UNIVERSITI PUTRA MALAYSIA

EFFECTS OF ELASTIC RESISTANCE TRAINING ON LOWER EXTREMITY MUSCLE STRENGTH, BALANCE AND FUNCTIONAL MOBILITY AMONG INSTITUTIONALIZED ELDERLY IN MALAYSIA

SEYEDEH AMENEH MOTALEBI

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By

SEYEDEH AMENEH MOTALEBI

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

April 2015

DEDICATION

This thesis is dedicated to:

My late parents, whom I owe everything I having my life

The memory of my late brother-in-law, Sadroddin Naji

My father and mother-in-law, Hasan and Sareh, for their love, prayers, and caring

My husband, Dr. Hamid Reza, for his remarkable patience, unwavering love, and endless support

My lovely sons, Sadra and Parsa for their patience, and understanding

My sisters and brothers for their support, encouragement, and prayers

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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Chairman: Loke Seng Cheong, MBBS, MRCP, FAMS
Institute: Institute of Gerontology

To provide and make accessible the benefits of the resistance exercises for older people, development of a low-cost and also useful alternative equipment are essential. So, this study examined the effects of a 12-week progressive elastic resistance training on lower-extremity muscle strength, static and dynamic balance and functional mobility of older adults residing in a governmental welfare home (Rumah Seri Kenangan), in Cheras, Selangor, Malaysia. Fifty one subjects were qualified to participate in this quasi-experimental designed study. They were allocated to either the 12-week progressive elastic resistance training (N= 26) or in the control group (N = 25). Forty-five of them (male = 26 and female = 19) with mean age 70.7 ± 6.6 years successfully completed the program. The majority of the subjects were Malay ethnicity (73.3%). The exercise group was trained twice per week, performing 1-3 sets of 8-10 repetitions for each of nine lower-extremities elastic resistance exercises. Exercises were performed in both sitting and standing positions at moderate intensity (5 or 6 of OMNI perceived exertion scale) using elastic bands in different resistances. The dependent variables consisted of lower-extremity muscle strength [sit-to-stand test (STS)], dynamic balance [forward functional reach test (FFRT), lateral reach test (LRT) for right and left hands, four square step test (FSST), and step test for right and left leg], static balance performance [tandem stand Test (TST), one leg stand (OLS) test with the eyes opened and closed], functional mobility [timed- up-and-go (TUG) test and 6-minute walking Test (6MWT)] were measured before and after 6 and 12 weeks intervention. There were no significant differences in the distributions of all tests scores for the dependent variables between the exercise and control groups prior to the intervention. The post-intervention measurements showed significant improvements in lower-extremity muscle strength (22.60%, $p < 0.001$) and functional mobility (18.71% in TUG test and 12.09% in 6MWT, $p < 0.001$). There was also a significant increase in the dynamic balance ability by FFRT (18.51%, $p < 0.001$), LRT for right hand (19.98%, $p < 0.001$) and for left hand (17.69%, $p < 0.001$), FSST (14.67%, $p < 0.001$), and step test for right leg (18.36%, $p < 0.001$) and for left leg (18.80%, $p < 0.001$). No significant improvements were observed in the

static balance measured by tandem stand test (3.25%, $p > 0.05$), OLS with eyes opened (9.58%, $p > 0.05$) and with eyes closed (-0.61%, $p > 0.05$).

The findings support the feasibility and efficacy of a simple and inexpensive resistance training program for improving lower-extremity muscle strength, dynamic balance and mobility in the institutionalized older adults. This training can be considered as an effective public health strategy for improvement of daily activity performance and reducing the risk of falling in the growing older population.

