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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 Functional 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

Contents

Preface	V
Contributors	XI
Color Plates	XIV

Part 1 Osteoporosis Basic and Clinical Research

The Biomechanical “Face” of Osteoporosis: Emerging Views with Insights from the Utah Paradigm H.M. FROST	3
The Present State and Future Prospects for Bone Mass Measurement M. FUKUNAGA, T. SONE, T. TOMOMITSU, Y. IMAI, R. NOGAMI, N. OTSUKA, K. NAGAI, A. KITAYAMA, and M. ITAYA	13
Anisotropic Behavior in Viscoelasticity and Fracture Mechanics of Compact Bone Y. TANABE	25
Development and Differentiation of Macrophages, Osteoclasts, and Dendritic Cells M. NAITO, G. HASEGAWA, S. ITO, and Y. EBE	35
Histomorphometric and Node-Strut Analysis of Effects of Exercise or Incadronate Disodium on hPTH (1–34)-Induced Bone Mass in Ovariectomized Rats H.E. TAKAHASHI, N. YAMAMOTO, Y. TAKANO, T. MASHIBA, T. TANIZAWA, N. ENDO, T. UCHIYAMA, and A. ITO	43
Human Parathyroid Hormone (1–34) Increases Cortical Bone Mass by Activating Bone Modeling in the Formation Mode in Ovariectomized Rats L. ZHANG, H.E. TAKAHASHI, T. TANIZAWA, N. ENDO, and N. YAMAMOTO.....	57
Osteoporotic Vertebral Pseudarthrosis: Another Instability of the Spine K. HASEGAWA	69

Part 2 Mechanical Loading and Its Regulation in Bone

The Mechanics of Bone Adaptation C.H. TURNER and M.P. AKHTER	79
Biomechanics of Articular Joints: Review of a Decade of Progress of the Niigata Biomechanics Group T. HARA, Y. TANABE, and M. SAKAMOTO	93
Mechanical Unloading and Bone Marrow Cells T. NAKAMURA, K. SAKATA, H. TSURUKAMI, and A. SAKAI	105
Changes in Bone Tissue of Tail-Suspended Rats Y. KODAMA, K. NAKAYAMA, H. FUSE, T. KUROKAWA, T. NAKAMURA, and T. MATSUMOTO	115
Bending Load and Bone Formation Response H. HAGINO, T. OKANO, M. ENOKIDA, H. KISHIMOTO, and K. YAMAMOTO	123
Adaptive Bone Remodeling Under Mechanical Stimuli K. TAKAKUDA	131
Bone Microdamage and Its Repair: Pathophysiology of Bone Fatigue S. MORI	139

Part 3 Joint Destruction and Its Regulation in Rheumatoid Arthritis

The Immune System Under the Regulation of the Autonomic Nervous System T. ABO and S. YAMAMURA	149
Effects of Stem Loosening on Periprosthetic Bone Remodeling After Cementless Hip Replacement T. NISHII, M. TANAKA, N. SUGANO, S. TAMURA, K. OHZONO, and T. OCHI	159
Abnormalities in Bone Marrow of Patients with Rheumatoid Arthritis T. TOMITA, H. HASHIMOTO, E. TAKEUCHI, M. KANEKO, H. TAKANO, K. SUGAMOTO, and T. OCHI	173
Extrathymic Differentiation of Resident T Cells in the Joint and Rheumatoid Arthritis T. HANYU, K. ARAI, and T. ABO	181
Relationship Between HLA-DRB1-DQB1 Haplotypes and the Effect of Chicken Cartilage Soup Containing Type II Collagen on Rheumatoid Arthritis Y. TODA, S. TAKEMURA, T. MORIMOTO, and R. OGAWA	197
Notes on the Disease Mechanism and Genetics of Rheumatoid Arthritis S. SHIOZAWA, H. KAWASAKI, Y. TSUKAMOTO, S. HAYASHI, Y. KONISHI, K. KOMAI, N. MUKAE, E. YAMAMOTO, N. YOSHIKAWA, and K. SHIOZAWA	207

