

ASSESSMENT OF THE RELATONSHIP BETWEEN MENOPAUSEAND OSTEOPOROSIS AMONG WOMEN

¹ Mabel Ekpedotse ULOKO ² Isoken IHENSEKHIEN

¹ Federal College of Education (Tech), Asaba
+2348139131051
ulokomabel@gmail.com

²Department of Vocational and Technical Education, Faculty of Education
University of Benin, Benin City
isokenihenseken@uniben.edu
+2348023401288

Abstract

This paper assessed the relationship between menopause and osteoporosis among women. Menopause is the permanent cessation of menstruation and ovulation due to ovarian failure. Osteoporosis is a bone disease that develops when bone mineral density and bone mass decreases, or when the quality or structure of bone changes. Method adopted for this study was a comprehensive review of related literature. The review provided insights into the relationship between menopause and osteoporosis among women. The findings seem to suggest that Menopausal hormonal changes can impact bone health, potentially influencing the development or progression of osteoporosis. The authors concluded by recommending that women going through menopause should increase vitamin D and calcium levels intake, as well as engaging in weight-bearing exercises like walking, jogging, or resistance training, as this can help improve bone density and reduce the risk of osteoporosis.

Keywords: Menopause, Osteoporosis, Women

Introduction

Menopause entails any of the changes or symptoms women of a certain age experience before or after they completely stop menstruating. It marks the end of a woman's reproductive life and the menstruation cycle. Technically, menopause starts when a woman's menstruations have ceased for 12 months straight, as her ovaries no longer produce two main sex hormones — progesterone and estrogen, (Okeke, Anyaehie and Ezenyeaku, 2013). Some of the most common symptoms women experience during this intense period include irritability, sleep disturbances, night sweats, chills, hot flashes, and erratic periods (Huang, Goodship, Webber, *et al.* 2023).

One of the complications of menopause is that it significantly speeds up bone loss and increases the risk of osteoporosis. Women should be aware of a connection between menopause and osteoporosis. In this write-up we shall examine the connection between the two, (Bartl, Frisch, Springer-Verlag, and Berlin Heidelberg, 2009).

Caggiari, Leali, Mosele, Puddu, Badessi and Doria, (2016) stated that osteoporosis is by far the most common metabolic bone disease and is characterized by low bone mass with microarchitectural alteration of bone structure, leading to reduced bone strength, which predisposes to an increased fracture risk. The authors further opined that the definition of osteoporosis is based on densitometric measurement of bone mass in the spine or hip and not on clinical criteria. The World Health Organization (2020) defines osteoporosis as a bone mineral density (BMD) 2.5 or more standard deviations (SDs) below that of a young adult at any site (T score), whereas osteopenia is defined when BMD is >1 SD and <2.5 SD lower than the young- adult mean end. This paper shall attempt to critically examine the relationship between menopause

and osteoporosis, but before discussing such interrelationships, it will be expedient to discuss in detail the pathophysiology of the aforementioned health challenges.

Menopause

Menopause is one point in a continuum of life stages for women and marks the end of their reproductive years. After menopause, a woman cannot become pregnant, except in rare cases when specialized fertility treatments are used. Most women experience menopause between the ages of 45 and 55 years as a natural part of biological ageing. Menopause is caused by the loss of ovarian follicular function and a decline in circulating blood oestrogen levels, (Ceylan and Özerdoğan, 2015).

The menopausal transition can be gradual, usually beginning with changes in the menstrual cycle. 'Perimenopause' refers to the period from when these signs are first observed and ends one year after the final menstrual period. Faubion, Kuhle, Shuster and Rocca, (2015) suggested that perimenopause can last several years and can affect physical, emotional, mental and social well-being. Okeke, Anyaehie and Ezenyeaku in 2013 stated that a variety of non-hormonal and hormonal interventions can help alleviate perimenopausal symptoms and that menopause can be a consequence of surgical or medical procedures.

