

Effect of Strengthening Exercise in Postmenopausal Osteoporosis : Literature Review

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Abstract

Background: Osteoporosis is a decrease in bone mass and worsening of bone tissue, which causes a decrease in bone density or porous bones. Muscle strengthening exercise is a voluntary exercise to increase skeletal muscle's strength, power, endurance, and mass that includes the use of weight machines, hand-held weight, exercise band, or own body weight. People do strengthening exercise for many purposes, including aesthetic, physical therapy, sports, conditioning for sports performance, and general fitness and health. This literature review aims to review the effect of strengthening exercise in postmenopausal osteoporosis focusing on the bone density and the risk of falling. **Methods:** This study is a literature review which assembled by searching, compiling, and analyzing various studies that focused on the effect of strengthening exercise in postmenopausal osteoporosis. **Results:** For the bone density, the osteogenic effect in increasing bone mass can be stimulated by means of bone tissue being exposed to mechanical loads that exceed what is experienced during daily activities. For the risk of falling, the special population such as osteoporotic women and/or osteoporotic postmenopausal women, overall, the general idea of falling risk results in older adults can be decreased with exercises and/or exercises programs. **Conclusion:** strengthening exercise can increase the bone density and reduce the risk of falling, hence postmenopausal women whose at risk of osteoporosis should receive strengthening exercise in accordance with the recommendation to prevent worsening of the disease and complications.

Keywords: exercise ; muscle strengthening ; resistance training ; osteoporosis ; postmenopausal

1. Introduction

Osteoporosis is a decrease in bone mass and worsening of bone tissue, which causes a decrease in bone density or porous bones. Patients suffering from osteoporosis will be more at risk of experiencing fractures due to low bone mineral density or BMD, microarchitectural disturbances or bone mineralization, and decreased bone strength. It is estimated that more than 200 million people suffer from osteoporosis worldwide. More than 70% of individuals over the age of 80 have osteoporosis. This condition is more common in women than men. It is estimated that around 9 million cases of fractures per year occur due to osteoporosis. In a meta-analysis and systematic review that evaluated data from 86 studies with a total sample of more than 103 million people, it was reported that the prevalence of osteoporosis is 2 times higher in women than men. The prevalence of osteoporosis is also reported to be highest in African countries. Based on the data from the Ministry of Health, the prevalence of osteopenia in Indonesia is around 41.7% and the prevalence of osteoporosis is around 10.3%. This means that 2 out of 5 Indonesians are at risk of osteoporosis. This data also shows that 41.2% of the sample aged less than 55 years have osteopenia. In addition, osteoporosis is also 2 times more common in women than men. Death in people with osteoporosis is not directly due to the disease, but due to complications and risks that arise in people with osteoporosis. Osteoporosis' complications such as fractures may lead to bleeding, embolism, and head injuries that can lead to death. Vertebral fractures in osteoporosis patients can cause kyphosis, chronic pain, respiratory problems, and an increased risk of pneumonia.

According to Bennie et al. (2020), muscle strengthening exercise is a voluntary exercise to increase skeletal muscle's strength, power, endurance, and mass that includes the use of weight machines, hand-held weight, exercise band, or own body weight. According to 2008 Physical Activity Guidelines for Americans (2008), this type of exercise causes the body's muscles to work or hold against an applied force or weight and has three main components including intensity, frequency, and repetitions. Muscle strengthening exercise sometimes can be referred as strength/ weight/ resistance training or exercise. People do strengthening exercise for many purposes, including aesthetic, physical therapy, sports, conditioning for sports performance,

and general fitness and health (Bennie et al., 2020). According to Mora and Valencia (2018) and the 2008 Physical Activity Guidelines for Americans (2008), there are some strengthening exercise that can be applied for elderly people, including exercise using exercise bands, weight machines, callisthenic exercises (such as push-ups, pull-ups, and sit-ups), climbing stairs, hand-held exercises, digging, lifting, and carrying as part of gardening, carrying groceries, some yoga exercises, and some tai chi exercises. This study aims to review the effect of strengthening exercise in postmenopausal osteoporosis focusing on the bone density and the risk of falling.

