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Medical Implications of Developmental Mechanobiology

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Editorial

Mechanobiology is a new discipline of study that straddles the boundaries of biology, engineering, chemistry, and physics. It examines how physical stresses and alterations in cell and tissue mechanical characteristics affect development, cell differentiation, physiology, and disease. Mechanical forces are felt and can be processed by cells to produce biological reactions. Mechanical forces in human tissues include joint movement, compressive pressures on cartilage and bone during exercise, and shear pressure on a blood artery during blood circulation. Understanding mechanotransduction—the molecular mechanisms by which cells receive and respond to mechanical signals—is a fundamental challenge in the science. While traditional medicine has focused on the genetic and biochemical causes of disease, discoveries in mechanobiology imply that changes in the environment may also play a role. Despite its reputation as a new field, mathematical biologist D'Arcy Wentworth Thompson first introduced the concept of mechanobiology more than a century ago. Life forms were imagined to represent physics and mathematical concepts in his book On Growth and Form, published in 1917. Since then, mechanobiologists have worked to turn cell and developmental biology into a quantitative science and technology, which has been aided by the invention and deployment of novel methods such as virtual power theory and random placement machines.

Cells divide into tissues that perform specialised activities, and the embryo is generated through self-assembly. Only chemical signals, it was previously thought, provided cues for spatially oriented changes in cell growth, differentiation, and fate switching that govern morphogenetic regulation. This is due to the chemical's capabilities. During development and from the heart pumping blood flow, forces emerge from and operate on the cardiovascular system. Protein translation regulation by mechanical stimulation, mTOR signalling, endoplasmic reticulum stress, atherosclerosis, and cardiac hypertrophy were all discussed. Following up on the nucleus's cytoskeletal force exertion. Terriac and colleagues characterise and quantify the turnover of vimentin intermediate filament rings, which distort the nucleus during cell spreading. Force exerted on the nucleus can, in fact, cause transcriptional alterations.

As a result, atomic force microscopy was used to study Yap/Taz nuclear translocation, transcription, and mechanotransduction. The efficacy of several mechanical therapies currently in clinical use demonstrates the importance of physical forces in physiological control. This point is shown by a number of cases. Premature newborns benefit from pulmonary surfactant, and adjusting the tidal volumes of mechanical ventilators lowers morbidity and mortality in patients with acute lung damage. Coronary artery constriction is physically prevented with expandable stents. Tissue expanders enlarge the amount of skin that can be used for reconstructive surgery. Bone fracture repair, orthodontics, cosmetic breast expansion, and the closure of non-healing wounds all require surgical tension application devices.

The application of biophysics or biomechanics to understand and interpret biological and physiological activities at various hierarchical levels is at the heart of this burgeoning field of mechanobiology. At the cellular level, this can range from protein complexes and modules that drive cell migration, transmit force through cell adhesions, and transport materials such as ions within and between cells to conformational changes or interactions of proteins that control gene transcription at the molecular level. As a result, these molecular and cellular forces have the ability to shape cells and tissues. The intricate architecture of tissues like the epithelium is determined by the physical and chemical interactions between and among cells, as well as with the surrounding extracellular matrix. It's also how these physical and biological variables are integrated within the body [1-5].

Conflict of Interest

None.

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