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

KESAN LATIHAN RINTANGAN ANJAL TERHADAP KEKUATAN OTOT ANGGOTA BAWAH, IMBANGAN DAN MOBILITI FUNGSIAN DALAM KALANGAN DIINSTITUSIKAN WARGA TUA DI MALASIA

Oleh

SEYEDEH AMENEH MOTALEBI

April 2015

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Bagi menyediakan dan menjadikannya manfaat latihan ini boleh diakses, pembangunan alatan kos rendah dan alternatif bermanfaat adalah penting. Oleh itu, kajian ini mengkaji kesan 12 minggu latihan rintangan anjal progresif pada kekuatan otot anggota bawah, statik dan keseimbangan dinamik dan mobiliti fungsian terhadap orang tua yang tinggal di rumah kebajikan kerajaan (Rumah Seri Kenangan), di Cheras, Selangor, Malaysia. Lima puluh satu subjek layak untuk menyertai kajian berbentuk kuasi-eksperimen ini. Mereka telah diagihkan sama ada di 12 minggu latihan rintangan anjal progresif (N = 26) atau dalam kumpulan kawalan (N = 25). Empat puluh lima daripada mereka (lelaki = 26 dan perempuan = 19) dengan umur minimum 70.7 ± 6.6 tahun berjaya menamatkan tempoh program. Majoriti subjek adalah berbangsa Melayu (73%). Kumpulan latihan telah dilatih dua kali seminggu, melakukan 1-3 set 8-10 ulangan bagi setiap sembilan latihan rintangan anjal anggota bawah. Latihan telah dijalankan pada posisi duduk dan berdiri pada pada intensiti sederhana (5 atau 6 pada *OMNI perceived exertion scale*) menggunakan jalur anjal di rintangan yang berbeza. Pembolehubah bersandar terdiri daripada kekuatan otot anggota bawah [*sit-to-stand test (STS)*], keseimbangan dinamik [*forward functional reach test (FFRT)*, *lateral reach test (LRT)* bagi tangan kanan dan kiri, *four square step test (FSST)*, dan ujian melangkah bagi kaki kanan dan kiri], prestasi keseimbangan statik [*tandem stand Test (TST), one leg stand (OLS)*, ujian dengan mata terbuka dan tertutup], mobiliti fungsian [*timed- up-and-go (TUG) test* dan *6-minute walking Test (6MWT)*] diukur sebelum dan selepas 6 dan 12 minggu intervensi. Tiada perubahan signifikan dalam pengagihan skor pada kesemua ujian untuk pembolehubah bersandar antara latihan dan kumpulan kawalan sebelum intervensi. Pengukuran pasca intervensi menunjukkan peningkatan yang ketara dalam kekuatan otot anggota bawah (22.60%, $p < 0.001$) dan mobiliti fungsian (18.71% dalam ujian TUG dan 12.09% pada 6MWT, $p < 0.001$). Terdapat juga peningkatan yang ketara dalam keupayaan keseimbangan dinamik dengan FFRT (18.51%, $p < 0.001$), LRT untuk tangan kanan (19.98%, $p < 0.001$) dan untuk tangan kiri (17.69%, $p < 0.001$), FSST (14.67% , $p < 0.001$), dan ujian melangkah bagikaki kanan (18.36%, $p < 0.001$) dan kaki kiri (18.80%, $p < 0.001$). Tiada peningkatan

signifikan telah diperhatikan dalam keseimbangan statik diukur dengan TST (3.25%, p> 0.05), OLS dengan mata terbuka (9.58%, p> 0.05) dan dengan mata tertutup (-0.61%, p> 0.05). Tiada perbezaan signifikan didapati dalam kumpulan kawalan bagi mana-mana pembolehubah diukur.

Hasil kajian menyokong kelayakan dan keberkesanan program latihan rintangan yang mudah dan murah bagi meningkatkan kekuatan otot anggota bawah, keseimbangan dinamik dan mobiliti bagi orang tua di dalam institusi. Latihan ini boleh dianggap sebagai satu strategi kesihatan umum yang berkesan untuk peningkatan prestasi aktiviti harian dan mengurangkan risiko jatuh dalam populasi warga emas yang semakin meningkat.