2. Methods

This is a literature review studies which assembled by searching, compiling, and analyzing various studies that focused on the effect of strengthening exercise in postmenopausal osteoporosis. The sources were cited from PubMed and the search terms used for searching were about the “strengthening exercise” and “osteoporosis postmenopausal”. The articles selected were published between 2008 – 2021 which a total number of 20 articles is included in this literature review.

3. Result

Pathophysiology of Postmenopausal Osteoporosis

In principle, the pathophysiology of osteoporosis is related to the imbalance of bone resorption and remodeling which causes a decrease in bone mass. In most individuals, bone mass peaks in the third decade, after bone resorption exceeds bone formation. Failure to achieve normal peak bone mass or accelerated bone loss can lead to osteoporosis.

- Osteoimmunology: Osteoclasts that play a role in bone resorption can be considered as prototype osteoimmune cells. Osteoclasts share precursor cells with monocytes, macrophages, and dendritic

cells. Recent studies have shown that many molecules are involved in the immune system and bone such as transcription factors, signaling factors, cytokines, and chemokines.

In osteoporosis, T-cells are considered to be the main proinflammatory cytokine. In addition, there is an important link between estrogen loss, T-cell-dependent inflammation, and osteoporosis.

- **Molecular:** Several regulatory pathways in osteoblasts involved in osteoporosis include the glucocorticoid receptor signaling pathway, the retinoic acid signaling pathway (RAR), the estrogen receptor signaling pathway, the peroxisome proliferator activated receptor signaling pathway (PPAR), the vitamin D receptor signaling pathway, the Ca²⁺ signaling pathway, nuclear receptor coactivator (NCOA), and the omega 3 fatty acid signaling pathway.
- **Role of Estrogen:** Estrogen is required for bone growth, development, and maintenance of bone health. The cellular response of osteoblasts and osteoclasts to estrogen is initiated via two high-affinity Er α and Er β receptors.
- **Role of Glucocorticoids:** Glucocorticoids are a class of steroid hormones that bind to glucocorticoid receptors that inhibit osteoblast proliferation and differentiation. In addition, glucocorticoids also regulate ion channels.
- **Role of Retinoic Acid:** Retinoic acid works by binding retinoic acid receptors (RARs), which are members of the nuclear receptor superfamily. Retinoic acid is essential for the physiological regulation of various biological processes including bone development, differentiation, proliferation, and apoptosis.
- **Role of PPAR Nuclear Receptors:** PPARs are a group of nuclear receptors that can form heterodimeric complexes and are involved in metabolic and inflammatory processes that are important in controlling cell proliferation, osteoclasts, and osteoblasts.
- **Oxidative Stress:** Molecular oxygen very easily reacts with some radicals and turns into free radicals and continues to cause selective oxidation of fats, proteins, and DNA molecules. Although some

cells develop protective mechanisms against this oxidation process, imperfect protective mechanisms still cause molecular damage that leads to disease and aging. One of the protective mechanisms is the increased amount of tumor necrosis factor alpha (TNF- α) in the bone marrow and causes bone loss.

- Genetics: Studies of monogenic diseases prove the involvement of genes in bone physiology processes that cause incomplete osteogenesis and are associated with osteoporosis. Some of the genes considered to be involved include: COL1A1, COL1A2, BMP1, PLS3, SERPINH1, SEC24D, TCIRG1, CTSK, NOTCH2, LRP5, SOST, BLI, AXIN1, CLCN7, CREB3L1, CTNNB1, DMP1, EN1, FKBP11, FOXC2, SOX4

