ROLE OF BODYWEIGHT EXERCISE ON SKELETAL MUSCLE STRENGTH IN ELDERLY

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Abstract

Aging caused such overwhelming effects on the mass of skeletal muscle. The increasing period of rest and lack of physical activity that indicate the reduced movement most likely explain much in reducing the phenotype of muscle and bone in older individuals. Sarcopenia, the age-related loss of muscle mass and strength, is the term to explain this condition. Metabolic abnormalities such as alterations in insulin sensitivity, greater deposition of fat, myosteatosis, low level of hormones, systemic inflammation, and impaired oxidative defenses caused by decreased mitochondrial activity. Accumulated evidence showed that resistance training (RT) had an abundant effect on sarcopenia, functional status, bone density, and hip fracture. Although numerous studies showed resistance training had a significant effect to improve muscular strength in the elderly. This study aims to explore the role of bodyweight exercise in improving skeletal muscle strength in the elderly. From 19 original articles, we analyzed the effects of bodyweight exercise in the population who underwent aging. Several articles were also added to explain the muscular condition in aging and its improvement after exercise. Bodyweight training has a significant role in improving skeletal muscle strength in the elderly. It induced satellite cell activity, preventing excessive proteasomal degradation, and type II motor-unit fibers proliferation which has a significant role in muscular strength.

Keywords*: Muscle strength, Bodyweight exercise, Strength improvement, Resistance exercise, Elderly, Ageing*

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INTRODUCTION

Various efforts will be made to improve or maintain physical health and fitness such as exercise with a certain intensity.[1] It said also that lack of physical activity and a sedentary lifestyle has a significant impact on the reduction of muscle strength.[2] It would be difficult to change lifestyle dramatically but it is possible to help people out of muscle weakness by finding an effective and easy exercise or maximizing it with an affordable supplement either.[2]

Aging caused such overwhelming effects on the mass of skeletal muscle and bone.[3] The increasing period of rest and lack of physical activity that indicate the reduced movement most likely explain much in reducing the phenotype of muscle and bone in older individuals.[4,5] Age-related bone loss such as osteoporosis occurred as well as age-related muscle loss, referred to as sarcopenia at the same time

Physical activity and adequate nutrition are modifiable factors that potentially reduce sarcopenia progress and prevent frailness in the elderly.[9] Accumulated evidence showed that resistance training (RT) had abundant positive effects to deal with sarcopenia, enhancing functional status, elevating bone density, and preventing hip fracture.[10] Although behavioral and daily physical activities affect muscle mass and are still not fully noted, several studies have found that it has a meaningful impact on improving muscle strength.

Since muscular mass had a great determinant of the strength of skeletal muscle, researches related to muscle hypertrophy still provide significant interest to the public. Although it is well known that exercise with sufficient mechanical load, duration, and frequency helps increase the muscular quality and quantity represented by its mass and strength, there is still required information regarding the role of bodyweight modality in improving skeletal muscle strength in the elderly. Besides, there is still no study providing information on how effective bodyweight exercise is one of the resistance exercise modalities to be used for the elderly as a therapy to improve muscular strength directly.

This study is carried out to review information related to the role of bodyweight exercise modality in improving muscular strength in the elderly and it's expected to be the basic reference or initial step for further research. Moreover, the understanding of resistance exercise modalities in improving muscular strength in the elderly such as bodyweight exercise is beneficial for medical advancement.

MATERIAL AND METHODS

Research Design

The design of this research is a qualitative study with a literature study approach. This literature study provides information about a topic based on current knowledge as notes and descriptive data.12 It summarizes and concludes the previous research knowledge related to a certain topic. It also helps the researcher in deciding to justify, identify, refine hypotheses, and avoid pitfalls from previous research. The formation of a theoretical framework, the overview of current evidence, and the identified gap in knowledge of the study are the main goals of the literature review. A literature review assists the researcher to conduct more focused further research in the future.13,14

The type of this literature review is a narrative literature review or a traditional literature review. In this review, the author summarizes, concludes knowledge of a certain topic, and identifies gaps and inconsistencies in the knowledge of a related topic. This process leads to more focused research questions for future research.14

In a qualitative investigation, descriptive analyses are needed. The analytical method will describe obvious results systematically and critically regarding the role of resistance exercise in skeletal muscle strength in aging. The qualitative approaches are based on the collected data, classification, and rewriting them.