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INTRODUCTION

1.1 Introduction

The world's population is growing fast towards aging (Hairi, Cumming, Naganathan, Handelsman, Le Couteur, Creasey et al., 2010). Aging is one of the most important demographic phenomena of 21st century (Chan, 2005). It is expected that by the middle of this century one in every five persons will be old (Mujahid, 2006). Therefore, for the first time in history, worldwide aged population will be more than the children (Marques, Rosa, Soares, Santos, Mota, & Carvalho, 2011). Like other countries, population ageing in Malaysia is rapidly growing as a result of declining fertility and mortality rates, increasing life expectancy, and improvements in the health systems (Ambigga, Ramli, Suthahar, Tauhid, Clearihan, & Browning, 2011). It is expected that Malaysia will become an aged nation by 2030 when 15 per cent of the population is categorized as elderly (Sulaiman & Masud, 2012).

Population ageing has become a challenge for both developed and developing countries (Ahmad, Ismail, & Rahman, 2011). The rapid changes in the number of aged people create important concern, particularly in relation to the health of seniors (Thanakwang, Soonthorndhada, & Mongkolprasoet, 2012). Ageing is associated with reduction in both physiological and psychological function (Nakasato & Carnes, 2006; Mazzonna & Peracchi, 2012) that may lead to a significant level of dependency (Singh & Hiatt, 2006). Health problems occur more commonly with ageing that are the main reason for functional decline and inability of older people for maintaining simple activities of daily living (Singh, Paw, Bosscher, & van Mechelen, 2006).

The incidence of age-related diseases has largely increased over time (Christensen, Doblhammer, Rau, & Vaupel, 2009). So, most patients admitted into the hospitals are older adults and two-thirds of them have two or more chronic illnesses (Duque, Freitas, Silvestre, Fernandes, Pinto, Sousa et al., 2011). Many Malaysian elders also suffer from multiple chronic non-communicable disorders. The medical care costs increase by raising chronic conditions among the older adults (Ambigga et al., 2011). Therefore, by growing Malaysian older people, their health status seems to be a concern (Haron, Sharpe, Masud, & Abdel-Ghany, 2010).

A major factor leading to the loss of functional ability is sarcopenia or extreme muscle strength and mass loss (Sagiv, 2009; Seene & Kaasik, 2012; Garatachea & Lucía, 2013). Sarcopenia is the result of ageing process, atrophy disuse, and poor nutrition (Evans, 2010; Morley, 2012). Muscle decline becomes obvious at the age of 45 years (Liu & Latham, 2011), and it is accelerated at the age 60 years and above (Paterson et al., 2007). The prevalence increases by advancing age (Cruz-Jentoft, Baeyens, Bauer, Boirie, Cederholm, Landi et al., 2010). People in their eighties have 40% less muscle strength than in their twenties (Liu & Latham, 2011).

Lower-extremity strength is the major factor for maintaining mobility and physical abilities. Strong lower-extremity muscles and flexible joints play key roles in balance performance (Alpert, 2013). Leg muscle weakness was documented to be an important predictor of balance impairment in older adults (Toraman & Yıldırım, 2010). Balance ability is related to not only accurate sensory and neurological systems but also on good muscle strength (Wallmann, Schuerman, Kruskall, & Alpert, 2009). Ageing is accompanied with atrophy of type II muscle fibers (fast-twitch) (Bottaro, Machado, Nogueira, Scales, & Veloso, 2007). Hence, remaining muscle is weaker and slower and may not able to produce enough strength for preserving balance control (Pijnappels, Reeves, & van Dieën, 2008; Boirie, 2009).

Sufficient balance control is essential for independent and safe performance of activities of daily living such as walking, stair climbing or bending forward (Paterson, Jones, & Rice, 2007). Muscle strength loss and balance impairment are two of the major risk factors for falls (Busing, 2006; Pijnappels, Reeves, & van Dieën, 2008). Moreland, Richardson, Goldsmith, and Clase (2004) in their meta-analysis study reported that older people with lower-extremity muscles' weakness had 1.76 more risk for falls and 3.06 more risk for repeated falls.

