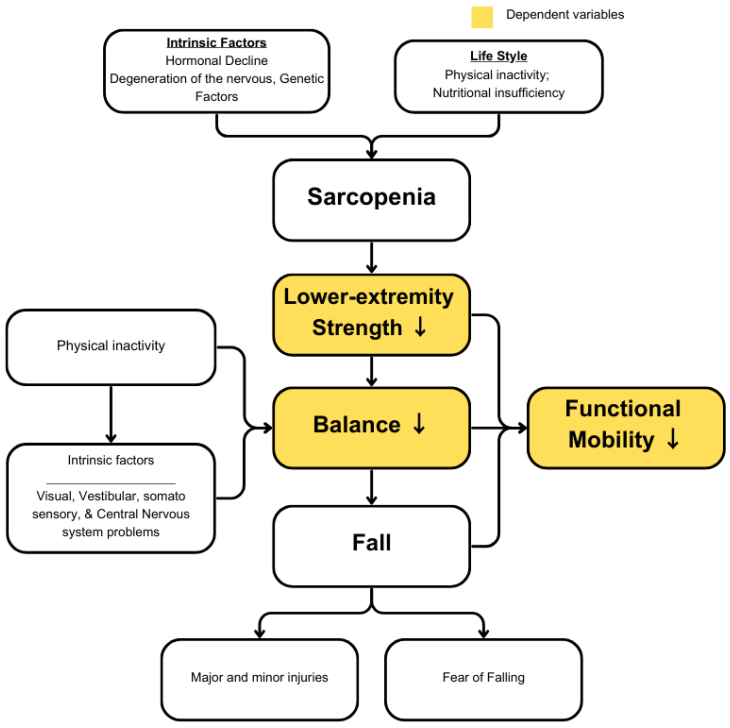

Figure 1.1: Relationship Between Dependent Variables

Conceptual framework presented below (Figure 1.2) is connected with the study's objectives. This indicates that the 12-week lower-extremity RT with different exercise intensities can improve muscle strength, dynamic and static balance, and accordingly, functional mobility in older women.

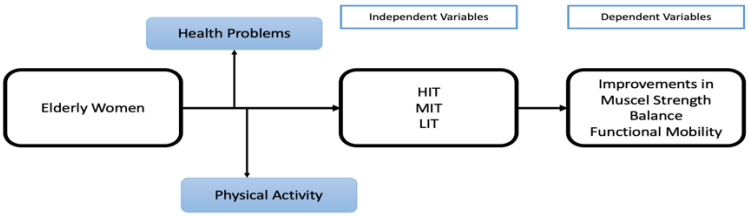

Figure 1.2: Conceptual Framework

The most remarkable modifiable risk aspect of physical inactivity is sarcopenia. Sarcopenia decreases lower-body strength and increases balance weakening, and these fluctuations are important reasons for weakened mobility in senior people.

RT is practical to increase functional ability, but when it comes to the intensity, it would have different effects on muscle strength, balance ability, and mobility. However, to the best of author's knowledge, no study has shown the effectiveness of high, moderate, and low-intensity training on muscle strength, balance, and mobility and the interaction of this training with time. This gap may be attributed to various factors, including the historically narrow focus of some research inquiries, divergent definitions of intensity levels, resource constraints, and evolving nature of scientific inquiry. Methodological complexities associated with ensuring consistency across different intensity levels and potential publication biases may have also played a role. This study endeavors to address these gaps by providing a comprehensive examination of the distinct impacts of high, moderate, and low-intensity training on elderly individuals, thus contributing valuable insights to the existing body of knowledge in this field.

Following this study's objectives, the data collection flow chart is presented in Figure 1.3, And the research framework in Figure 1.4.

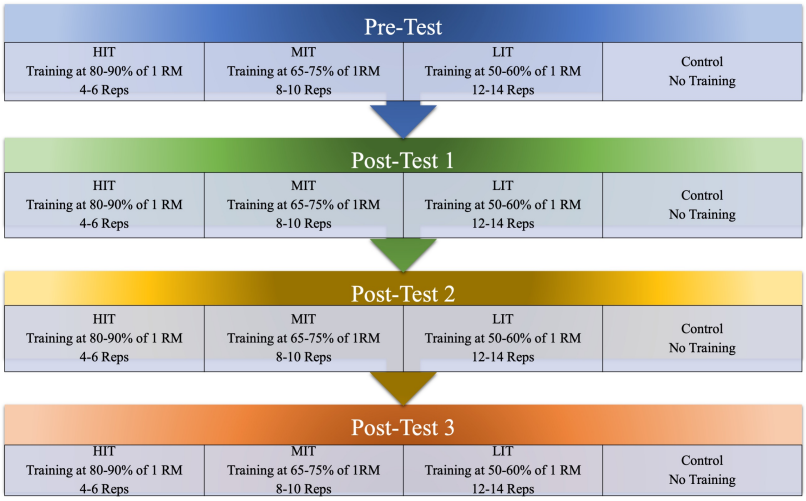

Figure 1.3: The Flow Chart of Data Collection
(HIT = High-Intensity Training; MIT = Moderate-Intensity Training; LIT = Low-intensity Training; CG = Control Group; 1RM = One Repetition Maximum; Reps = Repetitions)

