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Bone microstructure and the size of your femur

Human bones are often thought to be static tissues because of their hard structure. However, in addition to mineral they also contain collagen. This combination gives your bones flexibility in adapting to exercise. Adult bones can respond to the stress exerted by physical activity through an intricate process of renewal known as remodelling. This process involves teams of highly specialised bone cells that resorb old compromised bone to replace it with new bone. This makes bone a metabolically active and dynamic tissue.

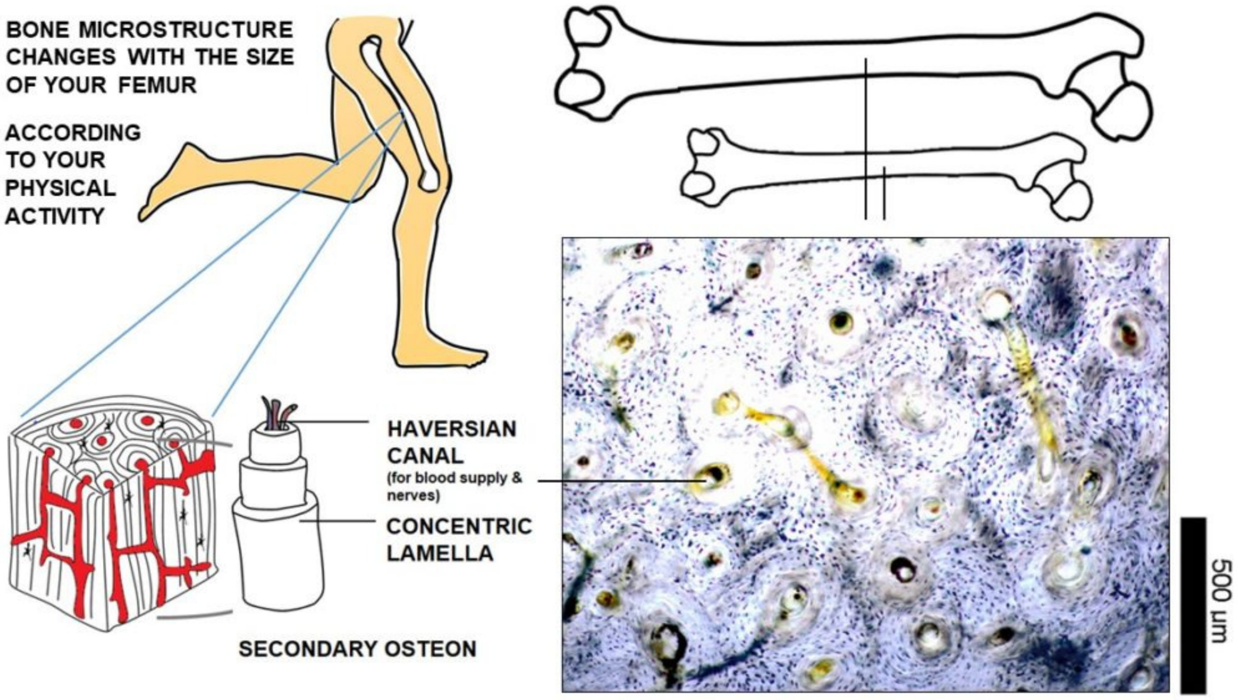

Fig. 1. At the microstructural level, adult cortical bone is composed of secondary osteons which contain a central Haversian canal surrounded by lamellar layers. It also houses osteocyte cells that occupy lacunae cavities (tiny black dots in the bone histology image on the right) and maintain bone when alive.

The thick outermost cortical walls of your thigh bones are tightly packed with microstructural units called secondary osteons that are a product of remodelling. These are tube-like structures formed by groups of osteoblast (bone building) and osteoclast (bone resorbing) cells, that house a central canal to facilitate blood supply. Your bones can “bleed” because of this complex network of vessels and canals, which are surrounded by billions[1] of cells that maintain bone (osteocytes). These osteocytes enable mechanical signals to be transmitted around a bone, and they also exchange nutrients and oxygen. Histologists, scientists who study the microstructure of biological tissues, can take measurements of these osteons and osteocytes to calculate the rate at which bone remodels or the density of osteons and osteocytes. In doing so, this enables them to gain insights into the way bone responds to physical activity, which we call “functional adaptation”.

In our paper, we examined the relationship between the size of adult human thigh bones (femora) and the underlying bone microstructure. We measured these secondary osteon characteristics in hundreds of femora from a medieval English skeletal collection to evaluate if larger thigh bones always have a characteristic microstructure that differs to adults with smaller thigh bones.

Not only is your femur the biggest and longest bone in your whole body, it is an important bone for movement that we use on a daily basis. As it experiences weight bearing and a range of behaviours, it adapts microstructurally to ensure you are equipped with the right amount of bone support. Biological anthropologists often study the femur to reconstruct the degree of physical activity in the human past. Clinicians and bio-scientists examine it to determine whether some of us suffer from decreased bone density that may indicate abnormal bone loss. However, we still do not fully understand how the process of bone remodelling relates to femur size.

Some of us are genetically pre-disposed to have smaller bones, but others develop larger bones. If the size of secondary osteons and osteocyte density increases with bone size, then this challenges simple assumptions about the link between bone remodelling and activity. We tested this question to clarify these relationships, so that bone remodelling research is better informed going forward. We found that thicker and larger femora were actually associated with smaller microstructural features and higher cell densities. This fitted well with current biomechanical principles of engineering beam theory explaining thicker walls in strained bone sites. Therefore, as your bone functionally adapts, its remodelling reflects that. Our findings have also shown that to fully understand the way femoral bone responds to physical activity, histologists need to incorporate bone size into their microstructural research. Our finding will help future studies better understand how femur anatomy relates to its dynamic metabolism at the internal level. Next time you go for a run, remind yourself that it is not only you who is active – your bones are alive as well!

[1]in 2015, Pascal Buenzli & Natalie Sims estimated that there are approximately 42 billion of these in the whole adult human skeleton – see their article in Bone (vol 75, pages 144-150)

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Publication

Histomorphometry and cortical robusticity of the adult human femur.
Miszkiewicz JJ, Mahoney P
J Bone Miner Metab. 2018 Jan 13