# Nonpharmacologic Measures to Maintain or Increase Bone Density in Patients at Risk for Osteoporosis: An Integrative Review

A Scholarly Project

Submitted to the

Faculty of Liberty University

In partial fulfillment of

The requirements for the degree

Of Doctor of Nursing Practice

By

Katie Saporsky

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Lynchburg, VA

May 19, 2023

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Scholarly Project Chair Approval:

Dr. Vickie Moore, RN, DNP, FNP-C Date

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**Abstract**

Osteoporosis is a major phenomenon, impacting a large proportion of the population of the United States. Effective prevention and mitigation strategies for this condition and its related complications are necessary to promote health and well-being for the aging population. Current pharmacologic agents used to combat osteoporosis bring the risk of adverse effects, resulting in poor patient adherence. Nonpharmacologic methodologies, specifically weight-bearing exercise, targeted nutrition, and whole-body vibration, have proven to be successful in increasing bone mineral density and mitigating the risk of osteoporosis and its related complications. Implementing these methodologies results in increasing bone mineral density, strength, and well-being.

*Keywords:* osteoporosis, bone mineral density, nonpharmacologic methodologies, exercise, calcium, vitamin D, vitamin K2, vitamin C, whole-body vibration

## Dedication

I would like to dedicate this integrative review to my children, husband, and family who have supported me through this process. John, thank you for your love and support throughout this process and challenging me to excel in my work. A special word of thanks to my parents who have provided me endless support and encouragement personally, academically, and professionally. To my three children, Riley, Kasen, and Kenzie, thank you for being my inspiration. I hope that this inspires you to chase your dreams.

**Acknowledgments**

I would like to thank God for giving me the ability and provisions to complete this integrative review and doctoral degree. James 1:17 states, “Every good gift and every perfect gift is from above, and cometh down from the Father of lights, with whom is no variableness, neither shadow of turning” (*King James Bible*, 1769/2017). I would also like to thank my project chair, Dr. Vickie Moore, who was an amazing mentor and leader. She showed me great patience and guidance. I cannot thank her enough for her support throughout this journey.

## List of Abbreviations

Bone mineral density (BMD)

Integrative review (IR)

Menaquinones (MKs)

Office of Disease Prevention and Health Promotion (OASH)

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Randomized control trial (RCT)

Whole-body vibration (WBV)

# Nonpharmacologic Measures to Maintain or Increase Bone Density in Patients at Risk for Osteoporosis: An Integrative Review

Research has provided clarity on poor pharmacologic adherence to both preventative measures and treatment courses related to chronic illnesses due to the lifestyle and regimen changes required by medications, costs, and side effects. Considering the numerous physiological deteriorations and chronic illnesses that can be averted with nonpharmacologic interventions, preventative strategies should entail early alternative methodologies, especially concerning the pathophysiology of osteoporosis. Frequently, patients are informed that they either need to be screened for or are already at risk for osteoporosis, as evidenced by low bone mineral density (BMD). At this point, their treatment plan usually includes either pharmacologic medications or directions to exercise and supplement with calcium and vitamin D without individualized or comprehensive recommendations. In order for comprehensive recommendations to be provided, providers must first understand what nonpharmacologic methods are effective in increasing one's BMD through osteogenesis, angiogenesis, and the mitigation of bone resorption. As a result of this information, the triggering question for this integrative review (IR) was formulated: In patients at risk for osteoporosis, what nonpharmacologic measures can be employed to maintain or increase bone density?

## Background

Osteoporosis is a condition characterized by skeletal system effects, consisting of low BMD and microarchitectural disturbance that results in a cascade of effects (Rosen, 2022a). The resulting consequences include a reduction in bone mass and strength, fragility, and an increase in one's risk of falls and fractures (Cleveland Clinic, n.d.; Rosen, 2022a). It is important to consider that osteoporosis is often asymptomatic until the time a fracture occurs, illustrating the

importance of early screening, preventative strategies, and patient education, as this condition is preventable. Of note, the most common osteoporotic fractures occur in the spine, hips, and wrists (Cleveland Clinic, n.d.).

Osteoporosis is highly prevalent in the United States, affecting approximately 10 million individuals, including all races, ethnicities, and genders. Additionally, approximately 43 million individuals have been diagnosed with low bone mass or osteopenia, placing them at high risk for osteoporosis and correlating complications (Clynes et al., 2020; Office of Disease Prevention and Health Promotion, n.d.). Patients at greatest risk for osteoporosis include men who are older than 50 years of age, postmenopausal women, and individuals with fragility fractures (Yu, 2022). As osteopenia accounts for a significantly greater group of people, fractures are more prevalent in this category, although osteoporosis places an individual at higher risk. The importance of proactive interventions in patients at risk for osteoporosis is imperative. Prevention is also essential for patients with a high risk of falls and fractures independent of BMD. Examples of risk factors include older age, fracture history, long-term use of glucocorticoids, low body mass index, a parent who experienced a hip fracture, alcohol use, cigarette smoking, and Caucasian ethnicity (Yu, 2022).

Due to the silent nature of osteoporosis, the United States Preventive Services Task Force (2002) recommends routine, annual screening starting at the age of 65 in otherwise healthy individuals and at the age of 60 for individuals deemed at risk for osteoporotic fractures (Yedavally-Yellayi et al., 2019). The gold standard for osteoporosis diagnosis looks at one's *t* score, or the standard deviation from expected BMD. A normal *t* score would be a SD >/= -1. Osteopenia is defined as a *t* score of -1 to -2.5 (Rosen, 2022a). The diagnosis for osteoporosis is made due to one of two findings: a fragility fracture or a *t* score of </= -2.5 "standard deviations

(SDs) at any site based upon bone mineral density (BMD) measurement by dual-energy x-ray absorptiometry (DXA)" (Rosen, 2022a, para. 8).

**Defining Concepts and Variables**

Conceptually, nonpharmacologic methods of reducing osteoporosis include any methods individuals employ to reduce their risk of osteoporosis with the exclusion of medication. Such methods include exercise, nutritional supplements, and whole-body vibration (WBV). Operationally speaking, this IR defines nonpharmacologic interventions as those that can increase one's BMD through osteogenesis and angiogenesis while reducing bone resorption, as identified by peer-reviewed literature.

**Rationale for Conducting the Review**

Current osteoporosis treatment and prevention recommendations start with pharmacologic therapy, dependent upon normal blood calcium and 25-hydroxyvitamin D levels and supplementation when dietary intake is inadequate (Rosen, 2022b). The first-line pharmacologic treatment is a oral bisphosphonate, with alendronate and risedronate being the favorable bisphosphonate choices (Rosen, 2022b).

Adherence to medications that treat and prevent osteoporosis has been documented to be suboptimal at best (Senay et al., 2019). Poor adherence has also been documented historically, with reports of 20%–30% of patients reporting reduced compliance. Most of these patients report that their lack of compliance is due to unfavorable side effects of pharmacologic treatment (Papaioannou et al., 2007). Some side effects include muscle, bone, and joint pain, nausea, heartburn, indigestion, esophageal irritation, and difficulty swallowing (Bone Health & Osteoporosis Foundation, n.d.). In addition to adherence issues, providers have recently been more hesitant to prescribe long-term pharmacologic therapy due to identified adverse effects as

well. Two significant and concerning adverse effects are uncharacteristic femur fractures and osteonecrosis of the jawbone (OASH, n.d.). Understandably, patients and providers have decided to be more reserved in increasing one's risk for these unwanted effects, leading to a decline in osteoporosis preventive pharmacologic treatment. Still, with osteoporosis-related fractures on the rise, nonpharmacologic interventions are necessary to decrease osteoporosis risk by increasing BMD.

Therefore, a solution that increases BMD and positively affects patients' mental and physical well-being is warranted. Exercise and supplementation are recommended but could have a more robust effect if employed prior to the diagnosis of osteoporosis or osteopenia. Nonpharmacologic interventions demonstrate favorable outcomes in patients with reduced BMD scores. These interventions can also be used preventatively from early ages if awareness is provided during routine wellness visits.

A preliminary review of the literature revealed that many articles focus on one primary nonpharmacologic modality for the prevention of osteoporosis. The rationale for conducting this IR is to locate evidence on combining multiple preventative modalities to provide comprehensive and thorough interventions, increasing the effectiveness of patients' efforts.

