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H.E. Takahashi (Ed.)

Mechanical Loading of Bones and Joints

With 154 Figures Including 7 in Color

Springer

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Preface

Bones and joints of both the appendicular and axial skeleton are always under mechanical loading, a key concept for understanding bone metabolism. Each bone of the skeleton has its peculiar shape because of functional adaptation. Osteoporosis and osteoarthritis are the most important and common diseases of bones and joints in the elderly. Because of the unique shape of the spine, dynamic changes in mechanical loading to the spinal column give rise to local problems of content and container—that is, the spinal cord, cauda equina, and vertebrae—resulting in stenosis of the spinal column at the cervical, thoracic, and lumbar levels. Inflammation such as chronic rheumatoid arthritis also results in joint destruction, accelerated by mechanical loading.

This volume contains basic and clinical information about bones and joints, including the spinal column, related to mechanical loading at the tissue, cellular, and molecular levels. The clinical relevance of mechanical loading on bones and joints is provided for clinicians, basic scientists, and engineers. Most of the papers were presented at the 12th annual meeting of the Orthopaedic Research Meeting of the Japanese Orthopaedic Association (Japanese Orthopaedic Research Society) held October 17–18, 1997, in Niigata, Japan. This volume includes the symposia, the instructional course lectures, and other events in this annual meeting. The symposia were titled "Mechanical Loading and Its Regulation on Bone," moderated by Drs. Toshiaki Hara and Toshitaka Nakamura; "Joint Destruction and Its Regulation in Rheumatoid Arthritis," moderated by Drs. Toru Abo and Takahiro Ochi; "Response of the Spinal Cord and Cauda Equina to Dynamic Stress," moderated by Drs. Tetsuya Tamaki and Megumu Yoshimura; and "Advances in Basic Research to Analyze the Pathophysiology of Osteoporosis, Focused on Bone-Forming Cells," moderated by Drs. Hiromichi Norimatsu and Akira Yamaguchi. The special lectures were "From Wolff's Law to the Mechanostat: A New 'Face' of Physiology," by Dr. Harold M. Frost, and "Mechanotransduction and Fuctional Response of the Skeleton to Physical Loads," by Dr. Charles H. Turner.

I am particularly grateful to the staff members of the Department of Orthopedic Surgery and to the alumni of the Orthopedic Department of the Niigata University School of Medicine, especially the former president Dr. Mizuo Nyui and the current president Dr. Naoshi Hayashi. I also thank Ms. Yukino Ikegami and Ms. Tomoko Yuasa, who provided excellent secretarial work and support. Finally, I would like to

thank the staff of Springer-Verlag Tokyo for their patience and continuous efforts in the publication of this book.

Hideaki E. Takahashi
Editor

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Color Plates

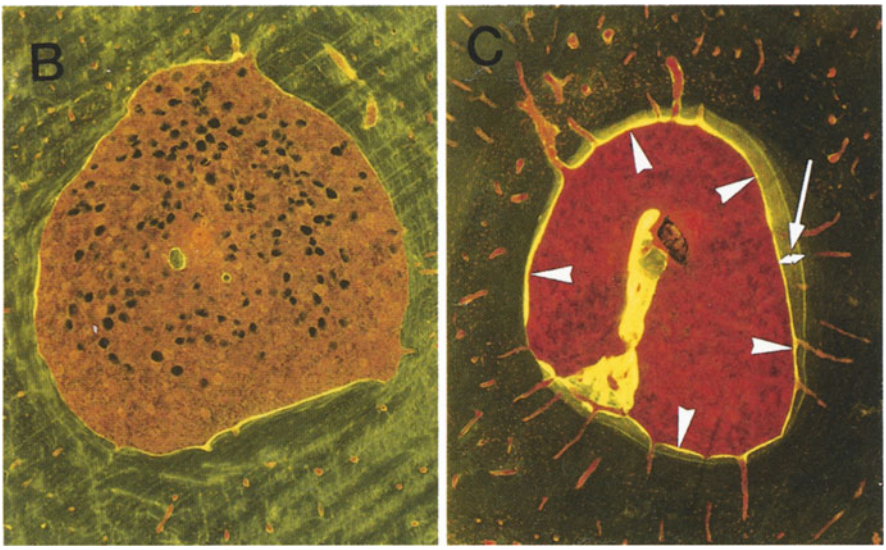
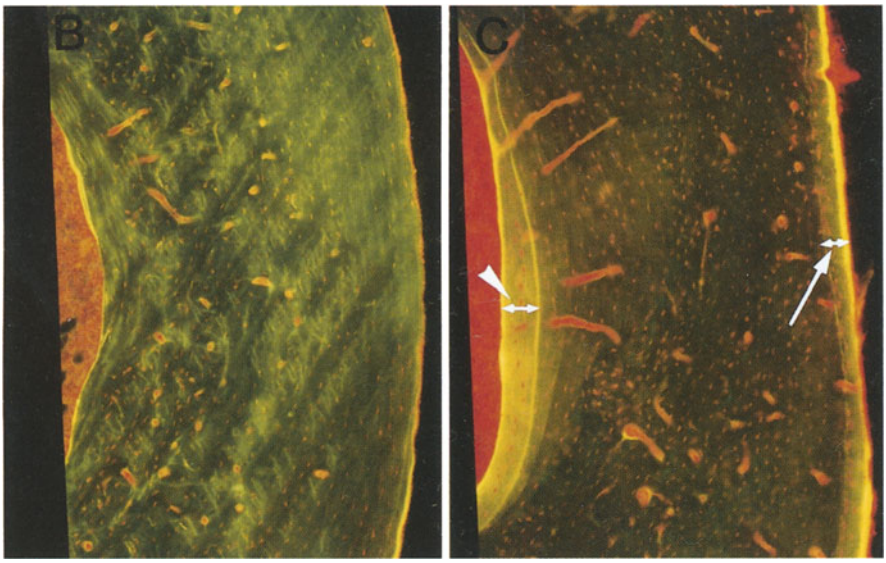