Research Strategy

This literature review consists of international research articles obtained from

Pubmed, ClinicalKey, and Google Scholar. Some keywords were used to find the appropriate articles that related to this research. Those keywords were "Muscle strength", "Bodyweight exercise", "Muscle ageing", "Strength improvement", "Resistance exercise", "Muscle regeneration", "Elderly", "Ageing". These keywords were used separately or combined by Boolean operators such as "and", "or" and "not" to find the logical relationship between its concepts. The article that is used as reference was limited only to last 10 years, article review or both in vitro and in vivo studies with animal or human models.

Data Collection

The data is collected from journal articles that are eligible for the inclusion criteria and not included in the exclusive criteria. From each eligible study, the following data were retrieved: First author, journal publisher, country, study objective, study design, and significant findings. The information was compiled and arranged within a table.

Bodyweight training as one of the resistance exercise modalities and its role related to skeletal-muscle strength improvement in the elderly were reviewed to explore how the exercise deal with aging in skeletal muscle and improves muscular strength in the elderly. There are a lot of molecular mechanisms to explain how exercise improves skeletal muscle quality. Thus, the author only explained the mentioned mechanisms from obtained articles in this study.

RESULT

This review collected 19 original articles which contain information related to bodyweight exercise, muscular strength, and aging. The collected articles were obtained by a searching process carried out through indexed-based electronics and selected through inclusion and selection criteria. Additional references were added to provide further explanation regarding the role of bodyweight exercise on skeletal muscles strength in the elderly. The result of the content analysis from collected articles presented in table 3.1.

Table 3.1 Studies Dealing with the Role of Bodyweight exercise in the Elderly

Author	Journal Publisher	Country	Study objective	Study design	Findings
Lipecki et al., 2015[15]	Polish Journal of Sport and Tourism	Poland	Assess how bodyweight exercise deals with physical fitness and body composition in untrained women	Experimental	1. Bodyweight exercise (BE) had positive impacts on all determinants of physical fitness. 2. Bodyweight exercise (BE) statistically had a significant role to increase the strength of muscle and endurance of the trunk (10.7%; $p<0.01$), explosive strength of the lower limbs (5.6%; $p<0.01$), and aerobic capacity (33.3%; $p<0.05$). 3. Bodyweight exercise (BE) had less impact on body-composition parameters without a proper nutritional program.
Patti et al., 2017[16]	Work	Italy	Evaluate the consequences of a standardized exercise without any equipment on balance skills and pain perception in elderly	Randomized Controlled Trial	1.Standardized equipment-free exercise is effective in improving sensation of pain ($p < 0.0001$) and balance skills ($p < 0.0001$) in the elderly. 2. Standardized equipment-free exercise might be the solution to overcome the rate of disability in the elderly by implementing a low-cost strategy program.
Vikberg et al., 2019[17]	Journal of the American Medical Directors Association	Norway	Examine functional strength and body composition after resistance exercise	Randomized Controlled Trial	Functional resistance training programs utilize the combination of body weight and the elastic band was significantly