Apoptosis Is a Novel Therapeutic Strategy for RA: Investigations Using an Experimental Arthritis Animal Model
 H. MATSUNO, K. YUDOH, I. MORITA, T. SAWAI, M. UZUKI, T. HASUNUMA, K. NISHIOKA, H. TSUJI, and T. KIMURA 215

Part 4 Response of Spinal Cord and Cauda Equina to Dynamic Stress

Evaluation of Dynamic Stress of the Cervical Spinal Cord Using a High-Resolution Positron Emission Tomography
 H. BABA, Y. MAEZAWA, K. UCHIDA, N. FURUSAWA, Y. KOKUBO, N. SADATO, and Y. YONEKURA 229

Dynamics of Cauda Equina Compression in Lumbar Spinal Stenosis
 K. TAKAHASHI and I. SHIMA 237

Neurophysiological Changes of the Nerve Root Induced by Mechanical Compression
 S. KOBAYASHI, H. YOSHIZAWA, S. NAKAI, and M. NAKAGAWA 245

Compound Muscle Action Potentials Under Dynamic Stress in Lumbar Spinal Canal Stenosis
 Y. FUCHIGAMI, T. ITOH, S. KAWAI, H. ODA, K. KANEKO, H. YONEMURA, H. FUJIMOTO, and M. SHINOHARA 259

Part 5 Human Iliac CFU-F Properties and Potential Uses

Immobilization Osteopenia—Bone Loss After Arthroplastic Surgery
 H. NORIMATSU, S. MORI, and J. KAWANISHI 269

Characterization of Osteoblast Progenitor Cells in Human Iliac Bone Marrow
 N. ENDO, H. YAMAGIWA, S. NISHIDA, K. TOKUNAGA, N. KINTO, T. HAYAMI, T. HORIKOSHI, L. ZHANG, T. TANIZAWA, and H.E. TAKAHASHI 279

Trabecular Bone Turnover and Bone Marrow Capacity for Bone Cells in Immobilization-Related Bone Loss
 A. SAKAI 287

Cbfa1 Is a Master Gene for Osteoblast Differentiation
 T. KOMORI 295

Which Activates Mechanotransduction in Bone—Extracellular Fluid Flow or Mechanical Strain?
 I. OWAN, K. IBARAKI, R.L. DUNCAN, C.H. TURNER, and D.B. BURR 303

X Contents

Bone Resorption Is Inhibited by an Osteocyte-Derived Protein

A. IKEDA, M. AOKI, K. TSURITANI, K. KAMIOKA, K. HIURA, T. MIYOSHI,
H. HARA, and M. KUMEGAWA 311

Keyword Index 317

Contributors

Abo, T. 149, 181
Akhter, M.P. 79
Aoki, M. 311
Arai, K. 181

Baba, H. 229
Burr, D.B. 303

Duncan, R.L. 303

Ebe, Y. 35
Endo, N. 43, 57, 279
Enokida, M. 123

Frost, H.M. 3
Fuchigami, Y. 259
Fujimoto, H. 259
Fukunaga, M. 13
Furusawa, N. 229
Fuse, H. 115

Hagino, H. 123
Hanyu, T. 181
Hara, H. 311
Hara, T. 93
Hasegawa, G. 35
Hasegawa, K. 69
Hashimoto, H. 173

Hasunuma, T. 215
Hayami, T. 279
Hayashi, S. 207
Hiura, K. 311
Horikoshi, T. 279

Ibaraki, K. 303
Ikeda, A. 311
Imai, Y. 13
Itaya, M. 13
Ito, A. 43
Ito, S. 35
Itoh, T. 259