FIG. 2B,C. Fluorescent micrographs of representative endocortical regions of the cross sections of tibial shafts. **B** OVX control animals with vehicle treatment (Group 4). **C** OVX rats with PTH treatment (Group 5). A well-mineralized layer of subendocortical bone (*arrowheads*) can be observed in the PTH-treated tibiae. Virtually 100% of the endocortical surface was labeled with calcein and tetracycline in the PTH-treated OVX rats. In PTH-treated rats, almost visible is the formation draft in the endocortical surface (*arrowheads*). The new endocortical bone (*arrow*) appeared to be well-mineralized bone which is lining the cortex ×40. (*See* page 64)



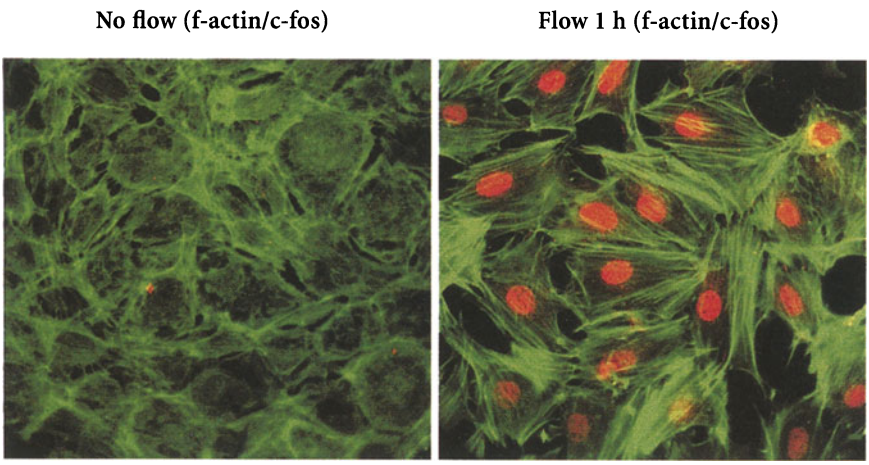


FIG. 7. MC3T3-E1 osteoblasts subjected to fluid shear (12 dynes/cm^2) for 60 min undergo dramatic reorganization of the actin cytoskeleton and express the early response gene c-fos. *Left panel*: Control cells not subjected to flow have poorly organized stress fibers labeled with Texas red-phalloidin (*green*), and expression of c-fos is not present. *Right panel*: Cells subjected to fluid flow for 60 min develop prominent stress fibers labeled with Texas red-phalloidin and demonstrate clear nuclear staining of c-fos protein (*red*). Copyright 1998 by Neil X. Chen, used with permission. (*See* page 88)

FIG. 3B,C. Fluorescent micrographs of periosteal and endocortical surfaces in the tibial shafts: **B**, Group 4; **C**, Group 5. The newly added subperiosteal (*arrow*) and subendocortical bone (*arrowhead*) were added circumferentially, and the new bone was well-mineralized layer bone and thickened the cortex. The faint yellow tetracycline label administered before the initiation of therapy helped to identify the newly formed bone and the previous location of the subendocortical and subperiosteal surfaces (**C**). ×60. (*See* page 64)