

EFFECT OF VITAMIN D AND EXERCISE ON MUSCLE STRENGTH IN AGING

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ABSTRACT

Introduction: Exercise can help you stay in shape and lower your risk of acquiring a range of lifestyle conditions. These have an impact on muscle aging, particularly skeletal muscle strength. Lack of Vitamin D has been associated to muscle effects such as fatigue and weakness. **Method:** Journals were search using Google Scholar, Mendeley and Proquest to find studies according to inclusion and exclusion criteria and then review them. **Results:** After conducting a literature review, eight studies showed different results regarding the role of vit D and exercise on muscle strength especially in aging process. **Discussion:** Vit D and exercise given altogether were found to increase muscle strength especially in aging process. It is found that the vitamin D intake variety of 800-1000 IU per day is helpful while fewer doses were often inefficient and doses beyond this range are reported to enhance the chance of falling. For older person, with a minimum of 3 months of resistance exercise training and vitamin D3 treatment, muscle strength can get improved and can achieve considerable results. Hence, improving the leg muscle strength, mass and postural control with good vitamin D concentration can contribute to reduced risk of falls and fractures in elderly. The study suggests that moderately intense aerobic exercise for 150 minutes or vigorously intense aerobic exercise for 75, for at least two days per week may strengthen the muscle.

Keywords : *exercise; muscle aging; muscle strength; vitamin D*

INTRODUCTION

Exercise is related to changes in skeletal muscle. The exercise mechanism, nutrition status, and light exposure are known to affect the physiological responses of skeletal muscle. Exercise can be carried out in a dynamic (e.g., cycling) or static manner, exhaustively or non-exhaustively¹. The exhaustive ones refer to an intense exercise done in a long duration and exceeding the normal limit, for instance, sprinting. Exercises are known to lower the risk of heart diseases and metabolic disorders. It is also reported to improve one's antioxidant defense system, which is pivotal in lowering free radicals². Aging process has a higher risk of muscle damage³. However, aging is indeed a period in the life cycle that will get experienced by everyone. Hence, successful aging has become an important concept to describe the quality of aging. To achieve this exercise is something common to do. It is because exercise individuals have long been associated with good health conditions. Individuals who do not exercise, on the other hand, are frequently associated with bad health. Exercise is found to be linked to vitamin D⁴. Thus, we need micronutrients like vitamin D in addition to exercise.

For a long time, vitamin D was thought to be primarily important in calcium phosphate metabolism control and as an anti-inflammatory drug⁵. Vit D is a micronutrient. Vit D level is usually identified by measuring the vit D, 25 (OH)D, and markers of vit D stores obtained from UV light and diet⁶. Calcium homeostasis is regulated by vit D, and skeletal muscle requires calcium. Vit D is essential for calcium and phosphate absorption and bone calcium balance⁷. Since vitamin D receptor can be found in the entire human body, lack of vitamin D appears to correlates with a several extra-skeletal effects, such as pregnancy-related issues and immunological malfunction⁸. Recent studies, on the other hand,

suggest that it may play a role in the pathophysiology of a variety of disorders, including muscle atrophy⁹. Vitamin D supplementation has been shown to improve muscle strength and gait in different settings, especially in elderly patients. It is also suggested to play an important role in skeletal muscle function and could be a simple and widely applicable public health intervention, especially in the certain field such as musculoskeletal diseases¹⁰.

Muscle strength is found to be associated with vitamin D levels. It is because vitamin D is strongly connected with the presence of VDRs (vitamin D receptors) in most human estraskeletal cells. Changes in vitamin D levels can affect one's physical performance. It is in line that during aging, all systems and organs are physiologically reduced in their function. Administration of several doses of calcium and vit D for 3 months exhibits an improvement of neuromuscular and skeletal muscle functions. Otherwise, vitamin D deficiency can result in muscle fatigue. Vitamin D administration can activate neuromuscular functions through type II muscle fiber, resulting in improved muscle performance⁵.

It can be seen that Vit D supplementation can boost muscle strength, according to prior research findings. Furthermore, the link between vit D, exercise and muscle strength or tiredness is crucial in this regard. It is important to understand the relation between vit D, exercise, and muscle strength to make a new elaboration in achieving healthy life for the older people because aging successfully is significant. Thus, this study is conducted to find the role of vit D and exercise on muscle strength especially in aging process.