For most women, menopause is marked by the end of monthly menstruation (also known as a menstrual period or 'period') due to loss of ovarian follicular function. This means that the ovaries stop releasing eggs for fertilisation. The regularity and length of the menstrual cycle varies across a woman's reproductive life span, but the age at which natural menopause occurs is generally between 45 and 55 years for women worldwide, (Faubion, Kuhle, Shuster, Rocca, 2015). Natural menopause is deemed to have occurred after 12 consecutive months without menstruation for which there is no other obvious physiological or pathological cause and in the absence of clinical intervention. Some women experience menopause earlier (before 40 years of age). This 'premature menopause' according to Garner, Sornay-Rendu, Duboeuf, and Delmas (1994), may be because of certain chromosomal abnormalities, autoimmune disorders, or other unknown causes. The authors further stated that menopause can also be induced as a consequence of surgical procedures that involve removal of both ovaries and medical interventions that cause cessation of ovarian function (for example radiation therapy or chemotherapy).

Changes Associated with Menopause

The hormonal changes associated with menopause can affect physical, emotional, mental, and social well-being. The symptoms experienced during and following the menopausal transition vary substantially from person to person. Some have few if any symptoms. For others, symptoms can be severe and affect daily activities and quality of life. Some can experience symptoms for several years, (Caggiari, Leali, Mosele, Puddu, Badessi and Doria, 2016).

Symptoms associated with menopause:

Okeke, Anyaehie and Ezenyeaku, (2013) identified hot flushes and night sweats as symptoms associated with menopause. Hot flushes refer to a sudden feeling of heat in the face, neck and chest, often accompanied by flushing of the skin, perspiration (sweating), palpitations, and acute feelings of physical discomfort which can last several minutes. Changes in the regularity and flow of the menstrual cycle culminating in cessation of menstruation; vaginal dryness, pain during sexual intercourse and incontinence; difficulty sleeping/insomnia; and changes in mood, depression, and/or anxiety.

Menopause can also result in the weakening of the pelvic support structures, increasing the risk of pelvic organ prolapse. Loss of bone density at menopause is a significant contributor to higher rates of osteoporosis and fractures, (Faubion, Kuhle, Shuster, and Rocca, 2015). There are a variety of non-hormonal and hormonal interventions that can help alleviate symptoms of menopause. Harlow, (2012) asserted that pregnancy is still possible during perimenopause and suggested that contraception should be recommended to avoid unintended pregnancy, until after 12 consecutive months without menstruation. Pregnancy after

menopause is unlikely without fertility treatment that involves the use of donor eggs or previously frozen embryos.

Treatment

Lewiecki, (2008) opined that menopause requires no medical treatment and that treatments should rather focus on relieving signs and symptoms and preventing or managing chronic conditions that may occur with aging. Treatments, according to him, may include:

Hormone therapy: Estrogen therapy is the most effective treatment option for relieving menopausal hot flashes. Depending on the person's personal and family medical history, the doctor may recommend estrogen in the lowest dose and the shortest time frame needed to provide symptom relief.

Vaginal estrogen: To relieve vaginal dryness, estrogen can be administered directly to the vagina using a vaginal cream, tablet or ring. This treatment releases just a small amount of estrogen, which is absorbed by the vaginal tissues. It can help relieve vaginal dryness, discomfort with intercourse and some urinary symptoms, (Lewiecki, 2008).

Low-dose antidepressants: Certain antidepressants related to the class of drugs called selective serotonin reuptake inhibitors (SSRIs) may decrease menopausal hot flashes. Clonidine, a pill or patch typically used to treat high blood pressure, might provide some relief from hot flashes. A low-dose antidepressant for management of hot flashes may be useful for women who cannot take estrogen for health reasons or for women who need an antidepressant for a mood disorder, (Nelson, Haney, and Humphrey, et al, 2005).