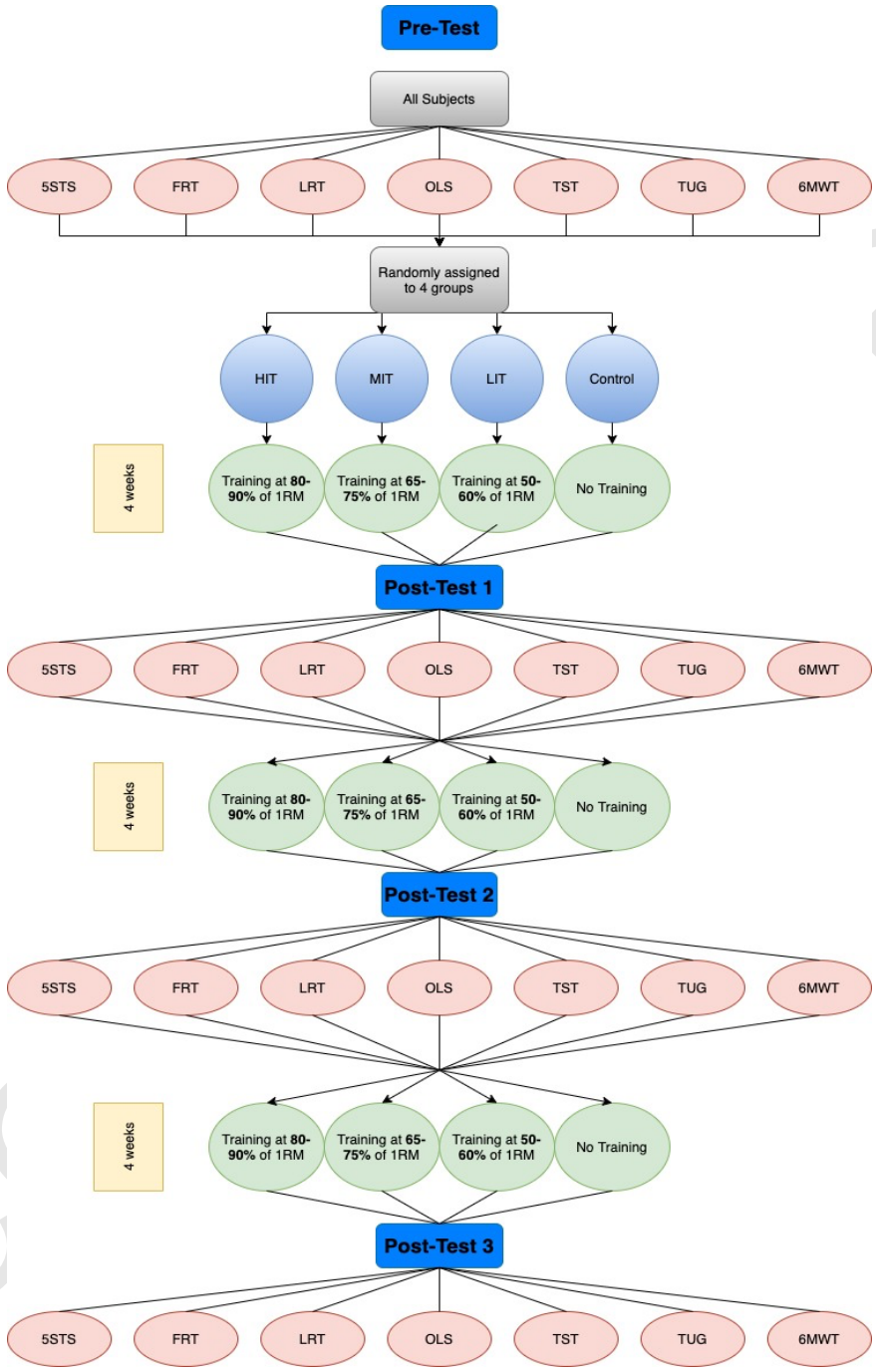

Figure 1.4: Research Framework
(5STS = Five Times Sit to Stand test; FRT = Front Reach Test; LRT = Lateral Reach Test; OLS = One Leg Stand; TST = Tandem Stand Test; TUG = The Timed Up and Go Test; 6MWT = Six Minutes Walking Test; HIT = High-Intensity Training; MIT = Moderate-Intensity Training; LIT = Low-Intensity Training; CG = Control Group)

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