

- **Foreword** (p. xi)
- **Preface** (p. xiii)
- **Acknowledgments** (p. xv)
- **1 Occupational Biomechanics as a Specialty** (p. 1)
 - **1.1 Definition of Occupational Biomechanics** (p. 1)
 - **1.2 Historical Development of Occupational Biomechanics** (p. 2)
 - **1.2.1 Kinesiological Developments** (p. 4)
 - **1.2.2 Developments in Biomechanical Modeling** (p. 4)
 - **1.2.3 Developments in Anthropometry** (p. 5)
 - **1.2.4 Methods for Evaluating Mechanical Work Capacity** (p. 5)
 - **1.2.5 Developments in Bioinstrumentation** (p. 5)
 - **1.2.6 Developments in Motion Classification and Time Prediction Systems** (p. 5)
 - **1.3 The Need for an Occupational Biomechanics Specialty** (p. 6)
 - **1.3.1 Epidemiological Support for Occupational Biomechanics** (p. 6)
 - **1.3.2 Social and Legal Support for Occupational Biomechanics** (p. 6)
 - **1.3.3 Ergonomic Support for Occupational Biomechanics** (p. 7)
 - **1.4 Who Uses Occupational Biomechanics?** (p. 7)
 - **1.5 Organization of The Book** (p. 8)
 - **Review Questions** (p. 8)
 - **References** (p. 8)
- **2 The Structure and Function of the Musculoskeletal System** (p. 11)
 - **2.1 Introduction** (p. 11)
 - **2.2 Connective Tissue** (p. 11)
 - **2.2.1 Ligaments, Tendons, and Fascia** (p. 11)
 - **2.2.2 Cartilage** (p. 13)
 - **2.2.3 Bone** (p. 13)
 - **2.3 Skeletal Muscle** (p. 17)
 - **2.3.1 The Structure of Muscles** (p. 17)
 - **2.3.2 The Molecular Basis of Muscle Contraction** (p. 19)
 - **2.3.3 The Energy Metabolism of Muscle** (p. 20)
 - **2.3.4 The Nerve Impulse Causing Muscle Contraction** (p. 21)
 - **2.3.5 Mechanical Aspects of Muscle Contraction** (p. 21)
 - **2.3.6 Muscle Fatigue** (p. 25)
 - **2.3.7 Quantification and Prediction of Fatigue** (p. 26)
 - **2.3.8 Age and Gender Sensitivity to Fatigue** (p. 28)
 - **2.3.9 The Action of Muscles** (p. 28)
 - **2.4 Joints** (p. 30)
 - **2.4.1 The Synovial Joint** (p. 30)
 - **2.4.2 Joint Lubrication** (p. 31)
 - **2.4.3 Osteoarthritis** (p. 32)
 - **2.4.4 Intervertebral Discs** (p. 32)
 - **Review Questions** (p. 33)
 - **References** (p. 33)
- **3 Anthropometry in Occupational Biomechanics** (p. 37)
 - **3.1 Measurement of Physical Properties of Body Segments** (p. 37)
 - **3.1.1 Body-segment Link Length Measurement Methods** (p. 37)

- **3.1.2 Body-segment Volume and Weight** (p. 39)
- **3.1.3 Body-segment Locations of Center of Mass** (p. 40)
- **3.1.4 Body-segment Inertial Property Measurement Methods** (p. 42)
- **3.2 Anthropometric Data for Biomechanical Studies in Industry** (p. 45)
- **3.2.1 Segment Link Length Data** (p. 45)
- **3.2.2 Segment Weight Data** (p. 46)
- **3.2.3 Segment Mass-center Location Data** (p. 48)
- **3.2.4 Segment Moment-of-Inertia and Radius-of-Gyration Data** (p. 48)
- **3.3 Summary of Anthropometry in Occupational Biomechanics** (p. 49)
- **Review Questions** (p. 49)
- **References** (p. 51)
- **4 Mechanical Work Capacity Evaluation** (p. 53)
- **4.1 Introduction** (p. 53)
- **4.2 Joint Motion: Methods and Data** (p. 53)
- **4.2.1 Methods of Measuring Joint Motion** (p. 54)
- **4.2.2 Normal Ranges of Joint Motion** (p. 56)
- **4.2.3 Factors Affecting Range-of-Motion Data** (p. 57)
- **4.3 Muscle Strength Evaluation** (p. 58)
- **4.3.1 Definition of Muscular Strength** (p. 58)
- **4.3.2 Static and Dynamic Strength-Testing Methods** (p. 60)
