

HOW CAN GOOD BACTERIA IMPROVE BONE HEALTH?

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Bones perform several important functions. They support the body and protect internal organs. However, with age and in some diseases such as osteoporosis, bones can become weaker and can break easily. But do not worry! Several treatments are currently available to improve bone health. However, some of those treatments cause unpleasant side effects, which is why scientists have studied alternative therapies for osteoporosis and bone loss. Did you know that good bacteria, known as probiotics, can improve bone health? Although this is a relatively new field of study, the results are encouraging. Curious about how good microbes can beat bone busters? Keep reading to find the answers.

BONE, ALWAYS UNDER CONSTRUCTION

The human body is like a large puzzle made of various parts including organs, muscles, and bones. The human skeleton consists of approximately 206 bones that support the body and protect the

OSTEOCLASTS

Bone cells that digest bone tissue.

OSTEOBLASTS

Bone cells that build bone tissue.

BONE HOMEOSTASIS

Is the process in which bone cells, like osteoblasts and osteoclasts, work together to keep the right balance of breaking down and building up bone tissue.

MENOPAUSE

Is the end of a woman's menstrual cycles, which means she no longer has periods and can no longer have children naturally.

INTESTINAL PERMEABILITY

Is like a gate in our intestine walls, controlling how easily things pass through the cells of the intestinal walls and enter the body.

INFLAMMATION

Is an important component of the body's defense mechanisms or immune system. However, maintaining a balance is key to good health, as an exaggerated inflammatory response may be harmful.

OSTEOPOROSIS

Is a bone disease that affects the structure of our bones, leading to a significant loss of bone mass, which makes bones fragile and more likely to break.

internal organs. Healthy bones can withstand strong and sudden movements and high pressures. Bone grows as we grow. Older bone is constantly being replaced by new bone to better support the body, repair tiny injuries that occur in everyday situations, and shape the skeleton. For bone replacement to occur, bone is digested by special bone cells called **osteoclasts** and rebuilt by other bone cells called **osteoblasts**. This process maintains the right balance within bone tissue, which is called **bone homeostasis**.

Around the age of 30 years, humans reach their maximum bone mass, when the skeleton is at its strongest [1]. However, bone homeostasis declines with age, resulting in a loss in the quality and amount of bone tissue. Other factors contribute to bone loss, such as a lack of exercise, smoking, and low levels of a hormone called estrogen, which occurs after women go through an age-related change called **menopause**.

ESTROGEN, AN IMPORTANT SUPERVISOR AT THE CONSTRUCTION SITE

Menopause is the end of a woman's menstrual cycles, marking when she can no longer have children naturally, and it generally occurs around the age of 45. After menopause, the ovaries decrease their production of estrogen, a sex hormone important for the sexual and reproductive systems that also plays an important role in maintaining bone homeostasis. Low estrogen levels lead to an imbalance between osteoblasts and osteoclasts, which results in bone loss. Interestingly, a reduction in estrogen also influences the intestine, which can also result in bone loss.

The intestine is one of the largest organs and is essential for all body functions because it is responsible for absorbing nutrients from food. The wall of the intestine is made of cells that are arranged side by side, normally held together very tightly. The decrease in estrogen that happens after menopause reduces how tightly these cells are held together and, consequently, increases **intestinal permeability** (Figure 1). Intestinal permeability describes how easy it is for things to pass through the cells of the intestinal walls to get into the body. Increased intestinal permeability is like an open door for disease-causing microorganisms and the substances they produce, allowing them to pass through the intestine into the tissues and cause **inflammation**. Inflammation then stimulates osteoclast activity and bone destruction.

OSTEOPOROSIS: WHEN DESTRUCTION OVERCOMES CONSTRUCTION

Healthy bone tissue has a honeycomb-like structure when viewed under a microscope. **Osteoporosis** is a bone disease that affects

Figure 1

The intestinal cells that form the intestine wall are normally held together tightly. The hormone estrogen strengthens this intestinal barrier, keeping the bacteria that can cause disease—and the substances they produce—in the intestine. Low estrogen decreases the tight connections between cells, increasing intestinal permeability. This allows bacteria and the substances they produce to enter the blood and tissues, resulting in inflammation. Inflammation stimulates osteoclast activity, leading to bone destruction. The figure was partly generated using Servier Medical Art, provided by Servier, licensed under a Creative Commons Attribution 3.0 unported license.