Sarcopenia has been identified as a main factor for disability and loss of independence in older people (Peterson & Gordon, 2011). Specifically in institutionalized older adults, muscle strength can decrease to a point which threatens their ability for independent living (Ribeiro, Teixeira, Brochado, & Oliveira, 2009). Fast increasing older population and the cost of sarcopenia-related health care highlight the necessity of effective interventions for prevention programs (Visvanathan & Chapman, 2010).

1.2 Problem Statement

Maintaining independent living is an important issue in the elderly (Mynatt & Rogers, 2001). Dependency is an effective factor for decreasing quality of life. It has been considered as a concern for older people and a burden on the funding of health care centers (Paterson, Govindasamy, Vidmar, Cunningham, & Koval, 2004).

Institution living older adults have limited opportunities for an active lifestyle (Lobo, Santos, Carvalho, & Mota, 2008). Physical inactivity and disability in institutionalized older adults may negatively affect their ability to perform activities of daily living (Dechamps, Diolez, Thiaudière, Tulon, Onifade, Vuong et al., 2010). This frailty is associated with impaired autonomy, loss in quality of life, increase the risk for falls, and use of health care facilities (Ribeiro et al., 2009; Shahar, Kamaruddin, Badrasawi, Sakian, Manaf, Yassin et al., 2013). As such, it is very crucial to keep the institutionalized older adults active.

Related to Malaysia, there are nine public residential care homes for the elderly as Rumah Seri Kenangan (RSK). In comparison with nursing homes, the residents in the RSK are more independent. RSK provides care, shelter, treatment, physiotherapy

services, work rehabilitation, prayer facilities, and recreation for older people without family and financial support (Chen, Ngoh, & Harith, 2012). About 27.2% of the older people aged 60 years and over are living in RSK were dependent in at least one activity of daily living (Zaitun, Nor Afiah, & Latiffah, 2006). So, it is crucial to familiarize institutionalized older adults to exercise intervention in view of their high prevalence of functional decline.

Regular physical activity and exercise are effective in improvement of health, prevention of age- related diseases (Motl & McAuley, 2010), maintaining psychological well-being, increasing physical functioning, and quality of life (Netz, Wu, Becker, & Tenenbaum, 2005; Acree, Longfors, Fjeldstad, Fjeldstad, Schank, Nickel et al., 2006). Although many studies have supported the importance of exercise for older population (Liu & Latham, 2009), but there has been relatively little number of researches examining the role of exercise in the institutionalized older adults (Marshall & Berg, 2010). It needs to replicate the researches in the institutions to explore the generalizability of the findings.

Health care providers need to promote the exercise interventions that help to increase the functional capacity and improvement of quality of life of institutionalized older adults (Csapo, Gormasz, & Baron, 2009; Justine, Hamid, Kamalden, & Ahmad, 2010). Resistance or strength training has been shown to be the main intervention for preserving functional independence among older persons (Dalgas, Stenager, Jakobsen, Petersen, Hansen, Knudsen et al., 2009). This training combined with balance training has played an important role in reduction of falls in the elderly (Sherrington, Whitney, Lord, Herbert, Cumming, & Close, 2008; Sherrington, Tiedemann, Fairhall, Close, & Lord, 2011). Sherrington et al. (2011) in a meta-analysis study highlighted that balance training is the main component of exercise that is important to achieve reduced falls. However, many of studies in this review have used combined balance and resistance training program. There is a little evidence that strength or resistance training by itself can reduce falls.