- **4.3.3 Population Muscle Strength Values** (p. 64)
- **4.3.4 Personal Factors Affecting Strength** (p. 68)
- **4.4 Summary and Limitations of Mechanical Work-Capacity Data** (p. 70)
- **Review Questions** (p. 71)
- **References** (p. 71)
- **5 Bioinstrumentation for Occupational Biomechanics** (p. 75)
- **5.1 Introduction** (p. 75)
- **5.2 Human Motion Analysis Systems** (p. 75)
- **5.2.1 Basis for Measuring Human Motion** (p. 75)
- **5.3 Muscle Activity Measurement** (p. 84)
- **5.3.1 Applied Electromyography** (p. 84)
- **5.3.2 Mechanomyography** (p. 88)
- **5.3.3 Intramuscular Pressure** (p. 88)
- **5.4 Muscle Strength Measurement Systems** (p. 89)
- **5.4.1 Localized Static Strength Measurement Systems** (p. 89)
- **5.4.2 Whole-Body Static Strength Measurement System** (p. 90)
- **5.4.3 Whole-Body Dynamic Strength Measurement System** (p. 91)
- **5.5 Intradiscal Pressure Measurement** (p. 91)
- **5.5.1 Measurement Concept** (p. 91)
- **5.5.2 Intradiscal Pressure Measurement System** (p. 92)
- **5.5.3 Applications and Limitations in Occupational Biomechanics** (p. 93)
- **5.6 Intra-Abdominal (Intragastric) Measurements** (p. 93)
- **5.6.1 Measurement Development** (p. 93)
- **5.6.2 Measurement System** (p. 93)
- **5.6.3 Applications and Limitations in Occupational Biomechanics** (p. 94)
- **5.7 Seat Pressure Measurement Systems** (p. 95)

- **5.8 Stature Measurement System** (p. 97)
- **5.9 Force Platform System** (p. 97)
- **5.10 Foot and Hand Force Measurement System** (p. 98)
- **5.11 Measurement of Vibration in Humans** (p. 99)
- **Review Questions** (p. 100)
- **References** (p. 100)
- **6 Occupational Biomechanical Models** (p. 109)
- **6.1 Why Model?** (p. 109)
- **6.2 Planar Static Biomechanical Models** (p. 110)
 - **6.2.1 Single-body-segment Static Model** (p. 110)
 - **6.2.2 Two-body-segment Static Model** (p. 113)
 - **6.2.3 Static Planar Model of Nonparallel Forces** (p. 115)
 - **6.2.4 Planar Static Analysis of Internal Forces** (p. 116)
 - **6.2.5 Multiple-Link Coplanar Static Modeling** (p. 119)
- **6.3 Three-Dimensional Modeling of Static Strength** (p. 121)
- **6.4 Dynamic Biomechanical Models** (p. 124)
 - **6.4.1 Single-segment Dynamic Biomechanical Model** (p. 124)
 - **6.4.2 Multiple-segment Biodynamic Model of Load Lifting** (p. 126)
 - **6.4.3 Coplanar Biomechanical Models of Foot Slip Potential While Pushing a Cart** (p. 128)
- **6.5 Special-Purpose Biomechanical Models of Occupational Tasks** (p. 130)
 - **6.5.1 Low-back Biomechanical Models** (p. 130)
 - **6.5.2 Biomechanical Models of the Wrist and Hand** (p. 146)
 - **6.5.3 Modeling Muscle Strength** (p. 150)
- **6.6 Future Developments in Occupational Biomechanical Models** (p. 153)
- **Review Questions** (p. 154)
- **References** (p. 155)
- **7 Methods of Classifying and Evaluating Manual Work** (p. 161)
- **7.1 Traditional Methods** (p. 161)
 - **7.1.1 Historical Perspective** (p. 161)
- **7.2 Traditional Work Analysis System** (p. 163)
 - **7.2.1 MTM: An Example of a Predetermined Motion-Time System** (p. 163)
 - **7.2.2 Benefits and Limitations in Contemporary Work Analysis Systems** (p. 165)
- **7.3 Contemporary Biomechanical Job Analysis** (p. 166)
 - **7.3.1 Identification of Musculoskeletal Injury Problems** (p. 166)
 - **7.3.2 Analyzing Biomechanical Risk Factors** (p. 168)