Author	Journal Publisher	Country	Study objective	Study design	Findings
			intervention in a population the age of 70 years and who underwent pre-sarcopenia		help to maintain functional strength and body composition in the elderly population with pre-sarcopenia.
Stojanovic et al., 202118	Journal of Sports Science and Medicine	Croatia	Examine how chair-based and low-load resistance exercise with elastic band affect functional fitness and body composition in aged woman	Randomized Controlled Trial	Strength measurements such as the handgrip strength test showed significant improvement in terms of muscular strength. Significant transformations were found for the level of glucose, total cholesterol level, HDL level, and LDL level in the pre against the post-treated group as well as blood glucose in the group without intervention ($p < 0.05$), respectively.
Chulvi-Medrano et al., 2017[19]	Journal of Sports Science and Medicine	USA	Compare the effects of conventional resistance training against manual resistance training on maximum strength and muscle endurance in trained men	Experimental	1. Manual resistance exercise (MRE) has no significant difference compared to conventional exercise in terms of muscle strength and endurance in men who underwent intense training previously. 2. Manual resistance exercise (MRE) is useful to utilize as an alternative strength training modality for trained individuals and also could be a consideration for personal trainers, especially in the condition of the low-equipped facility.
de ResendeNeto et al., 2019[20]	Journal of Sports Medicine and Physical Fitness	Brazil	Compare the effects of functional training against traditional training agility, gait determinants, and muscle strength and verified the maintenance of the effects after detraining for eight weeks in elderly female	Randomized Controlled Trial	1. Functional training was observed to cause higher dynamic balance and cardiorespiratory capacity variables compared to traditional training. 2) Functional training and traditional training were equally showed improvement for the joint mobility and strength components in active elderly females but no significant difference found between both pieces of training ($p \geq 5$).
Yamada et al., 2019[21]	Geriatrics and Gerontology International	Japan	Investigate the synergetic effect of bodyweight exercise with additional supplementation on improving muscular quantity and quality in sarcopenic and dynamic aged patients	Randomized Controlled Trial	The combination of bodyweight exercise with protein and vitamin D supplementation showed a significant effect in improving muscle mass and muscle strength in elderly who underwent sarcopenia and dynapenia.
Saeterbakken et al., 2018[22]	Journal of Aging Research	Norway	Demonstrate how home-based strength training deals	Pilot Study	Home-based resistance exercise had no significant effect on the improvement of muscle

Author	Journal Publisher	Country	Study objective	Study design	Findings
			with muscle properties, physical function, and physical activity in the elderly population underwent frailty		properties, physical function, and daily activity.
Watanabe et al., 2015[23]	Geriatrics and Gerontology International	Japan	Compare the effect of resistance exercise with different speeds for each elderly	Experimental	1. Both speed movements for the same resistance training showed significant improvement in agility and strength in the elderly. 2.No significant difference was found between the effects of slow movement and normal movement.
Zaman et al., 202124	BioMed Research International	Saudi Arabia	Investigate the biomarker levels after bodyweight resistance intervention in middle-aged obese men who live at high altitude	Randomized Controlled Trial	Positive findings after exercise: HDL was increased, so did interleukine-6, ($p \leq 0,01$), and leptin decreased significantly ($p \leq 0,01$), while there was a significant elevation in testosterone and adiponectin levels ($p \leq 0,01$). Bodyweight resistance exercise helped to lower the lipid profile in experimental subjects which help lower the risk of cardiac issues regarding obesity.
LaStayo et al., 201725	BMC Geriatrics	USA	Compare the effects of resistance exercise on mobility, balance-confidence skills, muscular power, and cross-sectional area in older adult fallers using negative, eccentrically-induced work against traditional resistance exercise (TRE)	Randomized Controlled Trial	Negative, eccentrically-induced work, as well as traditional exercise (TRE), showed a significant impact to improve mobility, agility/balance-confidence skills, muscular power, and cross-sectional area in older adult fallers without any significant difference results.
Tiggemann et al., 201626	American Ageing Association	Brazil	Compare the result of rated perceived exertion (RPE) between traditional resistance training against power training on improving muscle strength, muscle power, and functional ability in elderly women	Experimental	Both traditional resistance training (TRE), as well as power training, improved the functional performance after the training period (≈13 %; $p < 0.001$). Both exercises showed no significantly different results in improving muscle strength, muscle power, and functional ability in elderly women