It is well documented as the safest and most effective protocol for increasing and maintaining muscle mass and strength in aged people (Latham, Bennett, Stretton, & Anderson, 2004; Martins, de Oliveira, Carvalho, de Oliveira Damasceno, da Silva, & Silva, 2013). Liu and Latham (2009) in a Cochrane review, also reported some clear effects of resistance training in older people. However, a limited number has been related to the low-cost exercise programs. The majority of the previous studies have used gym-based training by fitness machines (Straight, Lofgren, & Delmonico, 2012). These programs are not economical or easily accessible for many older people. Older adults have difficulties traveling regularly to sport centers and maintaining their exercise program (Damush & Damush, 1999). Also, some estimation indicates that the average drop out of resistance training programs by machines can reach 50% in the first year of training. So, there are some questions about the adherence to this type of resistance training (Martins et al., 2013). Hence, more practical and cost-effective modality is required to provide its benefits to most older people (Mikesky, Topp, Wigglesworth, Harsha, & Edwards, 1994; Ribeiro et al., 2009).

Elastic resistance devices (bands or tubes) are simple and practical equipment for strength training (Martins et al., 2013). Elastic band is suitable for the elderly as its low cost, simplicity, lightweight, portability, and flexibility despite its ability to provide strong resistance (Thomas, Mueller, & Busse, 2005). So, it is a good alternative instrument for resistance training among the elderly including those residing in the institutions. These devices can help older people for strength improvement in a similar way to that of using free weights or a weight machine for training (Melchiorri & Rainoldi, 2011).

There is a scarcity of research examining the feasibility and effectiveness of elastic resistance training (Chen, Tseng, Chang, Huang, & Li, 2013) especially on balance performance and functional mobility in elderly subjects (Liu & Latham, 2009). More research needs to be conducted on this training in the elderly to determine its efficiency for improving muscle strength, balance and functional mobility. As such, the aim of the present study is to assess the efficacy of an exercise intervention in institutionalized older adults.

1.3 Objectives of the Study

1.3.1 General Objective

The main purpose of this study is to determine the effect of a 12-week group-based progressive resistance training (PRT) using elastic band, on lower-extremity muscle strength, static and dynamic balance and functional mobility among institutionalized elderly adults.

1.3.2 Specific Objectives

The specific objectives of the current study are:

1. To compare the effects of participation in a 12-week PRT program, using elastic band, on lower-extremity muscle strength as measured by five times sit to stand test (5STS) between the exercise and control groups.

2. To compare the effects of participation in a 12-week PRT program, using elastic band, on dynamic balance as measured by forward functional reach test (FFRT), lateral reach test (LRT), step test and four square step test (FSST) between the exercise and control groups.

3. To compare the effects of participation in a 12-week PRT program, using elastic band, on static balance as measured by as measured by tandem stand test and one leg stand (OLS) test with eyes opened and closed between the exercise and control groups.

4. To measure the effects of participation in a 12-week PRT program, using elastic band, on functional mobility as measured by as measured by timed up and go (TUG) test and six-minute walking (6MW) test between the exercise and control groups.

1.4 Research Hypotheses

The hypotheses for the present study include:

1. There will be significant difference between the control group and exercise group on the 5STS test before and after the intervention.

2. There will be significant difference between the control group and exercise group on the reach test at forward, right, and left directions before and after the intervention.

3. There will be significant difference between the control group and exercise group on the ST before and after the intervention.

4. There will be significant difference between the control group and exercise group on the FSST before and after the intervention.

5. There will be significant difference between the control group and exercise group on the TS before and after the intervention.

6. There will be significant difference between the control group and exercise group on the OLS test with eyes opened and closed before and after the intervention.

7. There will be significant difference between the control group and exercise group on the TUG test before and after the intervention.

8. There will be significant difference between the control group and exercise group on the 6MW test before and after the intervention.

1.5 Significance of the Study

In Malaysia, the rapid growth in the number of older people and the longer life expectancy increased the number of elderly that would require institutionalization (Mafauzy, 2000). This group of older people may not have easy access to weight training equipment, usually found in sport centers. So, it is required to use less expensive and practical alternative modes of resistance exercise for their effectiveness.

