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Changing of mechanical properties of bone tissue by loading and unloading hanging

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Studies performed in conditions of a microgravity models and microgravity models with putting on animal's feet. All tests were conducted on nonlinear laboratory rats (180-200 g). As a model of gravitational unloading we used antiorthostatic support model. All experiments were performed according to bioethical standards and were approved by local ethical committee of the Kazan Federal University. The femoral bones were dissected from all tested rats with following weight measurement, density evaluation and measurement of geometrical parameters. At the end, the stress tests with a three-points bending were performed. After testing Young's module an ultimate stress was calculated. It was investigated on different groups: Control, microgravity models for 7 days of unloading hanging and models 7 days of unloading hanging with putting on animal's feet for 3 hour every day. In hypogravitational models Young's module decreased slightly, but ultimate stress decreased significantly. In case of putting on animal's feet Young's module restores its value (deviation about 5%) and ultimate stress increases up to 33% (in comparison with hypogravitational models). Against the background of control group ultimate stress decreased up to 45%. These results emphasize that the bone strength can be decreased by influence of external forces. Biography Maxim Baltin has graduated from the Kazan Federal University with a bachelor degree in Physiology. He has graduated from the Kazan Federal University in the laboratory of motor neuro-rehabilitation.
Indeed, the greatest forces habitually applied to bone arise from muscular contractions, and the past two decades have seen substantial advances in our understanding of how these forces shape bone throughout life. Herein, we also highlight the limitations of in vivo methods to assess and understand bone collagen, and bone mineral at the material or tissue level. The inability to easily measure or closely regulate applied strain in humans is identified, limiting the translation of animal studies to human populations, and our exploration of how components of mechanical loading regimes influence mechanoadaptation.
Keywords: Adaptation, Strain, Magnitude, Rate, Frequency, Load, Tolerance, Injury

Introduction-
Skeletal fragility is directly related to mortality and injury risk, with lower bone strength increasing vulnerability to fracture. Given the incidence and severity of fractures can be minimised through causal prevention (i.e. falls, collision, overload) and/or through prophylactic or remedial intervention (i.e. mechanical, nutritional, pharmacological programs); a thorough understanding of bone strength and its mechanical behaviour under physical load is required. Indeed, the skeleton critically underpins movement and is highly sensitive, responsive and adaptive to its mechanical environment, thus knowledge of the interactions and interplay between bone material and bone structure to deliver bone strength, in addition to the synergy and neutrality of localised muscle mass to modify the behavioural mechanics of bone is of critical interest to clinicians, researchers and physical therapists.
Accrual of bone occurs most rapidly in teenage years,culminating in the third decade of life to achieve peak bone mass, providing practitioners with a considerable opportunity [window of adaptation] to optimise bone accretion and skeletal robustness during maturation and early-stage development. Beyond the evident ceiling of bone mass proliferation, bone strength is also increased through spatially relevant adaptations specific to geometrical rearrangement driven by the mechanical environment, in addition to bone health homeostasis driven by the stochastic and systemic endocrine environment through-out the lifespan (mediated by mechanical inputs).Bone is also hierarchically organised, where structures at macroscopic and microscopic levels co-exist at varying proportions through-out the body to manage (and adapt to) mechanical loads functionally. Bone strength is therefore a sophisticated and multifactorial proposition specific to the complex interplay of macroscopic tissue (trabecular and cortical), material properties (organic and inorganic) and structural properties (geometry and distribution); and is modulated by neighbouring muscle as a key osteogenic stimulant and modifier of mechanical behaviour.

Bone’s rapid and acute desensitisation to anabolic stimulus in response to mechanical loading is governed by a law of diminishing returns, such that received load differs from perceived load. Remarkably small amounts of mechanical stimulation at effective strain thresholds are required to promote osteogenesis prior to a rapid reduction in cellular responsiveness Specifically, ~95% of mechanosensitivity is dampened after only ~20 to 40 loading cycles at physiologic thresholds (~2000 $\mu\varepsilon$ in compression), with almost no discernible osteogenic benefit established beyond ~100 loading cycles within equivalent strain environments, at which point strain volume becomes asymptoticIndeed, the osteogenic relationship between strain volume and mechanosensitivity is fluid, such that a variety of effective strains along the magnitude-frequency continuum will adjust the number of loading cycles experienced prior to rapid sensory suppression. Nevertheless, the existence of a tangible saturation point beyond a given cyclical loading threshold has considerable implications for targeted mechanical loading programs.

Muscle is a potent osteogenic stimulant, routinely exerting contractile force onto the skeleton; the frequency, rate, magnitude and distribution of which provides bone with its primary delivery of mechanical load.Muscle therefore asserts synergistic dominance over bone, such that bone growth or loss is subservient to muscle hypertrophy or atrophy.In this regard, muscle and bone are stoichiometric, co-adapting together in response to anabolic or catabolic stimuli; highlighting the importance of muscle size and strength as trainable features to enhance and protect bone size and strength.

Future directions and conclusion-

Bone is a sophisticated and finely tuned biomaterial; the importance of which cannot be over-stated, as it forms the functional framework for human movement and is directly associated with injury incidence, quality of life and mortality. While bone has been the focus of research for centuries, our comprehensive understanding of the multidimensional and multifactorial components of bone strength and its mechanical behaviour remains elusive, particularly when translating evidence from animal models to humans.

References-

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