Author	Journal Publisher	Country	Study objective	Study design	Findings
Dias et al., 201527	American Ageing Association	Brazil	Compare knee extensor muscle strength and functional capacity of an elderly woman after undergoing eccentric training using a constant load with longer exposure at the eccentric phase with a conventional resistance training (RT) program on	Experimental	1. There was no significant difference found between the results of longer exposure exercise utilizing eccentric constant load with conventional resistance training. 2.Both exercises improved 6-m walk test (9–12 %; p=0.004), knee extension 1RM (24–26 %; p=0.021), stair-climbing test (8–13 %; p=0.007), timed up-and-go test (11–16 %; p<0.001), and chair-rising test (15–16 %; p<0.001).
Tokumaru et al., 201128	Journal of Physical Therapy Science	Japan	Assess the effect of manual resistance training (RT) performed by the elderly for muscular strength improvement in the lower extremities	Randomized Controlled Trial	1. Manual resistance training (RT) showed significant improvement in muscular strength in the elderly. 2. The intensity suggested for manual resistance exercise (MRE) is more than 70% of the 1-repetition maximum 3. Manual resistance exercise (MRE) showed less impact in trained or high-massed individuals.
Granacher et al. 201329	Gerontology	Germany	Investigate the effects of Core Instability Strength Training (CIT) on trunk muscle strength, spinal mobility, dynamic balance, and functional mobility in elderly	Randomized Controlled Trial	1.The intervention group showed significant result of muscle strength after training program: the maximal isometric strength of the trunk flexors (34%, p=0.001), extensors (21%, p=0.001), lateral flexors (right: 48%, p=0.001; left: 53%, p=0.001) and left rotators (42%, p=0.001). Moreover, the improvements were also found for spinal mobility in the sagittal (11%, p=0.001) and coronal plane (11%, =0.06) directions, for stride velocity (9%, p=0.05), the coefficient of variation in stride velocity (31%, p=0.05), the Functional Reach test (20%, p=0.05) and the Timed Up and Go test (4%, p=0.05). 2. CIT is feasible to exercise for the elderly that have a high adherence rate as an alternative resistance training to improve age-related deficits in trunk muscle strength, spinal mobility, dynamic balance, and functional mobility.
Davis et al. 201930	Osteoarthritis and Cartilage	USA	Compare sagittal walking gait biomechanics between older adults with knee osteoarthritis	Randomized Controlled Trial	4 weeks resistance training program consists of 15 minutes of warming up using a cycle ergometer and stretching, 20 minutes of daily progressive body weight resistance exercise for knee extension, knee flexion, and hip abduction exercises, and

Author	Journal Publisher	Country	Study objective	Study design	Findings
			(KOA) who increased quadriceps strength after a strengthening program for lower extremity and those who did not increase strength		10 minutes of balance exercise showed significant quadriceps strengthening that may be used to stimulate small changes in knee flexion angle in elderly with knee osteoarthritis.
Scanlon et al. 2014[31]	Muscle and Nerve	USA	Explore the strength and muscle architecture adaptation of short-term body weight resistance training in older adult	Randomized Controlled Trial	1.6 weeks of resistance training consisting of body weight squats, high knee walking, limb rotations and appropriate cool down as termination showed significant increases in strength and muscle quality of 32% and 31%, respectively in the elderly. 2. Cross-sectional area of the vastus lateralis increased by about 7.4% ($P \leq 0.05$). The physiological cross-sectional area (PCSA) of the thigh that related significantly to strength was also increased ($r = 0.57$; $P \leq 0.01$) and significant interaction following training ($P \leq 0.05$).
Voigt et al. 2019[32]	BMC Research Noted	USA	Explore the relationship of neural cell adhesion molecule (NCAM) expression to improvements in whole muscle strength and muscle fiber size after 14 weeks of RT program in elderly with knee osteoarthritis.	Experimental	1. After 14 weeks of moderate-intensity, unilateral, progressive bodyweight-load exercise program, it was found that greater NCAM expression in myosin heavy chain (MHC) II fiber was associated with greater whole muscle strength gains (knee extensor peak torque $r=0.93$; $P<0.01$) and greater MHC II fiber size ($r=0.79$; $P<0.01$).
Amasene et al. 201933	Nutrients	Spain	Examine the effect of a whey protein supplement enriched with leucine after resistance training to gain muscle mass and strength in a post-hospitalized elderly population	Experimental	1.12 weeks of resistance training with personal bodyweight load was enough for physical function improvement in a post-hospitalized elderly population ($p < 0.01$) but no further effect for the supplemented group ($p > 0.05$) and did not gain muscle mass in either group ($p > 0.05$).

