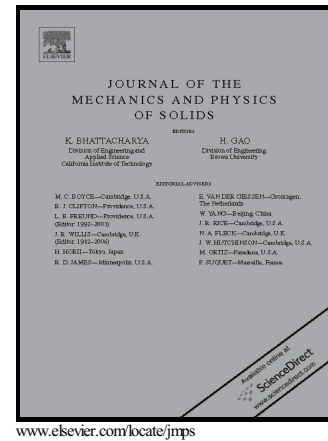


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On the relationship between the dynamic behavior and nanoscale staggered structure of the bone

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ABSTRACT

Bone, a typical load-bearing biological material, composed of ordinary base materials such as organic protein and inorganic mineral arranged in a hierarchical architecture, exhibits extraordinary mechanical properties. Up to now, most of previous studies focused on its mechanical properties under static loading. However, failure of the bone occurs often under dynamic loading. An interesting question is: Are the structural sizes and layouts of the bone related or even adapted to the functionalities demanded by its dynamic performance? In the present work, systematic finite element analysis was performed on the dynamic response of nanoscale bone structures under dynamic loading. It was found that for a fixed mineral volume fraction and unit cell area, there exists a nanoscale staggered structure at some specific feature size and layout which exhibits the fastest attenuation of stress waves. Remarkably, these specific feature sizes and layouts are in excellent agreement with those experimentally observed in the bone at the same scale, indicating that the structural size and layout of the bone at the nanoscale are evolutionarily adapted to its dynamic behavior. The present work points out the importance of dynamic effect on the biological evolution of load-bearing biological materials.

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