Osteoporosis

The word 'osteoporosis' means 'porous bone.' It is a disease that weakens bones, and if an individual has it, the person is at a greater risk for sudden and unexpected bone fractures, (Nelson, Helfand, Woolf and Allan, 2002). Osteoporosis means that an individual has less bone mass and strength. The disease often develops without any symptoms or pain, and it is usually not discovered until the weakened bones cause painful fractures. Most of these are fractures of the hip, wrist and spine.

Who gets osteoporosis?

Surveys seem to suggest that about 200 million people are estimated to have osteoporosis throughout the world, (Nelson, and Helfand, 2002). Although osteoporosis occurs in both men and women, women are four times more likely to develop the disease than men. After age 50, one in two women and one in four men will have an osteoporosis-related fracture in their lifetimes. Another 30% have low bone density that puts them at risk of developing osteoporosis. This condition is called osteopenia, (Nelson, Helfand, Woolf and Allan, 2002).

Lewiecki, (2008) stated that osteoporosis is responsible for more than two million fractures each year, and that this number continues to grow. There are steps to take to prevent osteoporosis from ever occurring. Treatments can also slow down the rate of bone loss, if osteoporosis has been diagnosed.

What causes osteoporosis?

Researchers, (Sandhu, and Hampson, 2011) understand how osteoporosis develops even without knowing the exact cause of why it develops. Bones are made of living, growing tissue. The inside of healthy bone looks like a sponge. This area is called *trabecular bone*. An outer shell of dense bone wraps around the spongy bone. This hard shell is called *cortical bone*.

When osteoporosis occurs, the "holes" in the "sponge" grow larger and more numerous, which weakens the inside of the bone. Bones support the body and protect vital organs. Bones also store calcium and other minerals. When the body needs calcium, it breaks down and rebuilds bone. This process, called bone

remodelling, supplies the body with needed calcium while keeping the bones strong, (Ceylan and Özerdoğan, 2015).

Up until about age 30, someone normally builds more bone than can be lost. After age 35, bone breakdown occurs faster than bone build up, which causes a gradual loss of bone mass. If the individual has osteoporosis, the person loses bone mass at a greater rate. After menopause, the rate of bone breakdown occurs even more quickly.

Symptoms and Causes

Sandhu and Hampson, (2011) affirmed that usually, there are no symptoms of osteoporosis and that is why it is sometimes called a silent disease. However, the authors advised that one should watch out for the following things:

- Loss of height (getting shorter by an inch or more).
- Change in posture (stooping or bending forward).
- Shortness of breath (smaller lung capacity due to compressed disks).
- Bone fractures.
- Pain in the lower back.

Who is at risk for developing osteoporosis?

There are many risk factors that increase one's chances of developing osteoporosis, with two of the most significant being gender and age. Everyone's risk for osteoporosis fractures increases with age. However, women over the age of 50 or postmenopausal women have the greatest risk of developing osteoporosis. Women undergo rapid bone loss in the first 10 years after entering menopause, because menopause slows the production of estrogen, a hormone that protects against excessive bone loss, (Sornay-Rendu, Munoz, Duboeuf and Delmas, 2005). Surprisingly, men over the age of 50 are more likely to have an osteoporosis-induced bone break than to get prostate cancer. About 80,000 men per year are expected to break a hip, and men are more likely than women to die in the year after a hip fracture, (Styrkarsdottir, Halldorsson and Gretarsdottir, 2009).

An individual's risk of developing osteoporosis is also linked to ethnicity, (Wu, Xu and Lin, 2019). Caucasian and Asian women are more likely to develop osteoporosis. However, African-American and Hispanic women are still at risk. In fact, African-American women are more likely than white women to die after a hip fracture. Bartl, Frisch and Springer-Verlag, (2009), identified bone structure and body weight as another factor responsible for osteoporosis. Petite and thin people, according to them, have a greater risk of developing osteoporosis because they have less bone to lose than people with more body weight and larger frames. Additionally, family history also plays a part in osteoporosis risk. If individual's parents or grandparents have had any signs of osteoporosis, such as a fractured hip after a minor fall, the person may have a greater risk of developing the disease.