 - **7.3.3 Specialized Biomechanical Risk Factor Evaluation** (p. 170)
 - **7.3.4 Emgs in Job Evaluation** (p. 179)
- **7.4 Future Impact of Occupational Biomechanics on Work Analysis Systems** (p. 179)
- **Review Questions** (p. 180)
- **References** (p. 181)
- **8 Manual Material-Handling Limits** (p. 183)
 - **8.1 Introduction** (p. 183)
 - **8.2 Lifting Limits in Manual Material Handling** (p. 184)
 - **8.2.1 Scope of NIOSH Work Practices Guide for Manual Lifting** (p. 186)

- **8.2.2 Basis and Structure of the 1994 NIOSH-Recommended Weight-Lifting Limit** (p. 187)
- **8.2.3 Example of NIOSH RWL Procedure** (p. 188)
- **8.2.4 Comments on the Status of the NIOSH Lifting Guide** (p. 189)
- **8.2.5 Alternative Recommendations for Evaluating Manual Lifting Tasks** (p. 190)
- **8.3 Pushing and Pulling Capabilities** (p. 191)
- **8.3.1 Foot-slip Prevention During Pushing and Pulling** (p. 193)
- **8.4 Asymmetric Load Handling** (p. 194)
- **8.4.1 Toward a Comprehensive Manual Material-Handling Guide** (p. 197)
- **8.5 Recommendations for Improving Manual Material-Handling Tasks** (p. 198)
- **8.6 Summary of Manual Material-handling Recommendations and Evaluation Methods** (p. 202)
- **Review Questions** (p. 203)
- **References** (p. 203)
- **9 Guidelines for Work in Sitting Postures** (p. 207)
- **9.1 General Considerations Related to Sitting Postures** (p. 207)
- **9.2 Anthropometric Aspects of Seated Workers** (p. 209)
- **9.3 Comfort** (p. 211)
- **9.4 The Spine and Sitting** (p. 211)
- **9.4.1 Clinical Aspects of Sitting Postures** (p. 211)
- **9.4.2 Radiographic Data** (p. 212)
- **9.4.3 Disc Pressure Data During Sitting** (p. 213)
- **9.4.4 Muscle Activity** (p. 214)
- **9.4.5 Sitting Postures and The Spine** (p. 216)
- **9.5 The Shoulder and Sitting** (p. 216)
- **9.6 The Legs and Sitting** (p. 217)
- **9.7 The Sitting Workplace** (p. 218)
- **9.7.1 The Office Chair** (p. 218)
- **9.7.2 The Table in a Seated Workplace** (p. 221)
- **9.7.3 Visual Display Terminal Workstations** (p. 222)
- **9.8 Summary** (p. 223)
- **Review Questions** (p. 223)
- **References** (p. 223)
- **10 Biomechanical Considerations in Machine Control and Workplace Design** (p. 227)
- **10.1 Introduction** (p. 227)
- **10.1.1 Localized Musculoskeletal Injury in Industry** (p. 227)
- **10.2 Practical Guidelines for Workplace and Machine Control Layout** (p. 231)
- **10.2.1 Structure-Function Characteristics of the Shoulder Mechanism** (p. 231)
- **10.2.2 Shoulder-Dependent Overhead Reach Limitations** (p. 234)
- **10.2.3 Shoulder- and Arm-Dependent Forward Reach Limits** (p. 235)
- **10.2.4 Neck-Head Posture Work Limitations** (p. 239)
- **10.2.5 Torso Postural Considerations In Workbench Height Limitations** (p. 241)
- **10.2.6 Biomechanical Considerations In The Design Of Computer Workstations** (p. 242)
- **10.3 Summary** (p. 243)

- **Review Questions** (p. 244)
- **References** (p. 244)
- **11 Hand-Tool Design Guidelines** (p. 249)
 - **11.1 The Need for Biomechanical Concepts in Design** (p. 249)
 - **11.2 Shape and Size Considerations** (p. 251)
 - **11.2.1 Shape for Avoiding Wrist Deviation** (p. 251)
 - **11.2.2 Shape for Avoiding Shoulder Abduction** (p. 252)
 - **11.2.3 Shape to Assist Grip** (p. 253)
 - **11.2.4 Size of Tool Handle to Facilitate Grip** (p. 254)