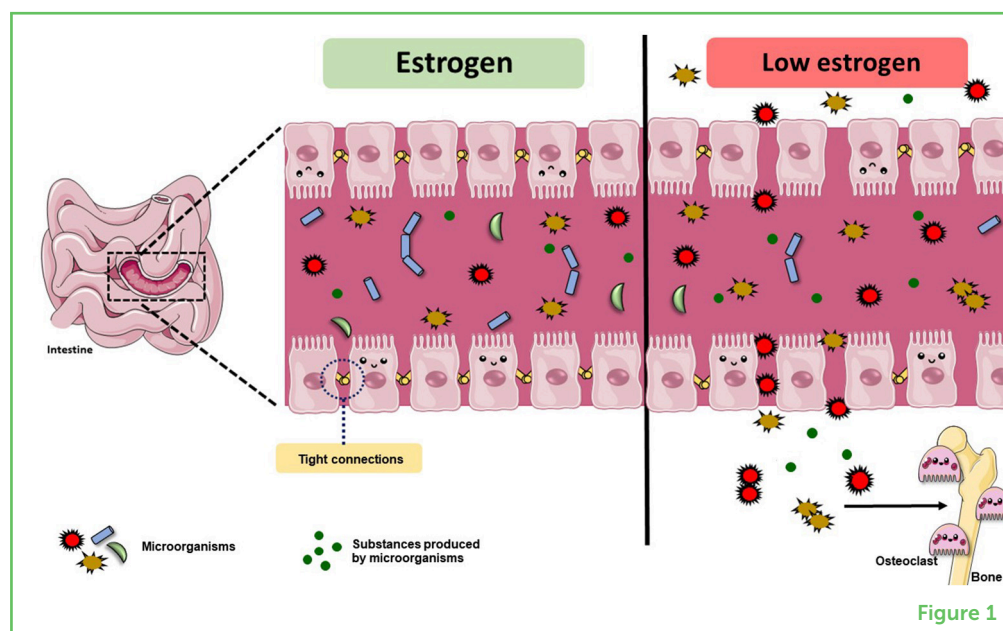


Figure 1

this structure and can cause a severe loss of bone mass, making bones fragile and more likely to break. The word “osteoporosis” means “porous bone,” where “porous” describes a material that has lots of small holes. In osteoporosis, there is an increase in the size of the holes and spaces in the normal honeycomb structure of bones (Figure 2).

Figure 2

Balance between building and breaking down bone, called bone homeostasis, is controlled by the action of cells called osteoclasts, which break down bone, and other cells called osteoblasts, which build bone. Bone homeostasis is important to bone health. Osteoporosis disrupts bone homeostasis, resulting in too much osteoclast activity and resulting in bone destruction, which makes bones fragile and more likely to break. The figure was partly generated using Servier Medical Art, provided by Servier, licensed under a Creative Commons Attribution 3.0 unported license.