Kamioka, K. 311
Kaneko, K. 259
Kaneko, M. 173
Kawai, S. 259
Kawanishi, J. 269
Kawasaki, H. 207
Kimura, T. 215
Kinto, N. 279
Kishimoto, H. 123
Kitayama, A. 13
Kobayashi, S. 245
Kodama, Y. 115
Kokubo, Y. 229
Komai, K. 207
Komori, T. 295
Konishi, Y. 207
Kumegawa, M. 311

XII Contributors

- Kurokawa, T. 115
- Maezawa, Y. 229
Mashiba, T. 43
Matsumoto, T. 115
Matsuno, H. 215
Miyoshi, T. 311
Mori, S. 139, 269
Morimoto, T. 197
Morita, I. 215
Mukae, N. 207
- Nagai, K. 13
Naito, M. 35
Nakagawa, M. 245
Nakai, S. 245
Nakamura, T. 105, 115
Nakayama, K. 115
Nezuka, T. 215
Nishida, S. 279
Nishii, T. 159
Nisioka, K. 215
Nogami, R. 13
Norimatsu, H. 269
- Ochi, T. 159, 173
Oda, H. 259
Ogawa, R. 197
Ohzono, K. 159
Okano, T. 123
Otsuka, N. 13
Owan, I. 303
- Sadato, N. 229
Sakai, A. 105, 287
Sakamoto, M. 93
Sakata, K. 105
Sawai, T. 215
Shima, I. 237
Shinohara, M. 259
Shiozawa, K. 207
Shiozawa, S. 207
- Sone, T. 13
Sugamoto, K. 173
Sugano, N. 159
- Takahashi, H.E. 43, 57, 279
Takahashi, K. 237
Takakuda, K. 131
Takano, H. 173
Takano, Y. 43
Takemura, S. 197
Takeuchi, E. 173
Tamura, S. 159
Tanabe, Y. 25, 93
Tanaka, M. 159
Tanizawa, T. 43, 57, 279
Toda, Y. 197
Tokunaga, K. 279
Tomita, T. 173
Tomomitsu, T. 13
Tsuji, H. 215
Tsukamoto, Y. 207
Tsuritani, K. 311
Tsurukami, H. 105
Turner, C.H. 79, 303
- Uchida, K. 229
Uchiyama, T. 43
Uzuki, M. 215
- Yamagiwa, H. 279
Yamamoto, E. 207
Yamamoto, K. 123
Yamamoto, N. 43, 57
Yamamura, S. 149
Yonekura, Y. 229
Yonemura, H. 259
Yoshikawa, N. 207
Yoshizawa, H. 245
Yudoh, K. 215
- Zhang, L. 57, 279