**Purpose and Clinical Question**

The purpose of this IR is to provide a comprehensive recommendation for multiple nonpharmacologic evidence-based modalities that patients can incorporate into their daily routines. Additionally, the use of multiple modalities can positively impact patients' functionality and vitality while also increasing their BMD and mitigating their risk for osteoporosis and related fractures through increased interventional adherence. The clinical

question posed in this IR is: In patients at risk for osteoporosis, what nonpharmacologic measures can be employed to maintain or increase bone density?

**Formulate Inclusion and Exclusion Criteria**

The systematic literature search consisted of the following inclusion criteria: peer-reviewed journal articles published in the last 5 years and historical osteoporosis findings and management, articles focused on evidence-based treatment modalities, and articles focused on nonpharmacologic interventions. Databases searched include Science Direct, CINAHL Ultimate, PubMed, and Google Scholar. As osteoporosis does not discriminate according to race, ethnicity, gender, or age, all of these variables were integrated into the inclusion criteria; however, most articles focused on women in the postmenopausal stage of life. Exclusion criteria consisted of pharmacologic methods in osteoporosis prevention and non-English articles.

**Conceptual Framework**

A conceptual framework provides a systematic process for conducting IRs. This IR utilized the Whittemore and Knafl (2005) framework. According to Whittemore and Knafl, IRs play a significant role in the foundations of evidence-based practice, as they investigate diverse research methodologies. This review specifically examined systematic reviews, meta-analyses, randomized control trials (RCTs), and descriptive studies, exploring both experimental and nonexperimental studies. As a result, a comprehensive approach to providing patients with nonpharmacologic interventions supported by a strong evidence base is provided. While reading this IR, one can expect the following structure to be adhered to: problem identification, literature search, data evaluation, data analysis, and presentation (Whittemore & Knafl, 2005). The purpose of a framework is to provide a systematic methodology that is easily followed and understood.

## Section Two: Literature Review

### Search Strategy

The literature review was conducted through Google Scholar and Liberty University's online library, where several databases could be searched, specifically PubMed, CINAHL Ultimate, and Science Direct. The combination of multiple databases allowed the review to be comprehensive. The preliminary search identified three main nonpharmacologic treatment categories which target the strengthening of BMD: targeted exercise, nutritional therapy, and WBV. These components guided the search terms in the comprehensive literature review. To filter the search and provide a focus, parameters were set to include articles that were published in the past five years, had full-text availability, and were peer reviewed. Different combinations of the following phrases were used as search terms: *osteoporosis nonpharmacologic interventions/treatment, exercise, strength training, nutrition, calcium, vitamin D, vitamin C,* and *whole body vibration.* The titles were first reviewed, followed by the abstracts. If the articles appeared to be consistent with inclusion criteria, the full text was then reviewed.

### Critical Appraisal

After analyzing articles for inclusion and exclusion criteria, the researcher analyzed the full text for reliability, validity, applicability, and generalizability. A total of 16 articles were analyzed and synthesized for this IR. The preliminary search produced nine articles; another seven were examined and included for further supporting evidence. Appendix A presents the literature matrix, which includes a systematic synthesis of the literature reviewed. The matrix affords the reader the ability to examine the following information extracted from each article: the study's purpose, sample characteristics, methods, study results, level of evidence (using Melnyk's framework), study limitations, and quality of evidence. Each article provides essential

information relevant to the clinical question and is laid out methodically, including study limitations, strengths, and future recommendations. According to Melnyk's level of evidence, 11 studies are identified as Level 1 (meta-analysis or systematic review), three studies are Level two (two RCTs and one prospective cohort study), and two studies are Level 6 (descriptive design), as displayed in the literature matrix as Appendix A (University of Michigan Research Guides, 2023).

**PRISMA**

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is a tool that provides a minimum set of requirements for both conducting and reporting on systematic reviews and meta-analyses. PRISMA was created to analyze the accuracy and reliability of studies, contributing to increased transparency (Liberati et al., 2009; Swartz, 2011). Furthermore, the use of PRISMA allows for the identification of bias and funding sources, allowing for additional analysis of the quality of studies (Swartz, 2011). This comprehensive tool consists of a 27-item checklist with a flow diagram (Swartz, 2011). Appendix B of this literature review provides a visual flow chart of the literature search undertaken in this IR.

**The Collected Data**

While conducting the comprehensive literature search, the researcher documented a list of relevant studies by systematically inputting them into the literature matrix. From here, the categories were depicted, ensuring inclusion criteria were adhered to. Additionally, the references were added to the IR's reference list. The matrix was updated accordingly upon the identification and analysis of applicable studies. A comparison of studies was conducted to eliminate duplicate entries. The selected 16 studies were included in the literature matrix, which can be found in Appendix A.

**Synthesis**

The literature review provided a robust substantiation of evidence supporting the effectiveness of nonpharmacologic interventions for osteoporosis prevention in at risk patients. Findings report that a significant proportion of patients are noncompliant with pharmacologic therapy, warranting the investigation and implementation of alternative methods (Papaioannou et al., 2007). As a result, it is necessary to accurately identify at risk patients and provide them with attainable and effective nonpharmacologic interventions. The goal is to reduce their risk for osteoporosis by increasing their BMD through supporting osteogenesis, angiogenesis, osteoblast, and osteocyte activity.

After the literature search and matrix were completed, specific nonpharmacologic methodologies were identified to increase patients' BMD, including strength training exercises, nutritional supplementation, and WBV. Progressive resistance (or strength) training has proven beneficial in increasing BMD at the lumbar spine and femoral neck, displaying positive osteogenic results by promoting osteogenesis (Montgomery et al., 2019; Sanchez-Trigo et al., 2022). Supplementation with calcium and vitamin D have been well known to benefit bone health. As vitamin D and vitamin K work synergistically together, greater consideration needs to be given to incorporating vitamin K, especially vitamin K2, into osteoporosis prevention (van Ballegooijen et al., 2017). Vitamin K has been indirectly linked to osteogenesis through the expression on osteoblast-specific genes and the downregulation of osteoclastogenesis (Akbari & Rasouli-Ghahroudi, 2018; Ma et al., 2022; van Ballegooijen et al., 2017). Research also demonstrates that the dietary intake of vitamin C-oriented foods is associated with increased BMD, bone preservation, and decreased hip fractures (Zeng et al., 2020). Therefore, a more comprehensive supplementation approach to BMD preservation shows compelling evidence for

osteoporosis prevention. Lastly, WBV involves a machine that utilizes a vibrating platform to transmit energy through one's body, resulting in muscle contractions and relaxation (Laskowski, 2022). Meta-analyses and RCTs have reported that WBV effectively supports and increases BMD in healthy and postmenopausal women (DadeMatthews et al., 2022; ElDeeb & Abdel-Aziem, 2020; Marín-Cascales et al., 2018).

**Summary**

In summary, the overall findings of the literature review support the efficacy of nonpharmacologic methods in osteoporosis prevention. The three main identified nonpharmacologic methods were exercise (strength training), nutrition (calcium, vitamin D, vitamin C, and vitamin K2), and WBV. In addition to BMD, functionality, vitality, and overall well-being were also positively impacted. Employing individualized and targeted education to patients identified as at risk for osteoporosis has demonstrated compliance optimization (Mohammadi et al., 2022). The combination of the identified constituents can significantly influence a patient's bone health, reducing the risk of fractures and other osteoporotic complications.

## Section Three: Results

The following section will analyze the thematic data from the selected articles and discuss their results. This section includes an overall synthesis of results, ethical considerations, and the project's completion timeline. The reoccurring themes discovered in the 16 articles from the literature matrix were exercise, nutrition/supplementation, and WBV. Additionally, targeted education has been identified to increase patient understanding and adherence (Mohammadi et al., 2022). The above themes will be discussed in detail regarding their correlation with the clinical question.

## Thematic Data Analysis

### *Exercise*

Osteoporosis and fragility fractures are significant issues that affect patients globally (Daly et al., 2019). Pharmacologic measures are the first line of treatment but fail to positively impact fragility fracture risks, such as "low muscle strength, power and functional capacity" (Daly et al., 2019, p. 170). Targeted exercise is the primary modality that significantly improves musculoskeletal and fall-related risk factors by stimulating angiogenic mediators (Daly et al., 2019; Tong et al., 2019). Additionally, exercise increases bone angiogenesis and osteoblast activity while mitigating bone resorption. The synergistic effects of mechanical loading accomplish work by activating hormonal receptor sites and activity, increasing the production of cytokines, and positively impacting signaling pathways that effect musculoskeletal mass (Tong et al., 2019).