DISCUSSION

Aging and Resistance exercise

Muscles retain their mass and function by keeping the balance stakes of protein synthesis and protein degradation. Post-birth, muscle grows when protein synthesis has a greater rate of protein degradation. Conversely, aging has a strong association with progressive muscle mass beak down that might lead to increase fragility, lower agility, and loss of body function.

Numerous mechanisms had been found to clarify the alteration of total muscle mass in aging. Lack of physical activity caused by a sedentary lifestyle, alterations in endocrine function (growth

hormone, insulin, cortisol, and testosterone), loss of neurological function that caused denervation of muscle, the deficit regulation between protein anabolism and catabolism, nutritional factors (especially for amino acids), programmed cell death or apoptosis, and disease or trauma.

Moreover, pro-inflammatory cytokines elevation in blood has been found in apparently healthy elderly as one of the function aging in aging that might cause systemic inflammations. The magnitude of muscle strength reduction is commonly greater than the reduction of muscle mass in older adults.

The skeletal muscle consists of various types of muscle fibers. Besides, the human body has commonly two different types of muscle fibers, the slow-twitch and the fast-twitch called type I and type II fibers respectively. The type II muscle fibers consist of type IIa and type IIb which has more portions in term of strength. In aging, the loss of type II fibers which have the most important role in building muscle strength is common to occur.

Age-related motor unit remodeling caused denervation on type II fibers which led to forming of collateral formations of type I fibers. Numerous biochemical signaling pathways have been explored regarding the effect of load-induced (resistance exercise) gained a mass of muscle and muscular strength improvement. Increased load such as resistance training or overload was activating the pathway which functions as a positive regulator to induce muscle mass growth.

Activated mTOR induced muscle growth by two main mechanisms. It allows the activation of the ribosome to conserve muscle fibers, especially for type II fibers which are very important to preserve muscular strength.

Body weight modality in Resistance exercise

Physical exercise requires a well-planned program, focusing on frequency, duration of the training, type of exercise, speed, intensity, repetition of activities, rest intervals, and according to competition. Resistance training is often suggested to the elderly to reverse or prevent mass loss in skeletal muscle and loss of function including skeletal muscle strength caused by age-related factors. Resistance exercise is able to perform utilize some modalities such as weight machine, free weight, resistance bands, and bodyweight. Resistance training with bodyweight modality utilizes a load of bodyweight to train the skeletal muscle. There are numerous movements to perform utilizing a load of bodyweight to strengthen the certain muscle with those equipment aids.

Bodyweight Exercise Variation

Similar outcomes were also found in a combination of bodyweight exercise (BE) and free-weight exercise. Even so, functional training and traditional training were equally showing similar results in improving ability and strength components in active elderly women and there were no significant differences found between both groups.

Based on another study, both traditional resistance training, as well as power training, improved functional performance after training intervention. In improving muscle power, maximal strength, and functional performance of lower extremities in elderly women, both exercises were similarly effective, and no significant difference was found between groups.

Core Instability Strength Training (CRT) as one of the bodyweight modality exercises was reported to be feasible for the elderly that have a high adherence rate as an alternative resistance training to improve age-related deficits in trunk muscle strength, spinal mobility, dynamic balance, and functional mobility.

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