METHODS

This literature research uses a multi-pronged approach, including finding publications in research journal databases, searching the internet, and reviewing articles. This literature review was performed using the Google Scholar, Mendeley and ProQuest databases using the search terms “exercise”, “muscle strength” and “aging” in combination with “vitamin D”. There were 9 articles obtained and 8 articles were analysed in terms of their objectives, topic relevance, research method, sample size, research ethics, findings, and limitations. The inclusion criteria were journals published between 2012-2022 and journals ranked Q1-Q3 according to Scimago Journal Ranks. 1 article was excluded because it was not listed in Scimago Journal Rank.

RESULTS

Table 1. Literature Review

No	Author	Sample	Method	Result
1	Barker <i>et al.</i> (2013) ⁶	Case: 15 Control: 13	Case control	- Vit D supplementation improved serum 25(OH)D levels. (p=<0.05) - Improved high point isometric force recovery (p= <0.05) - Supplemental vit d attenuated the immediate and delayed (p=<0.05) - Without ameliorating muscle soreness (p=>0.05)
2	Agergaard <i>et al.</i> (2015) ¹⁰	40 participants, divided into 4 groups	Case control	- On week-12, 25(OH) D concentrations in young and old men grew dramatically and became significantly different from placebo.

No	Author	Sample	Method	Result
				<ul style="list-style-type: none"> - The CSA ¹and isometric strength of the muscles increased. (CSA $p < 0.0001$, strength $p = 0.005$) - Old men (CSA $p = 0.001$, strength $p < 0.0001$) following a 12-week resistance training program - When comparing the old to the young, vitamin D intake and resistance training increased strength/CSA. ($p = 0.008$). - After 12 weeks of training, the shift in fiber type IIa percentage was larger in the young vitamin D group. ($p = 0.030$) - In comparison to the placebo group, myostatin mRNA expression was smaller ($p = 0.006$).
3	Goswami <i>et al.</i> (2012) ¹¹	173 participants, divided into 4 groups	Case control	<ul style="list-style-type: none"> - On cholecalciferol, 25(OH) D levels increased substantially to 29.9 8.35 and 27.0 9.54 ng/ml in 2 groups. - Adequate oral cholecalciferol/calcium supplementation can raise 25(OH) D levels but does not boost skeletal muscular strength.
4	Thomas <i>et al.</i> (2019) ¹²	396 participants	Randomized placebo control	<ul style="list-style-type: none"> - DAT² was the only trial that showed a decrease in IMCL³ and an increased in rVO²⁴ ($p = 0.011$). - In healthy, older people, vit D coupled with exercise may enhance the metabolic advantages by lowering IMCL and raising tissue-level VO₂. - Combination of aerobic training and vit D repletion would improve IMCL decrease, while vit D repletion alone did not raise IMCL over 13 weeks.
5	Welford <i>et al.</i> (2020) ¹³	114 participants,	Double-blinded randomized placebo controlled	When RET is combined with vitamin D administration, it is more beneficial than RET ⁵ alone in promoting the development of future multimodal interventions to support bone and muscle health in the elderly.
6	Mieszkowski <i>et al.</i> (2018) ¹⁴	42 participants, divided into 2 groups	Randomized controlled trial	<ul style="list-style-type: none"> - The HI-NW group improved their Vitamin D and elbow torque performance regardless of treatment dose. - The type of NW Training had an effect on 25(OH)D levels and muscle strength when combined with Vitamin D. - In elderly with insufficient 25(OH) D levels, a significant dose of Vit D supplementation may be required to induce effect on muscle strength after moderate-intensity exercise

¹ CSA: Cross-Sectional Area² DAT: Direct Antiglobulin Test³ IMCL: Intramuscular Lipid⁴ RVO₂: Renal Oxygen Consumption⁵ RET: Rearranged during transfection

No	Author	Sample	Method	Result
7	Aoki <i>et al.</i> (2018) ¹⁵	148 participants, divided into 3 groups	Randomized controlled trial	<ul style="list-style-type: none"> - Lower limb muscle mass grew in all three groups, with no significant variations in the degree of change between them. - After vit D treatment, the average blood 25-hydroxyvitamin D of all vit D-supplemented subjects increased from 28.1 ng/ml to 47.3 ng/ml.
8	Aschauer <i>et al.</i> (2022) ¹⁶	121 participants	Randomized controlled trial	<ul style="list-style-type: none"> - Vit D supplementation of 800 IU per day (VDD⁶) or four doses of 50,000 IU every 4 weeks (VDM⁷) for 16 weeks improved the 25(OH)D3 status of community-dwelling elderly people with vit D deficiency to a similar extent. - 10 weeks of RT enhanced lower and upper limb strength as measured by CST⁸ and ACT⁹; neither VDD nor VDM had an additive effect.