 - **11.2.5 Finger Clearance Considerations** (p. 255)
 - **11.2.6 Gloves** (p. 256)
 - **11.3 Hand-Tool Weight and Use Considerations** (p. 256)
 - **11.4 Force Reaction Considerations in Powered Hand-Tool Design** (p. 257)
 - **11.5 Keyboard Design Considerations** (p. 258)
 - **11.5.1 Posture Stress** (p. 259)
 - **11.5.2 Keying Exertion Force Repetition** (p. 259)
 - **11.6 Summary** (p. 260)
- **Review Questions** (p. 260)
- **References** (p. 260)
- **12 Guidelines for Whole-Body and Segmental Vibration** (p. 265)
 - **12.1 Definitions and Measurement** (p. 265)
 - **12.1.1 Definitions** (p. 265)
 - **12.1.2 Measurement of Vibration** (p. 267)
 - **12.2 General Effects of Vibration on Human Beings** (p. 269)
 - **12.3 Whole-Body Vibration** (p. 269)
 - **12.3.1 Effects of Low-Frequency Vibration** (p. 269)
 - **12.3.2 Effects of Middle-Frequency Vibration** (p. 270)
 - **12.3.3 Biomechanical Effects on the Spine** (p. 272)
 - **12.3.4 Physiological Responses** (p. 273)
 - **12.4 Hand-Arm Vibration** (p. 274)
 - **12.4.1 Transmission of Vibration in the Upper Extremity** (p. 274)
 - **12.4.2 Hand-Arm Vibration Syndrome** (p. 275)
 - **12.5 Sensorimotor Effects** (p. 276)
 - **12.6 Vibration Exposure Criteria** (p. 278)
 - **12.6.1 Whole-Body Vibration Recommendations** (p. 278)
 - **12.6.2 Hand-Arm Vibration Recommendations** (p. 279)
 - **12.7 Control and Prevention** (p. 280)
- **Review Questions** (p. 280)
- **References** (p. 281)
- **13 Worker Selection, Training, and Personal Protective Device Consideration** (p. 285)
 - **13.1 Worker Selection** (p. 285)
 - **13.1.1 Introduction To Worker Selection** (p. 285)
 - **13.1.2 History And Physical Examination** (p. 288)
 - **13.1.3 Radiographic Preplacement Examination** (p. 289)
 - **13.1.4 Quantitative Physical Preplacement Screening** (p. 289)

- **13.2 Preplacement Training** (p. 291)
- **13.2.1 General Content of Training** (p. 291)
- **13.2.2 How Workers Should Be Trained** (p. 293)
- **13.3 Biomechanical Aspects of Back Belts** (p. 294)
- **13.3.1 Passive Stiffness Effects of Back Belts** (p. 294)
- **13.3.2 Abdominal Pressure Effects of Back Belts** (p. 295)
- **13.3.3 Reduced Torso Mobility Effects Due to Back Belts** (p. 296)
- **13.4 Job Rotation and Psychosocial Stress** (p. 296)
- **13.5 Summary** (p. 297)
- **Review Questions** (p. 297)
- **References** (p. 297)
- **14 Summary** (p. 301)
- **References** (p. 303)
- **Appendix A** (p. 305)
- **Part 1 Anatomical and Anthropometric Landmarks as Presented by Webb and Associates** (p. 305)
- **Part 2 Glossary of Anatomical and Anthropometric Terms** (p. 308)
- **Appendix B Population Weight and Mass-Center Data** (p. 313)
- **Table B.1 Segment Weight Values Derived from Regression Equations Using Total Body Weight as the Independent Variable** (p. 314)
- **Table B.2 Anatomical Location of Segment Centers of Gravity (Center of Mass)** (p. 315)
- **Table B.3 Segment Moments of Inertia** (p. 316)
- **Table B.4 Joint Center Locations and Link Definitions** (p. 317)
- **Appendix C Terms and Units of Measurement in Biomechanics** (p. 319)
- **Appendix D NIOSH 1994 Tables** (p. 331)
- **Appendix E Push and Pull Fore Tables** (p. 335)
- **Appendix F Data Gathering-Job Risk Factors** (p. 337)
- **Appendix G Some General Web Sites that Complement References in Text** (p. 349)
- **Index** (p. 351)