Effect of Strengthening Exercise in Bone Density

Resistance training has been recommended as a widely used treatment strategy for bone loss. The osteogenic effect in increasing bone mass can be stimulated by means of bone tissue being exposed to mechanical loads that exceed what is experienced during daily activities. Several exercise programs such as resistance exercise (RE) are exercises that are very beneficial for maintaining bone mass (Sibonga et al., 2019). Resistance exercise is recommended to be done at least twice per week with five sets and five repetitions. This resistance exercise includes a 10-minute warm-up, an exercise of five sets and five repetitions (with two minutes of rest between sets), and 10 minutes of relaxation movements. This resistance exercise has been shown to increase bone density in postmenopausal women by 0.17 g/cm² in the spine, hips, and femoral neck. The results of a study conducted by Bella et al (2021) explained that from the type of exercise between step up and Zumba gymnastics, it is proven that step-up exercise has a more significant effect on bone density. This is because step-up sports put a mechanical load on the bones so that the bones will be "forced" to carry out the bone remodeling process. This is different from Zumba gymnastics. Zumba gymnastics is considered not to provide a mechanical load on the bones such as step-up sports so that the increase in bone mass density that occurs is not very significant (Triandini, 2019). Regular and regular physical activity is proven to increase bone mass

density. Regular physical activity can maintain bone health and prevent an early decrease in bone density. Physical activity that has a better effect on increasing bone mass density is anaerobic physical activity such as jumping, running, and lifting weights. The group of elderly who experience osteoporosis who are given interventions in the form of resistant physical exercise have been shown to experience an increase in bone mass density (Bella et al., 2021).

Effect of Strengthening Exercise in Risk of Falling

Risk of falling or fear of falling is a term used for describing how confident a person is in taking daily activity without falling or without thinking that they would fall during those times (Filipović et al., 2021). 11 studies also show the relation between this aspect and exercising (Zhang et al., 2021, Marini et al., 2019, Filipović et al., 2021, Hoke et al., 2020, Aibar-Almazán et al., 2019, Bragonzoni et al., 2020, Ferrara et al., 2019, Yong et al., 2021, Daly et al., 2019, and Sherrington et al., 2019). Zhang et al., 2021, mentioned that it can reduce the falling rate for up to 23% as well as the injuries caused by falling that requires hospitalization. It is mentioned also that exercise programs in general can help reduce the risk of falling in older people (more than 65 years old) (Zhang et al., 2021, and Sherrington et al., 2019). More specifically exercises that promote multiple categories like balance, functional and resistance (Sherrington et al., 2019). In special population such as Osteoporotic women and/or Osteoporotic postmenopausal women, overall, the general Idea of falling risk results in older adults, specifically female can be decreased with exercises and/or exercises programs (Marini et al., 2019, Filipović et al., 2021, Hoke et al., 2020, Bragonzoni et al., 2020, Ferrara et al., 2019, and Yong et al., 2021). The said exercises and/or exercises programs ranging from a 12 month exercise programs (Bragonzoni et al., 2020), a 6 months exercise program (Marini et al., 2019), a 12 week exercise plan (Filipović et al., 2021), exercises that focusing on specific core strengthening and weight bearing (Hoke et al., 2020), and Tai Chi Chuan practice (Ferrara et al., 2019). All shows a positive improvement regarding Fear of Falling reduction (Marini et al., 2019 and Filipović et al., 2021), fall reduction (Hoke et al., 2020, Bragonzoni et al., 2020, Ferrara et al., 2019, and Yong et al., 2021).

Strengthening Exercise Recommendation

Strengthening exercise in elderly people should be carried out carefully due to the probability of injuries. According to Mora and Valencia (2018), muscle strengthening exercise should be performed at least 2 times per week with moderate to vigorous intensity (≥ 6). There is no specific amount of time for muscle strengthening exercise, but it should be carried to the point where it would be difficult to do another repetition without help. 1 set of 8 to 12 repetition of each exercise is effective when using resistance training, although 2 or 3 sets may be more effective (Mora and Valencia, 2018).

4. Discussion

Fragility fractures, which are common in people with osteoporosis, are a leading cause of pain, disability, loss of functional independence, and increased morbidity and death worldwide, making osteoporosis a major clinical and public health issue worldwide (Wright et al., 2014). Furthermore, it is unfortunate that the existing therapeutic choices are not very beneficial once osteoporosis manifests, and exercise training is a strategy that can concurrently reduce the number of risk factors for skeletal problems and falls. However, it must be prescribed correctly and customized to the intended outcome(s) and the designated target group (Daly et al., 2019). A study of a large, community-based, representative group of women in Taiwan showed that regular exercise was strongly linked to a lower risk of osteoporosis in postmenopausal women and that longer exercise sessions (>1 h) were more effective at preventing postmenopausal osteoporosis (Chang et al., 2022). Numerous various exercise modalities, such as weightlifting, walking, jogging, jumping, step climbing, and even swimming and water aerobics, are suitable for postmenopausal women to practice for the prevention and treatment of osteoporosis, as long as the programs contain moderate to extensive exercises (70% to 90% of 1RM), are performed in a high pace for short intervals of time, and are done often (2 to 4 times a week) (Moreira et al., 2014). As shown in a study, postmenopausal women's bone density at the lumbar spine, femoral neck, entire hip, and entire body can be preserved by using combination exercise programs, such as