DISCUSSION

Exercise and Muscle Strength in Aging

Exercising helps to boost muscle strength. Muscle contractile characteristics strengthen with low-to-moderate intensity exercise¹⁷. The elderly can be affected by catabolism in the muscle¹⁸. These issues could result in a vicious cycle of muscle loss, injury, and poor healing, leading to an increase in inactivity among the elderly. Exercises are vital for older adults to increase muscle mass and regeneration¹⁴. Indeed, workout is thought to counteract various negative aspects of aging, including as mitochondrial malfunction and muscular inflammation, and is one of the most effective ways to avoid sarcopenia. Exercise and a high-protein diet both promote muscle protein synthesis^{19,20}.

Muscle strength in aging has drawn considerable attention of many studies recently²¹. It is widely accepted that loss of muscle strength represents a cumulative failure related to aging, malnourishment (including vitamin D deficiency), and lack of physical exercise²². The characteristics of aging is known to lead to progressive decline in muscle mass, eventually resulting in declined muscle strength. Loss of muscle mass and muscle atrophy are among the markers of muscle aging. In this process, decrease in muscle strength significantly leads to declined muscle functions²³.

Type of Exercise

Exercise divided into aerobic and resistance training. Aerobic exercise enhances cardiovascular adaptations, which raise peak oxygen use without compromising strength. Resistance exercise enhances neuromuscular adjustments that build strength without altering peak oxygen demand appreciably²⁴.

Resistance training increases in muscle hypertrophy. This is useful for elderly people because older people tend to have muscle atrophy. Resistance training has a significant impact on improving muscle condition in the elderly, especially increasing muscle mass so that it increases muscle strength²⁵. In terms of potential function and frailty reduction, combining aerobic and strength exercise is advantageous²⁴.

⁶ VDD: Vitamin D Deficiency

⁷ VDM: Vascular Disease Management

⁸ CST: Contraction Stress Test

⁹ ACT: Activated Clotting Time

Walking was the most popular form of exercise for elderly since it is the most cost-effective and accessible kind of exercise, as well as an extremely safe exercise option²⁶ Nordic Walking is one type of exercise that engaging not only lower limbs, but also upper body²⁷. Because cardiorespiratory fitness (CRF) declines with age, many elderly folks are likely to experience a feeling of high-intensity when going to walk²⁸. Those with a high CRF amount may wish to try other types of exercise, such as jogging or cycling, to maintain the same intensity level throughout their workout²⁹. In comparison to males, women are more likely to go for walks, swim, and dance, even if men are more likely to engage in jogging, cycling, and winter sports³⁰.

Vitamin D and Muscle

Vit D is a pleiotropic steroid hormone that is primarily produced in keratinocytes by the conversion of 7-dihydrocholesterol to pre-vitamin D₃³¹. The most common vit D metabolite in circulate is 25(OH)D₃. Regardless of the fact it was not the bio - active version, it is nonetheless useful., it has been the most extensively utilized indication of vit D in most epidemiological investigations, due to the lack of specific and sensitive dihydroxymetabolite detection methods³² Vit D deficiency is important for skeletal health. Although rickets and osteomalacia are well-known vit D deficiency disorders, low vitamin D levels may also contribute to bone density, extreme fatigue, falls, and fragility fractures in the senior, all of which are major public health concerns in Europe in cause of morbidity, life quality, and health-care expenditures³³. Deficiency in vit D is connected to muscle weakness and lethargy, as well as hormonal and neurological effects³⁴. In muscle function and plasticity, vitamin D interacts with calcium¹². Vit D is required for calcium regulation and intake in muscle cells, as well as protein synthesis and calcium and phosphate transfer in muscle, all of which contribute to muscular strength and contractility. Vitamin D appears to improve the anabolic effects of dietary protein on skeletal muscle. While the fact that the majority of vitamin D's direct and indirect activities are linked to simultaneous hypocalcaemia and hypophosphatemia, they seem to have an impact on muscular performance. Vitamin D benefits calcium-dependent muscular processes like contraction, mitochondrial function, and insulin sensitivity^{6,9,10,19,35}.