Finally, some medical conditions and medications according to Bonjour, Chevalley, Ferrari and Rizzoli, (2009) increase someone's risk. If a person has or had any of the following conditions, some of which are related to irregular hormone levels, the individual might consider earlier screening for osteoporosis.

- Overactive thyroid, parathyroid, or adrenal glands.
- History of bariatric (weight loss) surgery or organ transplant.
- Hormone treatment for breast or prostate cancer or a history of missed periods.
- Celiac disease or inflammatory bowel disease.
- Blood diseases such as multiple myeloma.

Some medications cause side effects that may damage bone and lead to osteoporosis, (Ciurlia, Leali and Doria, 2017). These include steroids, treatments for breast cancer, and medications for treating seizures. You should speak with your healthcare provider or pharmacist about the effect of your medications on bones. It may seem as though every risk factor is related to something that is out of your control, but that's not true.

You do have control over some of the risk factors for osteoporosis. You can discuss medication issues with your healthcare provider. Research findings, (Greendale, Sowers and Han, 2012) have shown that:

- **Eating habits:** You are more likely to develop osteoporosis if your body doesn't have enough calcium and vitamin D. Although eating disorders like bulimia or anorexia are risk factors, they can be treated.
- **Lifestyle:** People who lead sedentary (inactive) lifestyles have a higher risk of osteoporosis.
- **Tobacco use:** Smoking increases the risk of fractures.
- **Alcohol use:** Having two drinks a day (or more) increases the risk of osteoporosis.

Management and Treatment

Depending on individual needs, doctors may recommend medication to prevent or treat osteoporosis. Several medications are available that help reduce bone loss and risk of fractures. There are several classes of medications used to treat osteoporosis. Your healthcare provider will work with you to find the best fit. It is not really possible to say there is one best medication to treat osteoporosis. The 'best' treatment is the one that is best for you. Treatments for established osteoporosis may include exercise, vitamin and mineral supplements, and medications. Exercise and supplementation are often suggested to help you prevent osteoporosis. Weight-bearing, resistance and balance exercises are all important, (Langdahl and Andersen, 2018).

Prevention

Your diet and lifestyle are two important risk factors you can control to prevent osteoporosis, (Leali, Solla, Maestretti, Balsano and Doria, (2016). Replacing lost estrogen with hormone therapy also provides a strong defence against osteoporosis in postmenopausal women.

Diet: To maintain strong, healthy bones, you need a diet rich in calcium throughout your life, like milk, salmon with bones, sardines, kale, broccoli, calcium-fortified juices and breads, dried figs, and calcium supplements. It is best to try to get the calcium from food and drink. For those who need supplements, remember that the body can only absorb 500 mg of calcium at a time. You should take your calcium supplements in divided doses, since anything more than 500 mg will not be absorbed, (Sandhu and Hampson, 2011).

Lifestyle: Maintaining a healthy lifestyle can reduce the degree of bone loss. Begin a regular exercise program. Exercises that make your muscles work against gravity (such as walking, jogging, aerobics, and weightlifting) are best for strengthening bones, (Lewiecki, 2008).

Relationship Between Menopause and Osteoporosis

Menopause significantly speeds bone loss and increases the risk of osteoporosis. It is estimated that, on average, women lose up to 10 per cent of their bone mass in the first five years after menopause. Research, (Sandhu and Hampson, 2011), indicates that up to 20% of bone loss can happen during these stages and approximately 1 in 10 women over the age of 60 are affected by osteoporosis worldwide. Also studies, (Lewiecki, 2008), have shown that one in two postmenopausal women will have osteoporosis, and most will suffer a fracture during their lifetime. Fractures (broken bones) cause pain, decreased mobility, and function. Fractures are associated with decreased quality of life and increased mortality. Similarly, early menopause is also identified as a risk factor for osteoporosis, (Sapre and Thakur, 2014; Okeke, Anyaehie and Ezenyeaku, 2013).