Three main targeted therapies include high-impact weight-bearing activities, progressive resistance with the greatest attention to the hip and spine, and balance and mobility exercises (Daly et al., 2019). Furthermore, a meta-analysis reported long-term exercise is related to a reduction in falls and fractures in older adults (de Souto Barreto et al., 2019). Attention to early risk stratification and prevention implementation should be considered at routine wellness visits for young, healthy adults.

Exercise needs to be targeted to provide an effective osteogenic stimulus, particularly high-impact weight-bearing activities. Exercise recommendations need to be specific and individualized for osteogenic benefits, demanding tailored education beyond blanket recommendations of exercising for BMD benefits. Montgomery et al. (2019) identified that exercises need target specific osteogenic problematic areas. This article reviewed four high-

impact exercises, including countermovement jumps, box-drops, heel-drops, and stamp exercises. Results identified that countermovement jumps had the greatest impact on the rectus femoris, and countermovement jumps and box-drops both positively impacted the semitendinosus and tibialis anterior on electromyography reports. Additionally, countermovement jumps, box-drops, and heel-drops were all found to be superior to stamp exercises in postmenopausal BMD maintenance (Montgomery et al., 2019). When creating exercise recommendations for patients, it is vital that practitioners select exercises with the most significant benefit to optimize patients' effort, time, and results.

A network meta-analysis conveyed the findings of 97 studies that reported that mind-body exercises were optimal at increasing the BMD for the lumbar spine and femoral neck, with resistance training being the most effective at increasing total hip BMD (Zhang et al., 2022). Of note, mind-body exercises combine three essential themes: controlled breathing, focus, and movement, with the goal of exercising for flexibility, strength, and balance (National Cancer Institute, n.d.).

It is recommended that resistance training be performed a minimum of two to three times per week, with three times having more efficacious results, for 30 to 60 minutes (Zamoscinska et al., 2020). Results were directly linked to the intensity of the workouts, with higher intensity yielding greater improvements in BMD, but lower intensity being efficacious for maintenance (Zamoscinska et al., 2020). A systematic review and meta-analysis was conducted through the means of an extensive literature search, examining the effects of exercise on BMD when completed in nonsupervised settings (Sanchez-Trigo et al., 2022). Interestingly, BMD was improved at both the lumbar spine and the femoral neck, with improvements being more

prominent in populations with poor bone health compared to healthy BMD (Sanchez-Trigo et al., 2022).

***Nutrition/Supplementation***

Calcium and vitamin D are novel supplementations used in osteoporosis prevention and treatment. More clinical studies are needed to provide information on supplementation guidelines and weigh risks and benefits (Coronado-Zarco et al., 2019). A 2-year randomized control study, focused on the effect of calcium and vitamin D-enriched milk on bone metabolism and cardiovascular health (Reyes-Garcia et al., 2018). Along with cardiovascular improvements, the results reported a noteworthy increase in BMD at the femoral neck, demonstrating the positive benefits of calcium and vitamin D-enriched milk for postmenopausal women (Reyes-Garcia et al., 2018). Additionally, a systematic review of practice guidelines in multiple countries reported that adequate blood levels of calcium and vitamin D are essential to bone health, along with lifestyle changes, sufficient protein levels, exercise, and the avoidance of alcohol, caffeine, and tobacco (Coronado-Zarco et al., 2019). Along with calcium and vitamin D, other minerals have been shown to be beneficial to BMD. Additional benefits have been demonstrated from vitamin K2 and vitamin C.

The addition of vitamin K2 is an important factor for increasing and maintaining BMD. Vitamin K converts undercarboxylated osteocalcin into carboxylated osteocalcin (Ma et al., 2022). Carboxylated osteocalcin is the form that the body can utilize for calcium and hydroxyapatite development, contributing to the mineralization of bones. It is important to understand that osteocalcin is the molecular marker of bone metabolism, bearing responsibility in calcium metabolism regulation and therefore contributing to bone mineralization (Ma et al., 2022). A notable distinction between vitamin K2 and vitamin K1 is vitamin K2's subtypes,

particularly the menaquinones (MKs; Halder et al., 2019; Ma et al., 2022). Two of the 12 subtypes, MK-4 and MK-7, contribute to the deposition of calcium in the bones, increasing BMD and strength (Ma et al., 2022). The meta-analysis conducted by Ma et al. (2022) reported the effectiveness of vitamin K2 in improving and maintaining BMD at the lumbar spine. Given this knowledge and results, it is important to take advantage of the synergistic effect between vitamin K2, calcium, and vitamin D in the promotion of bone health.

Vitamin C provides a wealth of health advantages as it is "rich in vitamins, fiber, phytochemicals, and minerals" (Zeng et al., 2020, p. 2). The integration of dietary intake of vitamin C-oriented foods has been correlated with lowering the risk of many health conditions, such as "breast cancer, hypertension, metabolic syndrome, type 2 diabetes mellitus, depression, inflammatory bowel disease, and all-cause mortality" (Zeng et al., 2020, p. 2). Related to bone health, protective properties lie within vitamin C's anti-inflammatory constituents and antioxidants (Zeng et al., 2020). Furthermore, vitamin C plays a role in osteoblast genesis and collagen synthesis (Malmir et al., 2018). Due to controversial results, systematic reviews and meta-analyses have been conducted to create more concrete evidence (Malmir et al., 2018; Zeng et al., 2020). Zeng et al. and Malmir et al. reported similar results, the relationship between vitamin C and decreased hip fractures and a decrease in the loss of BMD at both the lumbar spine and femoral neck, showing a beneficial impact of vitamin C in the role of osteoporosis prevention (Malmir et al., 2018; Zeng et al., 2020).

### *Whole Body Vibration*

As WBV results in muscle contractions and relaxation through one's skeletal system through the means of a vibrating platform, it is proposed to impact BMD (Laskowski, 2022). An RCT evaluating 43 postmenopausal women found that WBV positively impacted leg muscle

work, specifically at the hip, knees, and ankles (ElDeeb & Abdel-Aziem, 2020). Furthermore, the findings suggest improvements in BMD at both the femoral neck and lumbar spine in women with low BMD. A systematic review and meta-analysis found that WBV protocols improved BMD at the lumbar spine in postmenopausal women (both younger and older) and enriched BMD at the femoral neck in postmenopausal women younger than 65 years of age (Marín-Cascales et al., 2018). Another meta-analysis that examined 30 studies discovered that WBV did not significantly affect bone formation or resorption biomarkers but resulted in BMD improvement in healthy and postmenopausal women (DadeMatthews et al., 2022). These investigators suggested WBV to be a beneficial modality in osteoporosis risk mitigation.

**Synthesis of Results**

Considering the above discussion, it is evident that nonpharmacologic therapies are effective in increasing BMD, providing protection against osteoporosis for at-risk patients. Due to poor adherence and concerns surrounding pharmacologic agents, nonpharmacologic methodologies should be considered. In addition to having favorable effects on BMD, these modalities have been shown to be effective in increasing quality of life.

Targeted exercise and education exhibited an increase in BMD in postmenopausal women. High-impact exercises and resistance training have been proven efficacious in impacting osteogenesis and causing an increase in BMD. Specifically, high-intensity exercise resulted in favorable results for increasing BMD, while low-intensity exercise was effective for BMD maintenance. Targeted plans should be utilized, as they consider one's time and effort, improving patient adherence.

With exercise, it is important to provide appropriate nutrition, empowering the mineralization of one's bones and promoting growth. Minerals are important alone but also work

synergistically with exercise, promoting osteogenesis. The synergistic interplay of calcium, vitamin D, vitamin K2, and vitamin C provide advantageous effects on BMD.

WBV is another modality shown to have beneficial osteogenic properties. Again, tailoring programs to specific areas prone to osteoporotic complications is a priority. Through multiple frequencies on one's muscles in a short amount of time while requiring minimal exertion, WBV has been shown to yield great results.

**Ethical Implications**

While conducting an IR, the researcher must make ethical considerations a priority by observing and following guidelines and regulations for research. To ensure ethical guidelines were properly adhered to, the project lead completed training through the Collaborative Institutional Training Initiative (CITI) modules on biomedical and health science research (see Appendix C). Following the CITI training completion, the project proposal was presented to the leader's appointed chair. Next, the project's information was submitted to Liberty University's Institutional Review Board (IRB) for approval (see Appendix D). There were no human subjects involved in this research project, as it is an IR.