resistance training, impact exercise, and dynamic aerobic exercises. For example, thinking of postmenopausal women, cycling could be recommended to improve general health, along with other alternative exercises (weight lifting, plyometrics, or other high-impact activity) to complement cycle training to help minimize bone loss (Zhao et al., 2017). In order to reduce their risk of fractures and injuries, postmenopausal women should take certain precautions when exercising. Therefore, it is strongly advised that the patient adheres to an exercise regimen established by a specialist in the area, such as a physical trainer or a physiotherapist, after consulting with a doctor.

Risk of falling or fear of falling is a term used for describing how confident a person is in taking daily activity without falling or without thinking that they would fall during those times (Filipović et al., 2021). It is mentioned also that exercise programs in general can help reduce the risk of falling in older people (more than 65 years old) (Zhang et al., 2021, and Sherrington et al., 2019). In special population such as Osteoporotic women and/or Osteoporotic postmenopausal women, overall, the general idea of falling risk results in older adults, specifically female can be decreased with exercises and/or exercises programs (Marini et al., 2019, Filipović et al., 2021, Hoke et al., 2020, Bragonzoni et al., 2020, Ferrara et al., 2019, and Yong et al., 2021)

5. Conclusion

Strengthening exercise increase bone density and reduce the risk of falling, hence postmenopausal women who's at risk of osteoporosis should receive strengthening exercise in accordance with the recommendation to prevent worsening of the disease and complications. Due to this population's age, they should be careful and tact with the type, frequency, and the intensity of the exercise.

6. Recommendation

It is necessary for patient with postmenopausal osteoporosis to receive strengthening exercise according to guideline to improve their physical health and reduce the risk of osteoporosis' complication.

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References

- Aibar-Almazán, A. et al. (2019) "Effects of pilates on fall risk factors in community-dwelling elderly women: A randomized, controlled trial," *European Journal of Sport Science*, 19(10), pp. 1386–1394. Available at: <https://doi.org/10.1080/17461391.2019.1595739>.
- Barnsley, J. et al. (2021) "Pathophysiology and treatment of osteoporosis: Challenges for clinical practice in older people," *Aging Clinical and Experimental Research*, 33(4), pp. 759–773. Available at: <https://doi.org/10.1007/s40520-021-01817-y>.
- Bella, A.K., Polii, H. and Wungow, H.I. (2021) "Pengaruh Latihan Resisten Terhadap kepadatan tulang," *Jurnal e-Biomedik*, 9(2). Available at: <https://doi.org/10.35790/ebm.v9i2.31799>.
- Bennie, J.A., Shakespear-Druery, J. and De Cocker, K. (2020) "Muscle-Strengthening Exercise Epidemiology: A new frontier in chronic disease prevention," *Sports Medicine - Open*, 6(1). Available at: <https://doi.org/10.1186/s40798-020-00271-w>.
- Bragonzoni, L. et al. (2020) "A randomized clinical trial to evaluate the efficacy and safety of the ACTLIFE Exercise Program for women with post-menopausal osteoporosis: Study protocol," *International Journal of Environmental Research and Public Health*, 17(3), p. 809. Available at: <https://doi.org/10.3390/ijerph17030809>.
- Ferrara, P. E. et al. (2019) "Evaluation of quality of life and static balance in postmenopausal osteoporosis women after Tai Chi Chuan practice: an observational randomized case control study," *Journal of biological regulators and homeostatic agents*, 33(2 Suppl. 1), .
- FILIPOVIĆ, T.N. et al. (2021) "A 12-week exercise program improves functional status in postmenopausal osteoporotic women: Randomized Controlled Study," *European Journal of Physical and Rehabilitation Medicine*, 57(1). Available at: <https://doi.org/10.23736/s1973-9087.20.06149-3>.
- Föger-Samwald, U. et al. (2022) "Age related osteoporosis: Targeting cellular senescence," *International Journal of Molecular Sciences*, 23(5), p. 2701. Available at: <https://doi.org/10.3390/ijms23052701>.
- Hoke, M. et al. (2020) "Impact of exercise on bone mineral density, fall prevention, and vertebral fragility fractures in postmenopausal osteoporotic women," *Journal of Clinical Neuroscience*, 76, pp. 261–263. Available at: <https://doi.org/10.1016/j.jocn.2020.04.040>.