Elastic resistance training is simple, practical, and economical resistance training for older people (Martins et al., 2013). Some recent studies (Fahlman, McNevin, Boardley, Morgan, & Topp, 2011; Kim & Kim, 2012; Seo, Kim, & Singh, 2012) have reported the beneficial effects of elastic resistance exercises for the elderly, but the experimental attempts are still inadequate and do not allow researchers to take clear conclusions about the efficacy of elastic resistance training on functional capacity in older adults. As such, this study will provide essential and beneficial data regarding the importance of a simple and effective exercise program to improve physical function and quality of life among institutionalized older adults.

This study was warranted in terms of:

Contribution to knowledge: There has been no specific study reporting the effect of elastic resistance training in institutionalized older adults in Malaysia. Hence, the results from this study provide additional knowledge to the literature with regard to efficacy of this training on physical function in the sedentary institutionalized older adults. This study may also help to establish the effects of this training on the balance control and functional mobility which have had contradictory results in the literature.

Contribution to practice: The findings from this study may provide some essential and scientific information for health providers and practitioners working with older people to use this simple and low-cost exercise training for their prevention or therapeutic program. Furthermore, it is expected that the knowledge obtained from this study may impel policy makers to develop the elastic resistance training programs for community or institutionalized older adults for maintaining or enhancing their independence living.

1.6 Definition of Terminology

The variables of the study are defined conceptually and operationally.

Elastic Resistance training:

Conceptual definition: Elastic resistance training is a type of resistance training that is performed by elastic bands or tubes for improving muscular mass or strength through a slow and gradual increase in the amount of perceived intensities over time (Yamauchi, Islam, Koizumi, Rogers, Rogers, & Takeshima, 2005).

Operational definition:

In this study, elastic resistance training consisted of nine resistance exercises using Dura band (Dura band, Dura Medical Sdn. Bhd, Malaysia) that involved the major lower-extremity muscles which are important for balance control.

Muscle Strength

Conceptual definition: Muscle strength refers to a maximal force that a muscle or a group of muscles can produce under a maximum contraction (Croix, Deighan, & Armstrong, 2003).

Operational definition: In this study, muscle strength was operationally defined as the quantitative scores obtained from the 5STS test. A lower score indicates a higher level of muscle strength.

Balance

Conceptual definition: Balance refers to the ability of people to maintain upright position above the base of support (Paterson et al., 2007). It normally is divided into two subcategories, including dynamic and static balance. Dynamic balance refers to the ability for maintaining stability inside the base of support when the body is moving (Rogers, Fernandez, & Bohlken, 2001). Static balance refers to the ability for maintaining balance inside the base of support while standing still (Cress et al., 2006).

Operational definition: Balance was operationally defined as different components of stability that was quantified by reach test, step test, FSST, tandem stand test, and OLS with eyes opened and closed.

Functional Mobility

Conceptual definition: Functional mobility refers to the balance and gait maneuvers used in everyday life such as getting in and out of a chair, walking, and turning (Ribeiro et al, 2009).

Operational definition: Functional mobility was operationally defined as the time for standing up from the chair, walk 3 meters, turn, return to the chair, and sit down (TUG) and also by distance walked in a period of 6 minutes (6MWT).

Older People

Conceptual definition: In Malaysia, individuals aged 60 and above has been accepted as older people (Samad & Mansor, 2013).

Operational definition: Older people was operationally defined as institutionalized older adults aged 60 years and over from Malaysia.

1.7 Conceptual Framework

Figure 1.1 shows the relationships between the dependent variables of this study, including lower-extremity muscle strength, balance, and functional mobility. As

depicted in this Figure, there are a number of intrinsic and extrinsic factors that are contributed to sarcopenia. The most important modifiable risk factor is physical inactivity. Sarcopenia reduces lower-extremity strength and raises balance impairment. The result of this is the increase of occurrence of falls. Falls may lead to the minor and major injuries or fear of falling. These changes are important reasons for impaired mobility in the older people.

Generally, maintenance of balance is interplay between detection of imbalance (sensory modalities) and the ability to correct for this (muscle strength or power) (Daubney & Culham, 1999). Hence, the lower-extremity muscle strength is an important predictor for maintaining balance. Furthermore, both lower-extremities muscle strength and balance ability are highly associated with functional mobility in older people (Hasselgren, Olsson, & Nyberg, 2011; Shubert, 2011).