**Timeline**

As this IR was planned and conducted during the completion of the lead's Doctor of Nursing courses, a timeline was created to ensure the timely progression of the project and academic progress. The components and timeline of the project are reflected below:

- Project initiation: September 13, 2022
- Completion of Sections One and Two: December 4, 2022
- First defense: January 27, 2023
- Completion of Section Three: February 26, 2023

- Completion of Section Four: April 15, 2023
- Final draft submitted to project chair: April 15, 2023
- Final draft submitted to editor: May 1, 2023
- Final defense: TBD
- End of academic term: August 18, 2023

## Section Four: Discussion

### Summary of Evidence

The literature review provided a robust substantiation for the effectiveness of nonpharmacologic methodologies in osteoporosis risk mitigation and BMD improvement. The studies utilized displayed the importance of employing alternative methodologies to pharmacologic treatment, with the goal of therapeutic optimization resulting in an increase in bone mass, strength, vitality, and functionality. Additionally, these methods were effective in mitigating osteoporosis-related fractures and complications. Although evidence was sufficient in supporting specific methodologies, specific protocols regarding exercise, nutrition, and WBV need to be developed. Regardless, there was reasonable evidence supporting the need for alternative methodologies, demonstrating the potential to increase BMD through nonpharmacologic methods, further improving patient care and outcomes.

### Implications for Practice

The comprehensive literature review displayed the effectiveness of nonpharmacologic approaches to osteoporotic risk mitigation and in the increase in BMD. Starting education during routine wellness visits from an early age can equip individuals with adequate BMD prior to the age when bone mass begins to decline, resulting in stronger bones and risk mitigation before complications occur. Additionally, employing these modalities during the postmenopausal period

also demonstrated robust benefits, such as increasing BMD, strength, functionality, and vitality, all of which promote autonomy later in life. Bringing attention to these nonpharmacologic modalities and promptly implementing them can minimize the need for pharmacologic agents, mitigating their unfavorable and adverse effects.

Future research is recommended. It is important for providers to assess each patient in an individualized manner, paying attention to their specific exercise and nutritional capabilities and needs. An interprofessional approach may be warranted, including referrals for physical therapy or a nutritionist consult. Although individualization is necessary, standardized guidelines could be beneficial alongside specific recommendations for different options for different needs and targeted areas, such as the lumbar spine, femoral neck, and the hip. Van Ballegooijen et al. (2017) discussed the need for researching the use of supplements, such as vitamin D and vitamin K2, from an earlier age compared to an older age to assess the impact on the bone but shared concerns about the possibility of side effects. Additionally, further studies are warranted to evaluate the primary mechanisms of WBV (DadeMatthews, et al., 2022). Additionally, setting homogenous WBV protocols for healthy individuals would be helpful, as the studies showed variation.

**Limitations**

Although effective methodologies were identified, limitations to this IR did exist. First, the studies focused on postmenopausal women, as this population accounts for the majority of osteoporosis cases and complications. Completing studies on other age groups, such as younger individuals and males, would create a more generalizable application to the overall population. Also, there were no long-term studies included in this IR. Longitudinal studies would provide beneficial information, especially if they were conducted on younger populations and observed

the implications of early implementation of nonpharmacologic modalities during the premenopausal time and the effects on BMD when the individuals transition into the postmenopausal period. Long-term studies on supplementation would also be advantageous. Ma et al. (2022) discussed the need for larger studies to be completed on vitamin K2 and the need for multistudy verification of vitamin K2's effects on BMD. Additionally, Malmir et al. (2018) recommended that long-term studies utilizing valid instruments be conducted on vitamin C's effects on intake, BMD, and hip fractures. Finally, although the use of WBV showed favorable results, there was heterogeneity between study protocols, so further research is recommended.

**Dissemination**

The findings in this IR aim to bring a comprehensive approach to combating osteoporosis and its associated complications through the use of nonpharmacologic methodologies. The purpose of dissemination of this project would be to provide awareness of these methodologies and their efficacious results. Furthermore, this review calls for further research and can be utilized therein. This researcher intends to submit this review to the Jerry Falwell Library for review and publication. Again, this will be done to bring awareness to effective therapies other than pharmacologic agents, as change cannot occur without awareness.

**Conclusion**

In conclusion, as pharmacologic agents are associated with poor patient compliance and adverse effects, such as osteonecrosis of the jaw, alternative therapies are necessary to mitigate osteoporosis and its related complications. Nonpharmacologic methodologies have demonstrated efficacious results in increasing BMD through angiogenesis and osteogenesis. Such methodologies include targeted exercise, nutritional supplementation, and WBV. In addition to providing osteogenic benefits, these methodologies also increase strength and overall well-being.

## References

Akbari, S., & Rasouli-Ghahroudi, A. (2018). Vitamin K and bone metabolism: A review of the latest evidence in preclinical studies. *Biomed Research International, 2018,* Article 4629383. https://doi.org/10.1155/2018/4629383

Bone Health & Osteoporosis Foundation. (n.d.). *Side effects of bisphosphonates (Alendronate, Ibandronate, Risedronate and Zoledronic Acid)*. Retrieved December 3, 2022, from https://www.bonehealthandosteoporosis.org/patients/treatment/medicationadherence/side-effects-of-bisphosphonates-alendronate-ibandronate-risedronate-and-zoledronic-acid/

Cleveland Clinic. (n.d.). *Osteoporosis*. Retrieved December 3, 2022, from https://my.clevelandclinic.org/health/diseases/4443-osteoporosis

Clynes, M., Harvey, N., Curtis, E., Fuggle, N., Dennison, E., & Cooper, C. (2020). The epidemiology of osteoporosis. *Europe PMC Author Manuscripts, 133*(1), 105–117. https://doi.org/10.1093/bmb/ldaa005

Coronado-Zarco, R., Olascoaga-Gómez de León, A., García-Lara, A., Quinzaños-Fresnedo, J., Nava-Bringas, T., & Macías-Hernández, S. (2019). Nonpharmacological interventions for osteoporosis treatment: Systematic review of clinical practice guidelines. *Osteoporosis Sarcopenia, 5*(3), 69–77. https://doi.org/10.1016/j.afos.2019.09.005

DadeMatthews, O., Agostinelli, P., Neal, F., Oladipupo, S., Hirschhorn, R., Wilson, A., & Sefton, J. (2022). Systematic review and meta-analyses on the effects of whole-body vibration on bone health. *Complementary Therapies in Medicine, 65*, Article 102811. https://doi.org/10.1016/j.ctim.2022.102811

Daly, R., Dalla Via, J., Duckham, R., Fraser, S., & Helge, E. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: An evidence-based guide to the optimal

prescription. *Brazilian Journal of Physical Therapy, 23*(2), 170–180. https://doi.org/10.1016/j.bjpt.2018.11.011

de Souto Barreto, P., Rolland, Y., Vellas, B., & Maltais, M. (2019). Association of long-term exercise training with risk of falls, hospitalizations, and mortality in older adults: A systematic review and meta-analysis. *JAMA Internal Medicine, 179*(3), 394–405. https://doi.org/10.1001/jamainternmed.2018.5406

ElDeeb, A. M., & Abdel-Aziem, A. A. (2020). Effect of whole-body vibration exercise on power profile and bone mineral density in postmenopausal women with osteoporosis: A randomized controlled trial. *Journal of Manipulative and Physiological Therapeutics, 43*(4), 384–393. https://doi.org/10.1016/j.jmpt.2019.12.003

Halder, M., Petsophonsakul, P., Akbulut, A., Pavlic, A., Bohan, F., Anderson, E., Maresz, K., Kramann, R., & Schurgers, L. (2019). Vitamin K: Double bonds beyond coagulation insights into differences between Vitamin K1 and K2 in health and disease. *International Journal of Molecular Sciences, 20*(4), Article 896. https://doi.org/10.3390/ijms20040896

*King James Bible*. (2017). King James Bible Online. https://www.kingjamesbibleonline.org/ (Original work published 1769)

Laskowski, E. (2022). *Is whole-body vibration a good way to lose weight and improve fitness?* Mayo Clinic. https://www.mayoclinic.org/healthy-lifestyle/fitness/expert-answers/whole-body-vibration/faq-20057958

Liberati, A., Altman, D., Tetzlaff, J., Mulrow, C., Gøtzsche, P., Ioannidis, J., Clarke, M., Devereaux, P., Klleinjen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions:

Explanation and elaboration. *BMJ, 339*, Article B2700. https://doi.org/10.1136/bmj.b2700

