

Ancient Bodies in a Modern World

Many now-common human diseases, such as heart disease, diabetes, and tooth cavities are the result of mismatches between our ancient bodies and our modern environments. One such possible mismatch disease is **osteoarthritis (OA)**. Osteoarthritis is a joint disease that results from a loss of cartilage in the knee joint (**Figure 1**). Cartilage is the flexible and cushioning material found at some joints and other places, such as the tip of your nose and ears. When cartilage is lost around the knee joint, your upper leg bone rubs directly against your lower leg bone, which causes a lot of pain and swelling.

Almost 20% (1 in 5) adults over the age of 45 have OA. While doctors know that individual instances of OA can be sometimes caused by an injury or by increased stress from being overweight, most people with OA aren't overweight and haven't suffered an injury. So what causes it? Until recently, scientists assumed that physical activity over a lifetime wears down the knees, making OA inevitable (impossible to avoid) in old age. However, recently some scientists have shown that this assumption may be incorrect and that it's not a lifetime of activity that causes knee damage, but a lifetime of *in*activity combined with our evolutionary history!

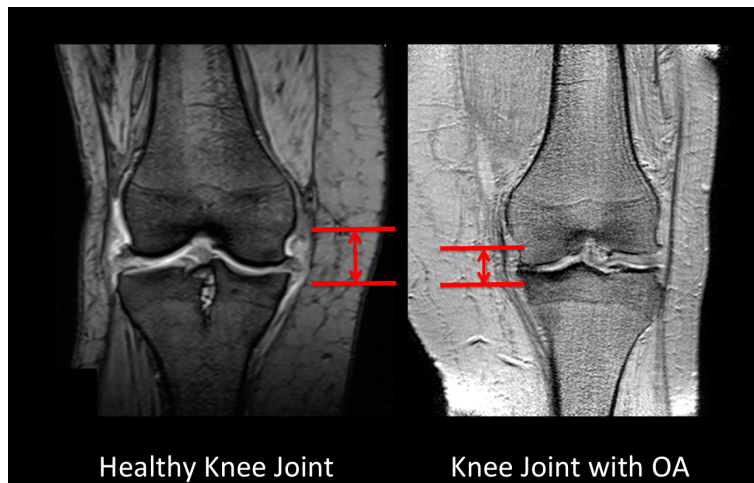


Figure 1. MRI of A Healthy Knee and a Knee with OA. Compare the thickness of the cartilage, marked with a red bracket. The OA knee has a much thinner layer of cartilage than the healthy knee does. OUCH!

Source: Eamon Callison.

A group of researchers were curious about whether or not OA was as common a disease in the past as it is today. But how do we determine whether or not OA was present in human knees hundreds of years ago? It's not like we can ask people from hundreds of years ago if their knees hurt...or can we? To understand whether or not the occurrence of knee OA has changed over time in the United States, the scientists went to museums around the country that had *Homo sapiens* (modern humans like us) skeletons in their collections and looked at their knees. In all, they looked at the knees of more than 2,500 skeletons, meaning they examined more than 5,000 knees!

The researchers categorized the humans they sampled according to when they died based on differences in lifestyles corresponding to different time periods. The oldest skeletons were the prehistoric ones, which came from humans that died between 6,000 and 300 years ago. The youngest skeletons were the post-industrial skeletons from people who died between 1976 and

2015. In between were the early industrial skeletons, which came from humans that died between 1905 and 1940. Scientists diagnosed knee OA by looking for evidence of eburnation, which is when bones get shiny and smooth as a result of grinding against each other after the cartilage has worn away.

Researchers found that across all individuals studied, knee OA was at least twice as common in persons who lived in postindustrial times relative to individuals living in early industrial and prehistoric times (**Table 1**).

Population	Prevalence of OA	
	controlling for biological sex	controlling for age, body mass, and sex
Postindustrial (died 1976–2015)	16%	11%
Early Industrial (died 1905–1940)	6%	5%
Prehistoric (died between 6000–300 years ago)	8%	Cannot be determined

Table 1. Prevalence of OA in Skeletal Samples. When controlling for sex, the prevalence of OA in postindustrial individuals was at least twice as common as in early industrial and prehistoric individuals. The trend holds when also controlling for body mass and age. Age and body mass were impossible to accurately estimate in the prehistoric skeletons, so data controlling for those factors cannot be determined. *Source:* Wallace et al 2017.