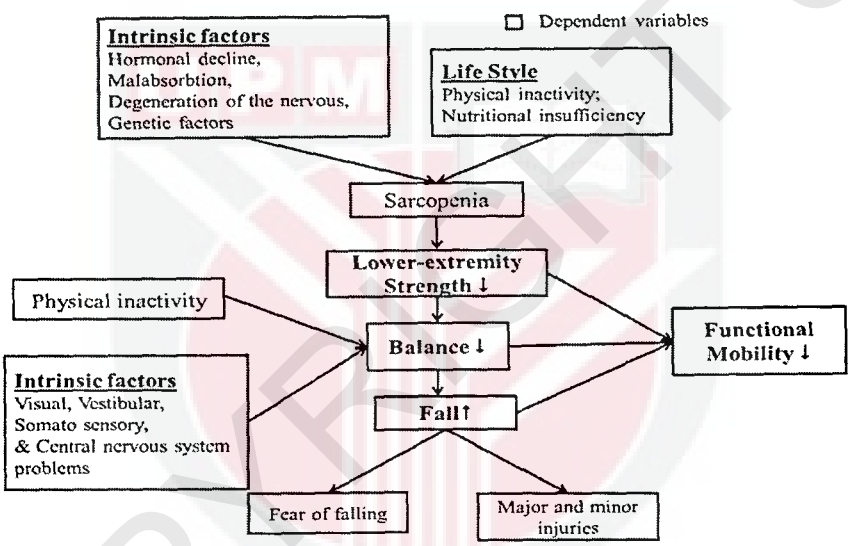

Figure 1.1 Relationships between the dependent variables

In accordance with the objectives of this study, the conceptual framework is presented in Figure 1.2. It indicates that the 12-week lower-extremity elastic resistance exercises can improve the lower- extremity strength, balance ability, and consequently, functional mobility in older adults.

The box demographic characteristics of the participants were evaluated in this study. The box physical activity level was assessed and subjects involving in regular balance or resistance training during three last months were excluded from the present study. The health problems such as myocardial infarction in past six months, recent heart attack, un-controlled hypertension, broken leg in the past six months, diagnosed osteoporosis, diagnosed heart failure were excluded from this study. All of these conditions may affect the participants' safety or response to the intervention.

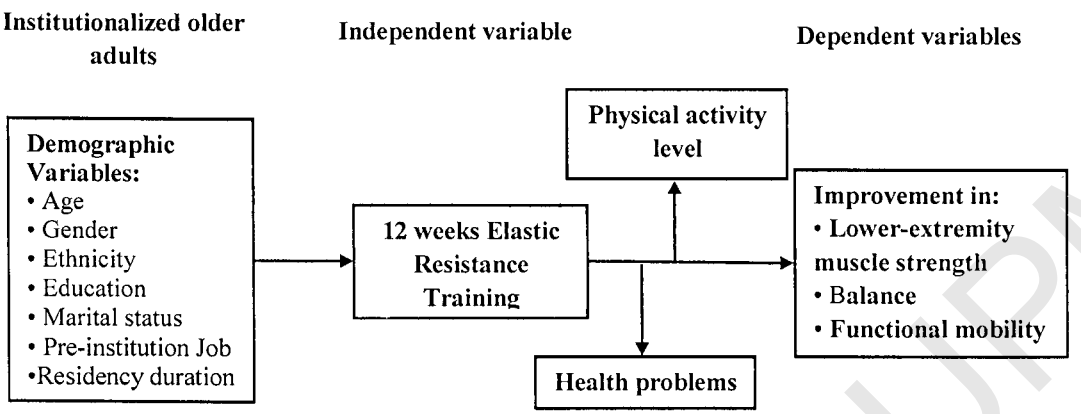

Figure 1.2 Conceptual framework

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