Ma, M., Ma, Z., He, Y., Sun, H., Yang, B., Ruan, B., Zhan, W., Li, S., Dong, H., & Wang, Y. (2022). Efficacy of vitamin K2 in the prevention and treatment of postmenopausal osteoporosis: A systematic review and meta-analysis of randomized controlled trials. *Frontiers in Public Health, 10,* Article 979649. https://doi.org/10.3389/fpubh.2022.979649

Malmir, H., Shab-Bidar, S., & Djafarian, K. (2018). Vitamin C intake in relation to bone mineral density and risk of hip fracture and osteoporosis: A systematic review and meta-analysis of observational studies. *British Journal of Nutrition, 119*(8), 847–858. https://doi.org/10.1017/S0007114518000430

Marín-Cascales, E., Alcaraz, P., Ramos-Campo, D., Martinez-Rodriguez, A., Chung, L., & Rubio-Arias, J. (2018). Whole-body vibration training and bone health in postmenopausal women: A systematic review and meta-analysis. *Medicine, 97*(34), Article e11918. https://doi.org/10.1097/MD.0000000000011918

Mohammadi, A., Behboodi Moghadam, Z., Ghelichkhani, F., Alidost, F., Naghizadeh, S., Haghparast, Z., & Azizi, M. (2022). Prevention of osteoporosis in menopausal women: A systematic review of nonpharmacological clinical trials. *Journal of Education and Health Promotion*, *11,* Article 287. https://doi.org/10.4103/jehp.jehp_1253_21

Montgomery, G., Abt, G., Dobson, C., Smith, T., Evans, W., & Ditroilo, M. (2019). The mechanical loading and muscle activation of four common exercises used in osteoporosis prevention for early postmenopausal women. *Journal of Electromyography and Kinesiology, 44*, 124–131. https://doi.org/10.1016/j.jelekin.2018.12.004

National Cancer Institute. (n.d.). Mind-body exercise. In *NCI dictionary of cancer terms.* Retrieved December 3, 2022, from https://www.cancer.gov/publications/dictionaries/cancer-terms/def/mind-body-exercise

Office of Disease Prevention and Health Promotion. (n.d.). *Osteoporosis workgroup.* U.S. Department of Health and Human Services. Retrieved December 3, 2022, from https://health.gov/healthypeople/about/workgroups/osteoporosis-workgroup

Papaioannou, A., Kennedy, C., Dolovich, L., Lau, E., & Adachi, J. (2007). Patient adherence to osteoporosis medications: Problems, consequences and management strategies. *Drugs Aging*, *24*(1), 37–55. https://doi.org/10.2165/00002512-200724010-00003

Reyes-Garcia, R., Mendoza, N., Palacios, S., Salas, N., Quesada-Charneco, M., Garcia-Martin, A., Fonolla, J., Lara-Villoslada, F., & Muñoz-Torres, M. (2018). Effects of daily intake of calcium and vitamin D-enriched milk in healthy postmenopausal women: A randomized, controlled, double-blind nutritional study. *Journal of Women's Health, 27*(5), 561–568. https://doi.org/10.1089/jwh.2017.6655

Rosen, H. (2022a). Clinical manifestations, diagnosis, and evaluation of osteoporosis in postmenopausal women. *UpToDate.* Retrieved December 3, 2022, from https://www.uptodate.com/contents/clinical-manifestations-diagnosis-and-evaluation-of-osteoporosis-in-postmenopausal-women

Rosen, H. (2022b). Overview of the management of osteoporosis in postmenopausal women. *UpToDate.* Retrieved December 3, 2022, from https://www.uptodate.com/contents/overview-of-the-management-of-osteoporosis-in-postmenopausal-women

Sanchez-Trigo, H., Rittweger, J., & Sañudo, B. (2022). Effects of non-supervised exercise interventions on bone mineral density in adult women: A systematic review and meta-analysis. *Osteoporosis International, 33*, 1415–1427. https://doi.org/10.1007/s00198-022-06357-3

Senay, A., Fernandes, J., Morin, S., & Perreault, S. (2019). Persistence and compliance to osteoporosis therapy in a fracture liaison service: A prospective cohort study. *Archives of Osteoporosis, 14,* Article 87. https://doi.org/10.1007/s11657-019-0633-y

Swartz, M. (2011). The PRISMA statement: A guideline for systematic reviews and meta-analyses. *Journal of Pediatric Health Care*, *25*(1), 1–2. https://doi.org/10.1016/j.pedhc.2010.09.006

Tong, X., Chen, X., Zhang, S., Huang, M., Shen, X., Xu, J., & Zou, J. (2019). The effect of exercise on the prevention of osteoporosis and bone angiogenesis. *Biomed Research International, 2019,* Article 8171897. https://doi.org/10.1155/2019/8171897

United States Preventive Services Task Force. (2002). *Screening for osteoporosis in postmenopausal women: Recommendations and rationale* (AHRQ Pub. No. 03-511A). https://www.uspreventiveservicestaskforce.org/home/getfilebytoken/nnkwqkX-Nk6v3gsphVATUD

University of Michigan Research Guides. (2023). *Nursing: Levels of evidence*. Retrieved December 3, 2022, from https://guides.lib.umich.edu/nursing/evidence

van Ballegooijen, A., Pilz, S., Tomaschitz, A., Grübler, M., & Verheyen, N. (2017). The synergistic interplay between vitamins D and K for bone and cardiovascular health: A

narrative review. *International Journal of Endocrinology, 2017,* Article 7454376. https://doi.org/10.1155/2017/7454376

Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. *Leading Global Nursing Research, 52*(5), 546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Yedavally-Yellayi, S., Ho, A., & Patalinghug, E. (2019). Update on osteoporosis. *Prim Care*, *46*(1), 175–190. https://doi.org/10.1016/j.pop.2018.10.014

Yu, E. (2022). Screening for osteoporosis in postmenopausal women and men. *UpToDate.* Retrieved December 3, 2022, from https://www.uptodate.com/contents/screening-for-osteoporosis-in-postmenopausal-women-and-men

Zamoscinska, M., Faber, I., & Büsch, D. (2020). Do older adults with reduced bone mineral density benefit from strength training? A critically appraised topic. *Journal of Sport Rehabilitation, 29*(6), 833–840. https://doi.org/10.1123/jsr.2019-0170

Zeng, L., Luo, M., Liang, G., Yang, W., Xiao, X., Wei, X., Yu, J., Guo, D., Chen, H., Pan, J., Huang, T., Liu, O., Guan, Z., Han, Y., Zhao, D., Zhao, J., Hou, S., Wu, M., Lin, J., . . . Liu, J. (2020). Can dietary intake of vitamin C-oriented foods reduce the risk of osteoporosis, fracture, and BMD loss? Systematic review with meta-analyses of recent studies. *Frontiers in Endocrinology, 10,* Article 844. https://doi.org/10.3389/fendo.2019.00844

Zhang, S., Huang, X., Zhao, X., Li, B., Cai, Y., Liang, X., & Wan, Q. (2022). Effect of exercise on bone mineral density among patients with osteoporosis and osteopenia: A systematic review and network meta-analysis. *Journal of Clinical Nursing, 31*(15–16), 2100–2111. https://doi.org/10.1111/jocn.16101