You may wonder whether this result is because of gender—women are more likely to have OA than men—maybe the pre-industrial skeletons were mostly female and the pre-industrial ones were mostly male? Nope! The researchers used math and statistics to control for the variable of sex. That means that they accounted for the effect of sex already when they reported their findings. What about the effects of age and body mass? We know that older and heavier people tend to have OA more often than younger and less massive people. Well, the researchers thought of that, too. By controlling for variables such as age and body mass in addition to sex (again by statistically accounting for and removing these variables' effects on the measured data), knee OA in postindustrial individuals was still more than twice as common in post industrial individuals than in early industrial people.

So what could account for the differences the researchers found? You can see in **Figure 2** that at any age, a person living in the postindustrial age is much more likely to have OA than a person living a generation or two earlier. What has changed? The researchers think the answer is: our lifestyles. Prehistoric and early industrial humans were much more active than postindustrial humans. They walked a lot more, were outside more, and spent far less time behind personal computers and televisions (those things weren't even common until the postindustrial age).

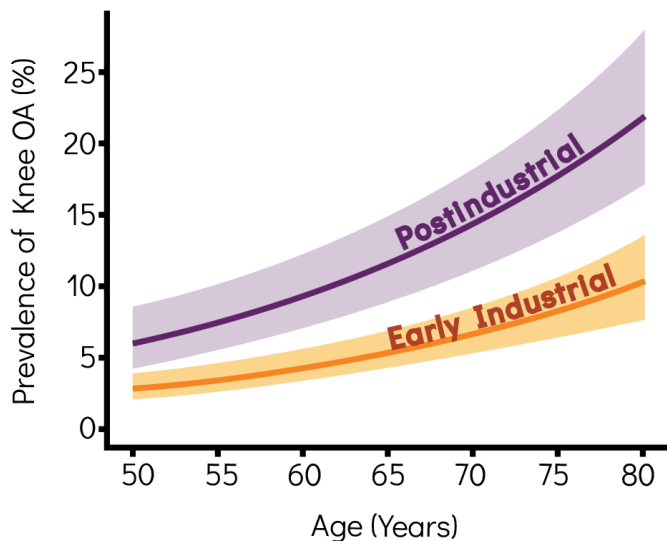


Figure 2. Age-Related Knee OA Rates in Early Industrial and Postindustrial Individuals.

Age-related change in knee OA prevalence *controlling for body mass, sex and ethnicity*. As you can see, while OA prevalence increases with age in both groups, early industrial individuals are much less likely to have OA than postindustrial individuals. *Source: Wallace et al 2017.*

So, while the causes of knee OA are still not fully understood, the most important takeaway from this research is that OA may not be the inevitable result of getting older. Instead, knee OA may be caused by preventable risk factors, like high BMI and physical inactivity, that have become much more common in today's world. From an evolutionary perspective, knee OA might very well be a mismatch disease that is both more common and serious because our bodies are poorly adapted to modern environments.

Reference

Wallace, Ian, Worthington, Steven, Felson, David, Jurmain, Robert, Wren, Kimberly, Majanen, Heli, Woods, Robert, and Daniel Lieberman. 2017. "Knee osteoarthritis has doubled in prevalence since the mid-20th century." *PNAS* 114(35): 9332-9336.

BiteScientist Profiles



Éamon Callison is a student in the Department of Human Evolutionary Biology at Harvard University. For his research, Éamon is interested in investigating the evolution, biomechanics and physiology of the human respiratory system and researching diseases that arise due to 'mismatches' between modern humans and our rapidly changing environments. When not in the lab, he can be found hiking/snowboarding in the White Mountains or rowing on the Charles River in Boston.



Bethany Spinks has been a biology and forensics teacher at Hopkinton High School for 16 years. She is highly interested in bringing real science into her classroom. She particularly enjoys seeing students connect science to their daily lives. In her spare time she loves spending time with her family and playing golf.