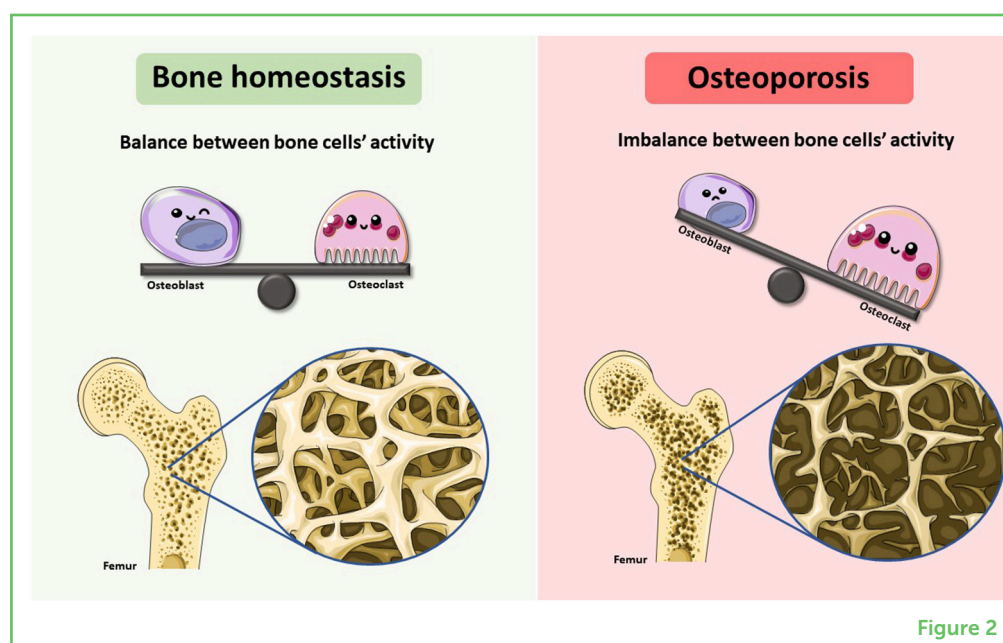


Figure 2

Many things can increase a person’s risk of developing osteoporosis, including aging, not getting enough calcium or vitamin D, not getting enough exercise, smoking, and importantly, hormonal factors. Osteoporosis can occur in both men and women but, as we noted, it happens more commonly in women after menopause. The dramatic

decrease in estrogen levels after menopause is an important factor that increases the risk of osteoporosis in women. In men, the sex hormone testosterone is also important for bone health, but testosterone levels decrease more slowly in men as they age, so they generally have a slower rate of bone loss compared to women.

Medications, hormone replacement therapy, and vitamins are often used to prevent osteoporosis or to treat the disease in postmenopausal women. However, the medications can have unpleasant and even dangerous side effects. Therefore, scientists have been trying to come up with new types of osteoporosis therapy, such as the use of specific bacteria.

WHAT ARE PROBIOTICS?

Bacteria can cause many diseases, but they are also an important part of the body's balance. The gut is home to various helpful microorganisms such as fungi, viruses, and bacteria living together in a community that helps us to digest food and protects us against certain diseases. As researchers learned more about these helpful bacteria, they discovered several types of good bacteria called **probiotics**, which may help to prevent and treat certain diseases, including osteoporosis. When live probiotic bacteria are eaten in adequate amounts, they can improve our health [2]. They are good guys!

Probiotics are the key to the creation of fermented foods and drinks such as yogurt, sauerkraut, cheese, and kombucha. There are records of fermented beverages from as long ago as 700 B.C.E. However, in addition to being found in fermented foods, probiotic bacteria also make up some of the normal, healthy microbes in the gut, mouth, and breast milk of humans and other animals.

Each type of probiotic bacteria can have unique health effects. For example, bacteria that are helpful for gut diseases may not be as helpful against bone diseases, and vice versa. Probiotics have been extensively studied for the treatment of gut diseases, such as inflammatory bowel disease and diarrhea. Recently, researchers have noticed that some probiotic bacteria can also be good for reducing bone loss due to osteoporosis.

HOW CAN PROBIOTICS IMPROVE BONE HEALTH?

Probiotics can reach the gut by being eaten in food or taken as pills or lozenges. Typically, they are not absorbed into the bloodstream. So, how do they affect bone tissue far from the gut? Scientists do not fully understand how this happens yet; however, there are several hypotheses, many of which are still being studied (Figure 3).

PROBIOTICS

Are good live bacteria that may help prevent and treat certain diseases, as well as improve our health.

Figure 3

Probiotics can be consumed through fermented foods and beverages, pills, or lozenges. Once in the gut, some of these good bacteria can help the intestinal cells to stick together more tightly, which stops microorganisms and their products from getting into the blood and tissues, thereby reducing inflammation. In addition, probiotics can help the intestine to absorb calcium, which is critical for bone health. Vitamins B12 and K are produced by some probiotic bacteria and are also associated with bone health. The figure was partly generated using Servier Medical Art, provided by Servier, licensed under a Creative Commons Attribution 3.0 unported license.