## Appendix A

## Article Critique and Leveling Matrix

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| Coronado-Zarco, R., Olascoaga-Gómez de León, A., García-Lara, A., Quinzaños-Fresnedo, J., Nava-Bringas, T., & Macías-Hernández, S. (2019). Nonpharmacological interventions for osteoporosis treatment: Systematic review of clinical practice guidelines. *Osteoporosis Sarcopenia*, *5*(3), 69–77. https://doi.org/10.1016/j.afos.2019.09.005 | To review clinical guidelines related to nonpharmacologic recommendations for osteoporosis prevention and treatment. | Systematic review including guidelines from America, Malaysia, Mexico, and Australia. | A systematic review using the PRISMA and Agree II tool approach; inclusion criteria required a grade of greater than 60 points. | Nonpharmacologic recommendations included supplements (calcium and vitamin D), exercise, sufficient protein, falls risk factor identification and precautions, alcohol and tobacco limitation. | Level 1: Systematic review | Although the inclusion criteria require high quality studies, the investigators identified that many of these guidelines are outdated and that the studies were observational or low quality, not equating to a high level on Melynk's level of evidence. | Yes, this article provides reliable data on nonpharmacologic interventions, but also sheds light on the need for updated recommendations, calling for further research and supporting the need for a practice change. |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| DadeMatthews, O., Agostinelli, P., Neal, F., Oladipupo, S., Hirschhorn, R., Wilson, A., & Sefton, J. (2022). Systematic review and meta-analyses on the effects of whole-body vibration on bone health. *Complementary Therapies in Medicine, 65*, Article 102811. https://doi.org/10.1016/j.ctim.2022.102811 | To examine the relationship between whole body vibration and bone biomarkers and BMD. | This meta-analysis consisted of 30 studies. | Six databases were searched, inclusive of RCTs. Outcomes included the measurement of serum biomarkers and BMD difference from baseline. | The results demonstrated improved BMD in women, in healthy and postmenopausal women. | Level 1: Meta-analysis | The study identified two main limitations: the study was very broad and further studies could be completed to focus on specific populations over generalizability, and the vibrative training methodologies varied amongst the studies. | Yes, this article supports the need for a practice change. This demonstrated the increase in BMD, further providing protective mechanism against the decline of BMD. |
| Daly, R., Dalla Via, J., Duckham, R., Fraser, S., & Helge, E. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: An evidence-based | To provide an evidence-based approach in reducing post-menopausal women's risk factors | A review consisting of 90 articles related to exercise and osteoporosis risk factor mitigation. | A non-experimental, descriptive study, synthesizing literature and research. | Exercise is a beneficial nonpharmacologic intervention to prescribe in reducing one's risk factors for osteoporosis. | Level 6: Descriptive design | The study identified the need for long term studies which include large numbers of participants, studying their results at the 5-year mark. | Yes, this study provides a comprehensive approach to mitigating osteoporosis risk factors while strengthening individual's |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| guide to the optimal prescription. *Brazilian Journal of Physical Therapy*, *23*(2), 170–180. https://doi.org/10.1016/j.bjpt.2018.11.011 | for osteoporosis which reach beyond bone mineral density (BMD) alone. | | | Exercise regimens should be tailored and individualistic, with great consideration given to progressive resistance training focusing on muscles which strengthen and support the spine, hips, and femurs. | | | functional capacity, which reaches beyond what pharmacologic agents can do. |
| de Souto Barreto, P., Rolland, Y., Vellas, B., & Maltais, M. (2019). Association of long-term exercise training with risk of falls, hospitalizations, and mortality in | To investigate the effect of long-term exercise (greater than 1 year) with the prevalence | The study included a total of 21,868 participants from 46 studies. | The inclusion criteria included a duration of one year or greater with participants 60 or older. | The studies reported a significant reduction in the risk of falls and related fractures but did not reduce the risk of multiple falls, | Level 1: Systematic review and meta-analysis | The biggest limitation was the lack of reporting on exercise regimen adherence. | Despite the limitation, results did display a positive correlation between a reduction in falls and related fractures, demonstrating |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| older adults: A systematic review and meta-analysis. *JAMA Internal Medicine, 179*(3), 394–405. https://doi.org/10.1001/jamainternmed.2018.5406 | of hospitalizations, fractures, falls, and mortality in older adults. | | | hospitalization, and mortality. | | | efficacy of exercise in increasing the overall wellbeing of older adults. So, this study does support a practice change. |
| ElDeeb, A. M., & Abdel-Aziem, A. A. (2020). Effect of whole-body vibration exercise on power profile and bone mineral density in postmenopausal women with osteoporosis: A randomized controlled trial. *Journal of Manipulative and Physiological Therapeutics, 43*(4), 384–393. https://doi.org/10. | To examine the relationship of WBV on both muscle strength and BMD in postmenopausal women. | A sample including 43 postmenopausal women who have low BMD. | There were two groups, including WBV interventional group and a control group. Each group was given supplements (calcium and vitamin D) while the interventional group also had WBV twice a week for 24 | Post treatment measurements demonstrated an increase in both muscle mass and BMD in the interventional group ($p <$ .05) compared to no difference measured in the control group ($p >$.05). | Level 2: RCT | This study is limited in the fact that it is inclusive of only females. | Yes, this study would make a valuable addition to a practice change as it demonstrated a satisfactory and plausible intervention which successfully had an effect on the interventional group. |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| 1016/j.jmpt.2019.12.003 | | | consecutive weeks. | | | | |
| Ma, M., Ma, Z., He, Y., Sun, H., Yang, B., Ruan, B., Zhan, W., Li, S., Dong, H., & Wang, Y. (2022). Efficacy of vitamin K2 in the prevention and treatment of postmenopausal osteoporosis: A systematic review and meta-analysis of randomized controlled trials. *Frontiers in Public Health, 10,* Article 979649. https://doi.org/10.3389/fpubh.2022.979649 | To determine if vitamin K2 has an effect on BMD and fracture incidence in postmenopausal women. | The sample included 16 RCTs and 6,425 participants. | Databases were searched with inclusion criteria from RCTs. Lumbar spine and fracture incidence were studied pre and post intervention. | This study reports that VK2 has a positive effect on BMD and bone strength, in an indirect manner. | Level 1: Meta-analysis | The study is limited to women of postmenopausal status. Also, as VK2 works synergistically with calcium and Vitamin D, it would be of benefit to know whether the participants were taking these supplements as well. | Yes, this supports the need for a practice change as VK2 plays a role in both maintaining and increasing BMD. |
| Malmir, H., Shab-Bidar, S., & Djafarian, K. (2018). Vitamin | To investigate the correlation | A meta-analysis and systematic review | This meta-analysis and systematic review | Vitamin C had a positive correlation for higher BMD | Level 1: Meta-analysis and | Limitations include the recommendation for determining | Yes, this provides a positive correlation |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| C intake in relation to bone mineral density and risk of hip fracture and osteoporosis: A systematic review and meta-analysis of observational studies. *British Journal of Nutrition, 119*(8), 847–858. https://doi.org/10.1017/S0007114518000430 | between vitamin C and BMD, as well as osteoporosis related complications. | including 12 studies. | utilized the PRISMA guidelines. | at the spine and neck, with the results finding a 33% reduction in the risk for osteoporosis. | systematic review | causality and the need for long term studies were identified. | between an increase in BMD with vitamin C intake. |
| Marín-Cascales, E., Alcaraz, P., Ramos-Campo, D., Martinez-Rodriguez, A., Chung, L., & Rubio-Arias, J. (2018). Whole-body vibration training and bone health in postmenopausal women: A systematic review | To examine the effect of whole-body vibration on the lumbar spine (LS), femoral neck (FN), and total BMD in postmenop | The sample consisted of two groups, one being a control group. There were a total of 462 postmenopausal women, younger than the age of 65. | Three databases were searched, with 10 studies and 14 groups being selected as they met the inclusion criteria. | Whole body vibration was effective in increasing and supporting BMD. | Level 1: Meta-analysis | The study was limited to female, with a wide age range. As whole body vibrative is not commonly prescribed, RCTs were limited. Also, vibrative methodologies varied amongst studies. | Yes, this article supports the need for a practice change. This article supports the other article on the positive effects of incorporating whole body vibration in osteoporosis risk reduction. |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| and meta-analysis. *Medicine, 97*(34), Article e11918. https://doi.org/10.1097/MD.0000000000011918 | ausal women. | | | | | | |
| Mohammadi, A., Behboodi Moghadam, Z., Ghelichkhani, F., Alidost, F., Naghizadeh, S., Haghparast, Z., & Azizi, M. (2022). Prevention of osteoporosis in menopausal women: A systematic review of nonpharmacological clinical trials. *Journal of Education and Health Promotion*, *11,* Article 287. https://doi.org/10. | To investigate nonpharmacologic interventions for osteoporosis in menopausal women. | The sample included 28 studies in total. | This systematic review included articles from databases which utilized nonpharmacologic treatment for osteoporosis, focusing on exercise and education. | The results displayed that nonpharmacologic therapy can be successful when optimized in women who have contraindications to pharmacologic treatment. | Level 1: Systematic review | The main limitation is that the included studies only consisted of postmenopausal women, not stating which stage of menopause they were in. | Yes, this supports the need for a practice change as it demonstrates that education and physical exercise can provide optimal alternatives for osteoporosis to pharmacologic treatment. |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| 4103/jehp.jehp_1253_21 | | | | | | | |
| Montgomery, G., Abt, G., Dobson, C., Smith, T., Evans, W., & Ditroilo, M. (2019). The mechanical loading and muscle activation of four common exercises used in osteoporosis prevention for early postmenopausal women. *Journal of Electromyography and Kinesiology, 44*, 124–131. https://doi.org/10.1016/j.jelekin.2018.12.004 | Although exercise is known to reduce bone loss, specific exercise is correlated with promoting osteogenesis. This study aims to investigate which exercises have higher impacts on this phenomenon. | A convenience sample of 14 postmenopausal women. | The effects of mechanical loading with stimulus frequency were measured with four specific exercises targeting common fracture sites with osteoporosis (countermovement jumps, box drops, heel-drops, and stamp exercises. | Specific exercises work together to provide greater results of osteogenesis, leading to bone adaptation. | Level 3: Quasiexperimental study | Peak accelerations are merely an indicator of bone adaptation but cannot singly measure internal loading. | Yes, this study provides evidence that bone adaptations occur to specific stimuli. |
| Reyes-Garcia, R., Mendoza, N., Palacios, S., Salas, N., | To examine the effect of milk | A sample size consisting of 500 healthy, | This study was a two-year, randomized | Results stated that a "significant improvement | Level 2: RCT | The study was limited to postmenopausal women and | Yes, this study supports a practice change as it |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| Quesada-Charneco, M., Garcia-Martin, A., Fonolla, J., Lara-Villoslada, F., & Muñoz-Torres, M. (2018). Effects of daily intake of calcium and vitamin D-enriched milk in healthy postmenopausal women: A randomized, controlled, double-blind nutritional study. *Journal of Women's Health, 27*(5), 561–568. https://doi.org/10.1089/jwh.2017.6655 | enriched with calcium and vitamin D when, consumed daily, on bone metabolism, vitamin D, and cardiovascular risk factors. | postmenopausal women. | control study. The study consisted of three groups and outcome measurements included serum 25(OH)D, BMD by DEXA scan, and biochemical information on glucose and lipid metabolism. | in vitamin D status" occurred, as well as "a significant increase in BMD at femoral neck, and also favorable effects on glucose and lipid profile" (p. 561). | | supplementation by the means of milk. | demonstrated "significant" results. |
| Sanchez-Trigo, H., Rittweger, J., & Sañudo, B. (2022). Effects of non-supervised | This study aims to examine the effects of | Seven electronic databases were searched, | Included control groups and randomized groups | The results indicated that exercise has positive osteogenic | Level 1: Systematic review and meta-analysis. | The major limitation included variations in the size of the | Yes, this study demonstrated the need for a practice change. Despite the |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| exercise interventions on bone mineral density in adult women: A systematic review and meta-analysis. *Osteoporosis International, 33*, 1415–1427. https://doi.org/10.1007/s00198-022-06357-3 | nonpharmacologic interventions on osteoporosis prevention, specifically when completed unsupervised. | including randomized control trials (RCTs). A total of ten studies were included, with 668 participants. | consisted of menopausal status and specific types of intervention. | results in participants with osteopenia, displaying increased BMD in the lumbar spine (LS) and FN. | | effects, possibly attributed to the need to confound variables such as diet or methodologies. Also, the study limited its examination to LS and FN and could be strengthened by studying other areas of BMD. | listed limitations, the results yielded a positive effect on BMD status. |
| Tong, X., Chen, X., Zhang, S., Huang, M., Shen, X., Xu, J., & Zou J. (2019). The effect of exercise on the prevention of osteoporosis and bone angiogenesis. *Biomed Research International, 2019,* Article 8171897. https://doi.org/10. | To examine, describe, and disseminate the mechanisms of how exercise impacts hormones, cytokines, RNA, and signaling pathways related to | This study reviewed 102 articles. | The method was focused on searching databases for osteogenesis and related mechanisms. | Exercise has a positive effect on regulating angiogenesis mediators, resulting in the increase of bone formation while mitigating bone resorption. | Level 6: Descriptive design | This study could be strengthened by researching the combination of nutritional recommendations, such as calcium and vitamin D, in conjunction with exercise for bone angiogenesis. | Yes, this study provides support for a practice change by describing and detailing the underlying mechanism as to why exercise mitigates osteoporosis risk factors. |