Color Plates

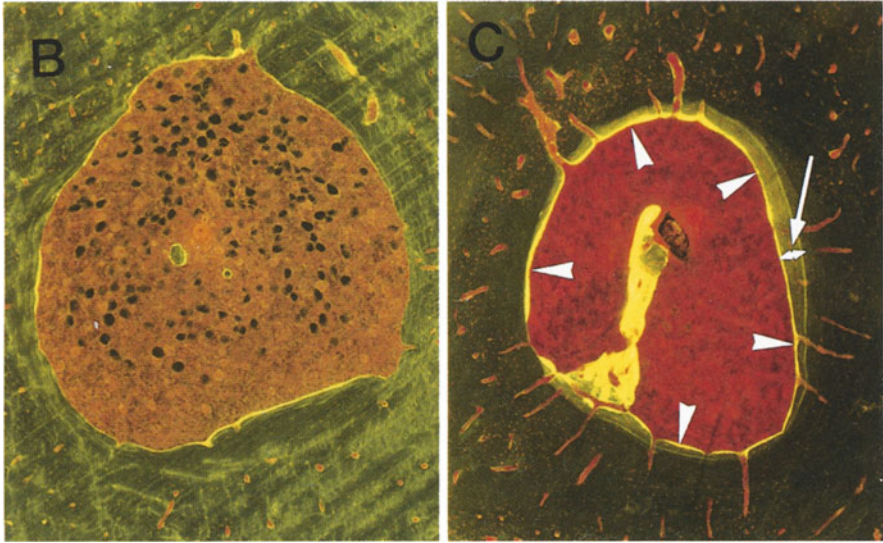
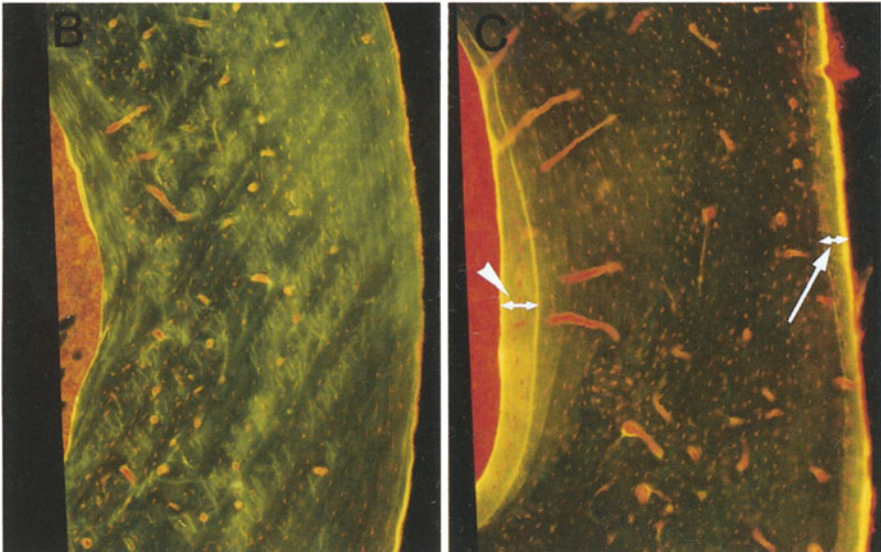


FIG. 2B,C. Fluorescent micrographs of representative endocortical regions of the cross sections of tibial shafts. **B** OVX control animals with vehicle treatment (Group 4). **C** OVX rats with PTH treatment (Group 5). A well-mineralized layer of subendocortical bone (*arrowheads*) can be observed in 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 $\times 40$. (See page 64)



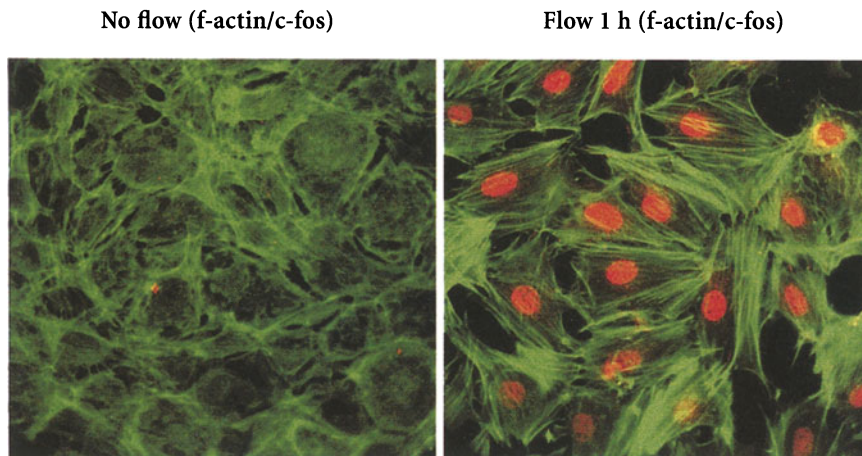


FIG. 7. MC3T3-E1 osteoblasts subjected to fluid shear (12 dynes/cm^2) for 60 min undergo dramatic reorganization of the actin cytoskeleton and express the early response gene *c-fos*. *Left panel*: Control cells not subjected to flow have poorly organized stress fibers labeled with Texas red-phalloidin (*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). $\times 60$. (See page 64)