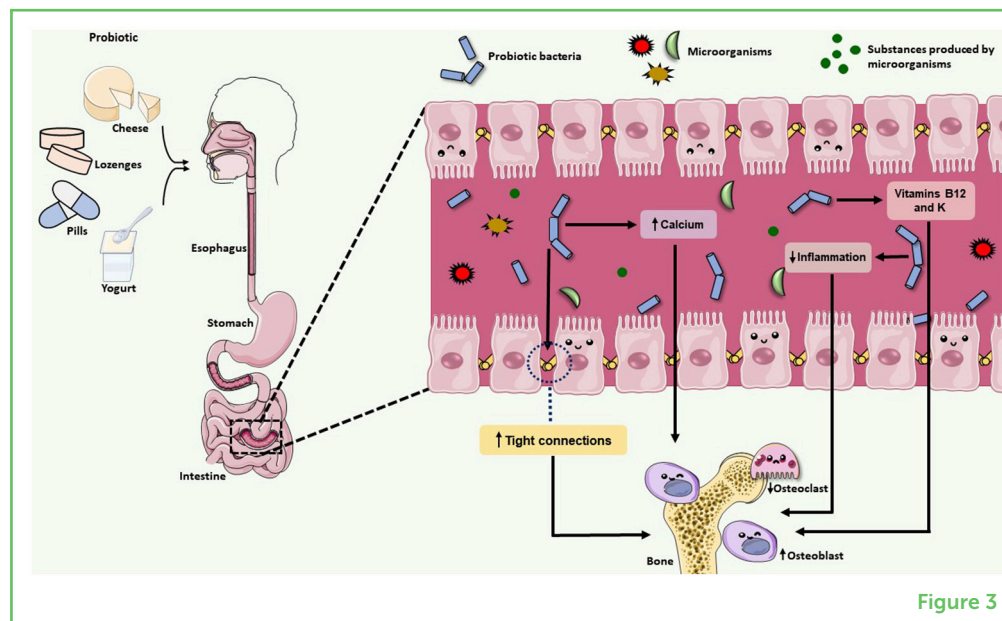


Figure 3

One hypothesis involves the immune system, which has cells and substances that defend the body against dangerous invaders. Sometimes, however, the immune system might be a little *too* active, and that overactivity can cause problems. Some substances produced by the immune system can increase the number and activity of osteoclasts, so if the immune system is too active for too long, too much bone can be broken down. Probiotics can adjust this kind of unbalanced immune reaction, settling it down to a normal level [3], which can decrease excessive osteoclast activity, protecting the bones.

Another hypothesis has to do with intestinal permeability, which we discussed earlier. Probiotics strengthen the gut barrier and prevent the bacteria and microbial products from getting into the bloodstream. This can help to prevent excessive activation of the immune system which, as we just described, can help to keep osteoclasts in check [4].

Finally, another hypothesis suggests that probiotics produce substances that help the intestine to absorb calcium. You have probably heard that calcium is important for healthy bones, so more calcium being absorbed can lead to stronger bones [3]. In addition, some probiotic bacteria produce vitamins B12 and K, which are also associated with bone health.

CONCLUSION

As more and more people live to older ages, osteoporosis is becoming a bigger public health issue. Recently, scientists have discovered that probiotics can help to prevent and fight osteoporosis. The exact

steps by which probiotics help to improve bone health are still being investigated; however, the results so far are encouraging. Probiotics can reduce intestinal permeability, decrease the overactivation of the immune system that can lead to bone loss, and increase the absorption and production of nutrients—all of which improve bone health! It is important for scientists to continue studying the role of probiotics in osteoporosis so that they can find explanations to many unanswered questions. These little puzzle pieces are slowly coming together to form the big picture of how good bacteria can boost bone health. There is much more to learn. Pay attention to future research to see if helpful microbes can beat bone busters!

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YOUNG REVIEWERS



HANIYEH, AGE: 15

Hi, I am Haniyeh. I am 15 years old, and I am drawn to just about anything relating to biology. Animals, humans, insects, and microbes especially have interested me since I was little. In my free time, I like to draw and create art as well.



HRISHIKA, AGE: 14

Hrishika loves to tell jokes. She loves science.



PRIYANKA, AGE: 14

Priyanka loves to draw dragons and is an amazing artist.

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I am a Ph.D. student in the oral biopathology program at the São Paulo State University, Institute of Science and Technology, where I also completed my master's degree. I love working with microorganisms and pathology! When I am not in the lab, I like to travel and experience new cultures.



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I am an undergraduate student in the dentistry program at the São Paulo State University, Institute of Science and Technology. I really love studying pathology and working with scientific research. I also enjoy cooking and traveling.



ANA LIA ANBINDER

I am a professor of oral pathology at the São Paulo State University. I teach undergraduate and graduate students in dentistry, and what I like the most is the sound I hear when a student discovers or understands something new: Ahhhh! When I started studying the effects of probiotics on bones, I found the subject so interesting that I myself made that sound I love. Chocolate and dogs are my other passions!

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