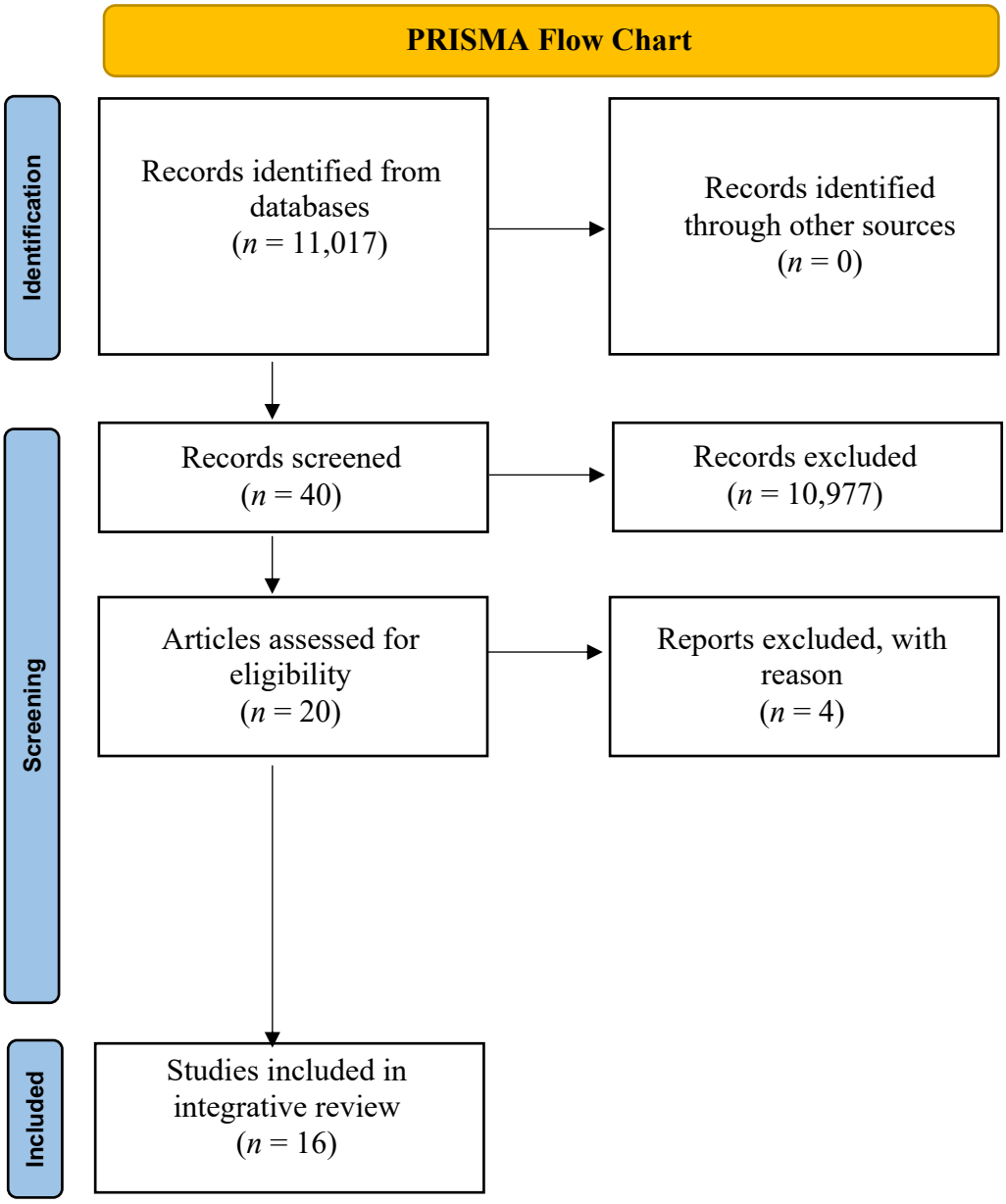
| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| 1155/2019/8171897 | bone angiogenesis and osteogenesis and its impact on bone formation in the aging population. | | | | | | |
| Zamoscinska, M., Faber, I., & Büsch, D. (2020). Do older adults with reduced bone mineral density benefit from strength training? A critically appraised topic. *Journal of Sport Rehabilitation, 29*(6), 833–840. https://doi.org/10.1123/jsr.2019-0170 | The purpose of this study is to examine if strength training is a suitable alternative to pharmacologic or supplementation in the role of osteoporosis prevention. | A meta-analysis examining five studies. | This analysis included only studies of level 3 evidence or higher, zoning in on the effects of strength training in increasing BMD in women who were diagnosed with osteoporosis or osteopenia. | Strength training, both 2 and 3x/ week yielded significant results in increasing BMD at the LS, FN, femur, trochanter, and overall total BMD. | Level 1: Meta-analysis and systematic review | Males were not included in this study, limiting the results to only female. | Yes, this supports the need for a practice change as strength training has a significant impact on increasing one's BMD. |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| Zeng, L., Luo, M., Liang, G., Yang, W., Xiao, X., Wei, X., Yu, J., Guo, D., Chen, H., Pan, J., Huang, T., Liu, O., Guan, Z., Han, Y., Zhao, D., Zhao, J., Hou, S., Wu, M., Lin, J., . . . Liu, J. (2020). Can dietary intake of vitamin C-oriented foods reduce the risk of osteoporosis, fracture, and BMD loss? Systematic review with meta-analyses of recent studies. *Frontiers in Endocrinology, 10,* Article 844. https://doi.org/10.3389/fendo.2019.00844 | To assess the association between the dietary intake of vitamin C-oriented foods (DIVCF) with BMD, osteoporosis, and risk for fracture. | The sample included 13 articles, 17 studies, with 19,484 participants. | Four databases were searched, relative risks and confidence intervals (CIs) of 95% were calculated, and any identified discrepancies were evaluated and resolved by a third party. | The results reported an inverse relationship with DIVCF and the risk of BMD loss, osteoporosis, and hip fracture, supporting a positive correlation with vitamin C having effective results for the use of osteoporosis prevention. | Level 1: Meta analysis and systematic review | The biggest limitation is that the rest of the diet was not taken into consideration, so DIVCF independent of other dietary vitamin C, calcium, or vitamin D was not identified. | Yes, this article supports the need for a practice change. DIVCF has shown protective properties against BMD loss and fractures, supporting a positive effect and consideration to be given to incorporation with a preventative routine. |