Kanis, Melton, Christiansen, Johnston and Khaltsev, (1994), have pointed out that post-menopausal women are susceptible to primary osteoporosis since osteoporosis is closely related to estrogen deficiency. According to the authors, during the menopausal transition period, the drop of estrogen leads to more bone resorption than formation, resulting in osteoporosis. The major health threat of osteoporosis is osteoporotic fractures.

Estrogen has been shown to influence osteocytes, as well as other cells such as osteoblasts and osteoclasts, (Greendale, Sowers and Han, 2012). Low estrogen levels affect how these cells function, making them produce too little new bone and not properly maintain bone structure.

Styrkarsdottir and Halldorsson, (2009) opined that experts do not understand exactly how estrogen affects bone, but they believe that the complex relationship between the two involves the following:

The immune system: Scientists think that estrogen affects bone homeostasis by regulating the immune system.

Effects on bone cells: Estrogen affects bone cells, including osteocytes, osteoblasts, and osteoclasts.

Oxidative stress: An imbalance between free radicals and antioxidants can cause oxidative stress.

Sema3A protein: There may be a relationship between estrogen and the sema3A protein in osteocytes. As people age, their levels of estrogen and sema3A deplete, which leaves the bones unable to maintain their structure.

Estradiol, one of three estrogen hormones naturally produced in the body is also worthy of mention. The effects of estradiol are clearly seen in women experiencing menopause. During this process, women naturally have lower levels of estradiol, as the ovaries no longer produce it, causing the menstrual cycles to stop. This change often causes mood swings, vaginal dryness, hot flashes, and night sweats - the symptoms commonly associated with menopause. Over time, lower estradiol levels can lead to osteoporosis.

Menopausal women are also at a higher risk of osteoporosis because they often do not get enough minerals to maintain healthy bones, (Sandhu and Hampson, 2011). If you don't get enough calcium, your body takes calcium from your bones to support important functions, leaving bones weak and vulnerable to fractures. You also need adequate vitamin D to absorb calcium. Without vitamin D, you can take all the calcium you please but it won't get absorbed.

In summary, it has been demonstrated that as women enter menopause, their estrogen and progesterone levels begin to fall. Estrogen acts as a natural protector and defender of bone strength. The lack of estrogen contributes to the development of osteoporosis commonly found among post-menopausal women.

Conclusion

This paper x-rayed two major health conditions especially predominant among women, namely menopause and osteoporosis. Menopause was defined as the permanent cessation of menstruation and ovulation due to ovarian failure. "Spontaneous" menopause was shown to occur after 12 months of amenorrhea as ovarian hormone secretion diminishes, on average around the age of 51 years. Osteoporosis on the other hand was identified as a bone disease that develops when bone mineral density and bone mass decreases, or when the quality or structure of bone changes. This can lead to a decrease in bone strength that can increase the risk of fractures (broken bones).

Finally, it was established through the review of relevant literature that there was a connection or interrelationship between these two health conditions. One health condition (menopause) was found to favour the onset of the other (osteoporosis), or exacerbate its pathophysiology.

Recommendations

Dealing with the interrelationship between menopause, and osteoporosis requires a comprehensive approach that addresses the specific needs of each condition. The following recommendations are made, but it is important to note that these recommendations are general in nature, and individualized medical advice should be sought from healthcare professionals to address specific concerns and conditions:

1. Avoid high-impact exercises. Activities such as jumping, running or jogging can lead to fractures in weakened bones.
2. Avoid bending and twisting. In people who have osteoporosis, bending forward at the waist and twisting at the waist can increase the risk for broken bones in the spine.
3. Dietary changes, increasing vitamin D and calcium levels. Adequate calcium and vitamin D intake is crucial for maintaining bone health.
4. Engaging in weight-bearing exercises like walking, jogging, or resistance training can help improve bone density and reduce the risk of osteoporosis.
5. Limiting or stopping smoking and alcohol consumption.