Vit D status is categorized into four categories: severely deficient, deficient (between 27.5 and 49.9 nmol/L) , insufficient (between 50 and 75 nmol/L), and optimum (above 75 nmol/L). (a) Oliveri et al. showed that vitamin D deficiency (serum level less than 50 nmol/L) was prevalent in 52 percent to 87 percent of healthy elderly people in Argentina. Vitamin D stimulates skeletal muscle fiber cross sectional area (CSA), the circumference and number of type IIa fibers, as well as neuromuscular coordination. When compared to young people, the elderly who are vit D deficient may gain the most from vit D supplementation^{12,36}. Muscle atrophy and weakness are closely linked to vitamin D insufficiency in older people. Sarcopenia can be exacerbated by hypovitaminosis D in elderly adults. Patients with vit D levels below 30 nmol/L had poorer muscle function, but not an increased risk of falling, according to a study³⁵.

Vitamin D is strongly linked to phosphate and calcium metabolism. The active metabolite of vitamin D, D (1,25(OH)₂D), commonly known as calcitriol, will improve the expression of type 2b sodium-phosphate co-transporter, boosting phosphate absorption in the intestine. Additionally, a phosphate deficiency promotes 1-hydroxylase to convert vit D to calcitriol, which enhances phosphate absorption in the small intestine. Calcitriol can also trigger osteocytes in bone to secrete Fibroblast-like growth factor-23, causing phosphate excretion in the kidney and vit D metabolism feedback. Because vit D is responsible for appropriate intestinal absorption of calcium and phosphate, it maintains optimal circulation amounts of these minerals, allowing normal bone mineralization and promoting the health of muscles. As a result, enough calcium and vitamin D intake, as well as a healthy lifestyle, are recommended for the aged¹⁹.

Vitamin D and Exercise for Muscle Strength in Aging

Existing studies have consistently reported the interplay between vit D supplementation and exercise in elderly. However, Agergaard et al report that, although twelve weeks of vit D supplementation and strength exercises does not affect muscle hypertrophy or muscle strength, they enhance muscle quality in older people¹⁰. Welford AE et al. indicates the combination of resistance exercise training (RET) and vitamin D supplementation is more effective than merely RET. RET is reported to support the improvement of bone and muscle health in older people. Mieszkowski J et al showed that high-intense and moderate intense Nordic Walking exercise that combined with supplementation of Vitamin D have beneficial effects in elderly women specifically increased muscle strength¹⁴.

Exercise and vitamin D supplementation both boost the skeletal muscle's VDR expression, which has been associated to muscle repair and regeneration. Exercise increases the sensitivity of skeletal muscle to vitamin D. Vitamin D stimulates skeletal muscle fiber cross sectional area (CSA), the circumference and number of type II muscle fibers. This combination causes increases muscle strength.

In various studies, the vitamin D intake variety of 800–1000 IU per day was found to be helpful; fewer doses were often inefficient, and doses beyond this range are reported to enhance the chance of falling³⁶. With a minimum of 3 months of resistance exercise training and vitamin D3 treatment, older persons can improve muscle strength and achieve considerable results³⁷. Improving the leg muscle strength, mass and postural control with good vitamin D concentration can contribute to reduced risk of falls and fractures in elderly²⁷. The study suggests that moderately intense aerobic exercise for 150 minutes or vigorously intense aerobic exercise for 75, for at least two days per week may strengthen the muscle³⁸.

CONCLUSION

Muscle strength is a well-known benefit of exercise. Exercising helps to boost muscle mass and strength. In senior citizens who can not participate in exercise, they may lose muscle mass and strength. Vitamin D insufficiency has long been linked to muscle weakness, and this research discovered that it is a key role in sarcopenia. Muscle weakness, as well as hormonal and neurological repercussions, have been related to vitamin D insufficiency. Vit D is essential for muscular function regulation. Some literature agree that vitamin D consumption and exercise can simultaneously improve muscle strength. It is found that the vitamin D intake variety of 800-1000 IU per day is helpful while fewer doses were often inefficient and doses beyond this range are reported to enhance the chance of falling. For older person, with a minimum of 3 months of resistance exercise training and vitamin D3 treatment, muscle strength can get improved and can achieve considerable results. Hence, improving the leg muscle strength, mass and postural control with good vitamin D concentration can contribute to reduced risk of falls and fractures in elderly. The study suggests that moderately intense aerobic exercise for 150 minutes or vigorously intense aerobic exercise for 75, for at least two days per week may strengthen the muscle. However, several studies report that vit D consumption and exercise are not associated with muscle strength. Addressing this difference, further investigation is necessary to scrutinize the relationship between vit.D, exercise, and muscle strength.

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