| Article | Study Purpose | Sample | Methods | Study Results | Level of Evidence | Study Limitations | Would Use as Evidence to Support a Change? |
|---|---|---|---|---|---|---|---|
| Zhang, S., Huang, X., Zhao, X., Li, B., Cai, Y., Liang, X., & Wan, Q. (2022). Effect of exercise on bone mineral density among patients with osteoporosis and osteopenia: A systematic review and network meta-analysis. *Journal of Clinical Nursing, 31*(15–16), 2100–2111. https://doi.org/10.1111/jocn.16101 | To review the effects of various exercise interventions on BMD on patients with osteoporosis and osteopenia. | A meta-analysis and systematic review including 97 studies. | This meta-analysis/systematic review included RCTs which used the outcome of BMD from different locations after exercise implementation. | The study found that resistance training had the best outcome for total hip BMD while mind-body exercise showed optimal results at the lumbar spine and femoral neck. | Level 1: Meta-analysis and systematic review | There were three identified limitations. First, there were significantly more female than male participants ($n$ = 7328 compared to $n$ = 1174, respectively). Secondly, RCT methodologies were underreported, questioning the clarity of bias. Lastly, 2 out of 3 of the studies were conducted in China, not displaying great diversity, and questioning cultural influence. | Yes, this demonstrates an increase in BMD due to exercise, with different exercise methods being studies. This supports a positive correlation between BMD and exercise training. |

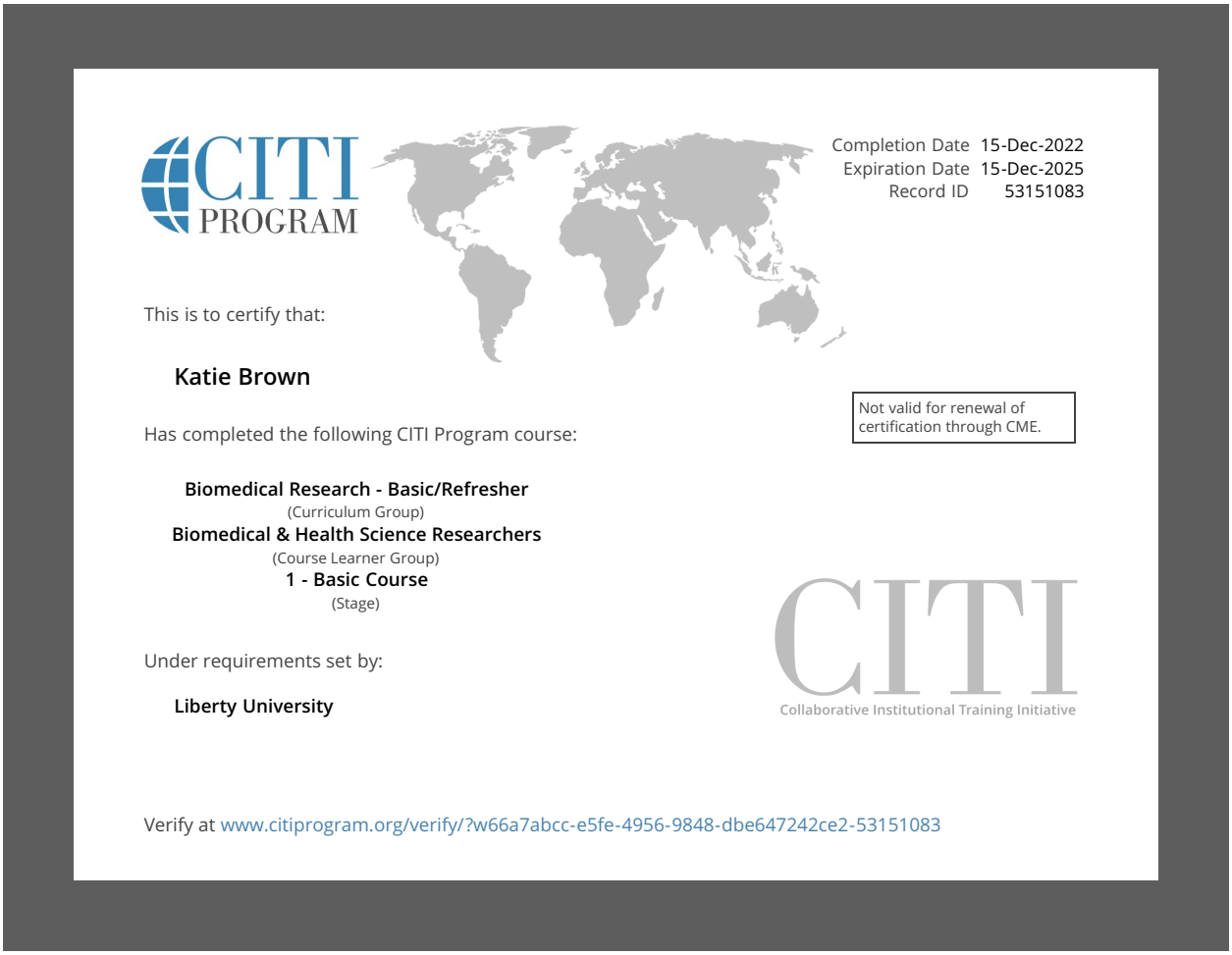
## Appendix B

## PRISMA Flow Chart



# Appendix C

## CITI Training Certificate



CITI PROGRAM

Completion Date 15-Dec-2022
Expiration Date 15-Dec-2025
Record ID 53151083

This is to certify that:

**Katie Brown**

Not valid for renewal of certification through CME.

Has completed the following CITI Program course:

**Biomedical Research - Basic/Refresher**
(Curriculum Group)
**Biomedical & Health Science Researchers**
(Course Learner Group)
**1 - Basic Course**
(Stage)

Under requirements set by:

**Liberty University**

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w66a7abcc-e5fe-4956-9848-dbe647242ce2-53151083

## Appendix D

## IRB Approval Letter

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

February 8, 2023

Katie Brown
Vickie Moore

Re: IRB Application - IRB-FY22-23-977 Non-pharmacologic measures to maintain or increase bone density in patients at risk for osteoporosis: An integrative review

Dear Katie Brown and Vickie Moore,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds that your study does not meet the definition of human subjects research. This means you may begin your project with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study is not considered human subjects research because it will not involve the collection of identifiable, private information from or about living individuals (45 CFR 46.102).

Please note that this decision only applies to your current application. Any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
*Administrative Chair of Institutional Research*
Research Ethics Office