References

- Bartl R., Frisch B. Springer-Verlag; Berlin Heidelberg, (2009). Osteoporosis: *Diagnosis, Prevention, Therapy*; 119–124.
- Bonjour J.P., Theintz G., Law F., Slosman D. & Rizzoli R. (1994) Peak bone mass. *Osteoporosis Int.* 4:7– 13.
- Bonjour J.P., Chevalley T., Ferrari, S. & Rizzoli, R. (2009) The importance and relevance of peak bone mass in the prevalence of osteoporosis. *Salud Publica Mex.* 51: S5–S17.
- Caggiari G., Leali P.T., Mosele G.R., Puddu L., Badessi F., Doria C, (2016). Safety and effectiveness of teriparatide vs alendronate in postmenopausal osteoporosis: A prospective non randomized clinical study. *Clin. Cases Min. Bone Metab.* 13:200–203.
- Ceylan B, Özerdoğan N. (2015). Factors affecting age of onset of menopause and determination of quality of life in menopause. *Turk J Obstet Gynecol. Mar*;12(1):43-49.
- Caggiari G., Leali P.T., Mosele G.R., Puddu L., Badessi F., Doria C, (2016). Hormonal and non-hormonal interventions for menopausal symptoms. *Maturitas. Mar*; 23(2):159-68.
- Ciurlia E., Leali P.T., Doria C, (2017). Use of teriparatide off-label: Our experience and review of literature. *Clin. Cases Min. Bone Metab.* 14:28–34.
- Doria C., Mosele G.R., Solla F., Maestretti G., Balsano M., Scarpa R.M, (2017). Treatment of osteoporosis secondary to hypogonadism in prostate cancer patients: A prospective randomized multicenter international study with denosumab vs. alendronate. *Minerva Urol. Nefrol.* 69:271–277.
- Faubion SS, Kuhle CL, Shuster LT, Rocca WA., (2015). Long-term health consequences of premature or early menopause and considerations for management. *Climacteric.*18(4):483-91.
- Garnero P., Sornay-Rendu E., Duboeuf F., Delmas P.D, (1994). Markers of bone turnover predict postmenopausal forearm bone loss over 4 years: the OFELY study. *J Bone Miner Res.* 14:1614– 1621.
- Greendale G.A., Sowers M.F., Han W, (2012). Bone mineral density loss in relation to the final menstrual period in a multiethnic cohort: results from the Study of Women's Health Across the Nation (SWAN) *J Bone Miner Res.* 27:111–118.
- Harlow, S. (2012). Executive Summary of the Stages of Reproductive Aging Workshop + 10: Addressing the Unfinished Agenda of Staging Reproductive Aging. *J Clin Endocrinol Metab.* 97(4):1159–68. PMID:

- Huang, D.R., Goodship, A. & Webber, I. (2023). Experience and severity of menopause symptoms and effects on health-seeking behaviours: a cross-sectional online survey of community dwelling adults in the United Kingdom. *BMC Women's Health* **23**, 373).
- Kanis, J.A., Melton, L.J., Christiansen, C. & Johnston, C.C. & Khaltaev N. (1994) The diagnosis of osteoporosis. *J Bone Miner Res.* Aug 9:1137–1141.
- Langdahl, B.L. & Andersen, J.D, (2018). Treatment of Osteoporosis: Unmet Needs and Emerging Solutions. *J. Bone Metab.* 25:133–140.
- Leali, P.T., Solla, F., Maestretti, G., Balsano, M. & Doria, C, (2016). Safety and efficacy of vertebroplasty in the treatment of osteoporotic vertebral compression fractures: A prospective multicenter international randomized controlled study. *Clin. Cases Min. Bone Metab.* 13:234–236.
- Lerner, U.H. (2006). Bone remodeling in post-menopausal osteoporosis. *J Dent Res.* 85:584–595. Lewiecki, E.M. (2008). Prevention and treatment of postmenopausal osteoporosis. *Obstet Gynecol Clin N Am.* 35:301–315.
- McKinlay, S.M., Brambilla, D.J. & Posner, J.G. (1992). The normal menopause transition. *Maturitas. Jan;*14(2):103–15.
- Nelson, H.D., Haney, E. & Humphrey L. (2005). Management of menopause-/related symptoms. *Evid Rep Technol Assess (Summ).* Mar;(120):1-6.
- Nelson, H.D., Helfand. M., Woolf, S.H. & Allan, J.D. (2002). Screening for postmenopausal osteoporosis: a review of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med.*137(6):529–541.
- Nelson, H.D. & Helfand, M. (2002). Screening for Postmenopausal Osteoporosis Systematic Evidence Review No 17 (Prepared by the Oregon Evidence-based Practice Center for the Agency for Healthcare Research and Quality). Rockville, MD: Agency for Healthcare Research and Quality;
- Okeke, T., Anyaehie, U. & Ezenyeaku, C. (2013). Premature menopause. *Ann Med Health Sci Res.* 2013 Jan;3(1):90-5.
- Proceedings from the NIH State-of-the-Science Conference on Management of Menopause-Related Symptoms, (2005); *Am J Med*; March 21-23: Bethesda, Maryland, USA. Dec 19, 1–171.
- Richelson, L.S., Wahner, H.W., Melton, L.J. & Riggs, B.L, (1984). Relative contributions of aging and estrogen deficiency to postmenopausal bone loss. *N. Engl. J. Med.* 311:1273–1275.
- Rogers, A., Saleh, G., Hannon, R.A., Greenfield, D. & Eastell, R. (2002). Circulating estradiol and osteoprotegerin as determinants of bone turnover and bone density in postmenopausal women. *J Clin Endocrinol Metab.* 87:4470–4475.
- Sapre, S. &Thakur, R. (2004). Lifestyle and dietary factors determine age at natural menopause. *J Mid-life Health.* 5:3.
- Sandhu, S.K. & Hampson, G. (2011). The pathogenesis, diagnosis, investigation and management of osteoporosis. *J Clin Pathol.* 64:1042–1050.
- Sornay-Rendu, E., Munoz, F., Duboeuf, F. & Delmas P.D, (2005). Rate of forearm bone loss is associated with an increased risk of fracture independently of bone mass in postmenopausal women: The OFELY study. *J. Bone Min. Res.*20:1929–1935.
- Styrkarsdottir, U., Halldorsson, B.V. & Gretarsdottir, S. (2009). New sequence variants associated with bone mineral density. *Nat Genet.*; 41:15–17.



- Su, H.I. & Freeman, E.W. (2009). Hormone changes associated with the menopausal transition. *Minerva Ginecol. Dec.* 61(6):483-9.
- U.S. Preventive Services Task Force. Screening for Osteoporosis in Postmenopausal Women, (2002). Rockville, MD: Agency for Healthcare Research and Policy.
- Woods, N.F. & Mitchell, E.S. (2005). Symptoms during the perimenopause: prevalence, severity, trajectory, and significance in women's lives. *Am J Med.* Dec 19;118 Suppl 12B:14–24.
- Wu, Q., Xiao, X. & Xu, Y. (2020). Evaluating the Performance of the WHO International Reference Standard for Osteoporosis Diagnosis in Postmenopausal Women of Varied Polygenic Score and Race. *J. Clin. Med.* 9:499.
- Wu, Q., Xu, Y. & Lin (2019). Trends and Disparities in Self-Reported and Measured Osteoporosis among US Adults, 2007–2014. *J. Clin. Med.* 8:2052.