- Marini, S. et al. (2019) "Proposal of an adapted physical activity exercise protocol for women with osteoporosis-related vertebral fractures: A pilot study to evaluate feasibility, safety, and effectiveness," *International Journal of Environmental Research and Public Health*, 16(14), p. 2562. Available at: <https://doi.org/10.3390/ijerph16142562>.
- Mora, J.C. and Valencia, W.M. (2018) "Exercise and older adults," *Clinics in Geriatric Medicine*, 34(1), pp. 145–162. Available at: <https://doi.org/10.1016/j.cger.2017.08.007>.
- Noh, J.-Y., Yang, Y. and Jung, H. (2020) "Molecular mechanisms and emerging therapeutics for osteoporosis," *International Journal of Molecular Sciences*, 21(20), p. 7623. Available at: <https://doi.org/10.3390/ijms21207623>.
- Rosen, C.J. et al. (tahun) judul buku, edisi langsung angka, Penerbit, Kota The Epidemiology and Pathogenesis of Osteoporosis. [Updated 2020 Jun 21]. In: Feingold KR, Anawalt B, Boyce A, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK279134/>
- Saxena, Y., Routh, S. and Mukhopadhyaya, A. (2021) "Immunoporosis: Role of innate immune cells in osteoporosis," *Frontiers in Immunology*, 12. Available at: <https://doi.org/10.3389/fimmu.2021.687037>.
- Sherrington, C. et al. (2019) "Exercise for preventing falls in older people living in the community," *Cochrane Database of Systematic Reviews*, 2019(1). Available at: <https://doi.org/10.1002/14651858.cd012424.pub2>.
- Sibonga, J. et al. (2019) "Resistive exercise in astronauts on prolonged spaceflights provides partial protection against spaceflight-induced bone loss," *Bone*, 128, p. 112037. Available at: <https://doi.org/10.1016/j.bone.2019.07.013>.
- Triandini, E. et al. (2019) "METODE systematic literature review untuk Identifikasi platform Dan metode Pengembangan Sistem Informasi di Indonesia," *Indonesian Journal of Information Systems*, 1(2), p. 63. Available at: <https://doi.org/10.24002/ijis.v1i2.1916>.
- Wright, N.C. et al. (2014) "The recent prevalence of osteoporosis and low bone mass in the United States based on bone mineral density at the femoral neck or lumbar spine," *Journal of Bone and Mineral Research*, 29(11), pp. 2520–2526. Available at: <https://doi.org/10.1002/jbmr.2269>.
- Yong, E.L. and Logan, S. (2021) "Menopausal osteoporosis: Screening, prevention and treatment," *Singapore Medical Journal*, 62(4), pp. 159–166. Available at: <https://doi.org/10.11622/smedj.2021036>.
- Zhang, Q. et al. (2021) "Exercise intervention for the risk of falls in older adults," *Medicine*, 100(5). Available at: <https://doi.org/10.1097/md.00000000000024548>.
- Zhao, R., Zhang, M. and Zhang, Q. (2017) "The effectiveness of combined exercise interventions for preventing postmenopausal bone loss: A systematic review and meta-analysis," *Journal of Orthopaedic & Sports Physical Therapy*, 47(4), pp. 241–251. Available at: <https://doi.org/10.2519/jospt.2017.6969>.