SECOND EDITION

Biomechanics of Human Movement

Marlene J. Adrian
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Biomechanics of Human Movement

To Charlianna Cooper, from both of us

FOREWORD

Little did Aristotle, the acknowledged father of kinesiology, realize where his practical observations on animal locomotion and human performance would lead. The study of biomechanics, as we know it today, is based on his work and those whose curiosity led them to follow in his footsteps. Those footsteps have led to what the present biomechanists consider to be the major purpose of biomechanics. That purpose is to scientifically analyze the techniques involved in the performance of human movement skills. It allows one to look at movement in terms of space, time, and direction (kinematics), or in terms of the forces responsible for causing motion (kinetics). Further, it allows one to examine the environment in which the movement is performed. No matter whether the movement is a daily movement task or whether the movement is a sport-related skill, the joy and satisfaction of performance occurs when it is done correctly, effortlessly, and safely.

When the first edition of this text was written, the 1988 Olympic Games had just been completed. Nowhere was the importance of biomechanics more evident. For the athletes and coaches, the very motto of the Olympics, *"Citius, Altius, Fortius"*—Swifter, Higher, Stronger—, implied a reliance on the knowledge inherent in the field of biomechanics. Their goal was to compete in an event in the most effective and efficient manner possible. While this book was in revision, another Olympic Games passed. Performances were even better than the previous Olympic Games, with World and Olympic records being broken. The goal of all athletes in the Olympics was to be the best that they could be. Achieving these goals could not have been possible without the advances in the field of the sport sciences, among them biomechanics.

In a sense, Adrian and Cooper have used the motto of the Olympics as their guiding theme in writing this revised text. The first edition of the text provided a comprehensive exploration of every aspect of human movement and biomechanics. They provided the background material for understanding movement effectiveness and efficiency. However, just as the athletes from one Olympics to another strived to improve the quality of their performances, the authors also strived to improve the quality of their text. They reorganized sections of the text for better clarity, strengthened some of the material on basic biomechanical concepts, and added new information to the application section.

This text represents one of the most comprehensive undertakings in the writing of texts for biomechanics. It covers almost every aspect involved in the living human body. For the teacher or student in biomechanics, the text provides a blend of theory and practice. Learning is

enhanced with motivational tools, such as mini-laboratory learning experiences, and excellent illustrations, tables, and graphs.

Adrian and Cooper long have been recognized as pioneers and leaders in the field of biomechanics. Their experience and wealth of knowledge have added to the value of this text. There is no doubt that they will take their place in history along with the others who have so ably promoted the study of human movement. Their enthusiasm for the field is contagious and their dedication to the field second to none.

Carole J. Zebas, P.E.D.
Past Chair, Kinesiology Academy
Past President, CSC-ACSM

PREFACE

This edition has been revised to provide the ideas, concepts, and facts for today's students of biomechanics that will enable them to adapt to changing technology, changing social demographics, and the unknown requirements of the future. This book is based on the premise that facts of today may not be facts of tomorrow. But we hope that our presentation of ideas and diversity of perspectives will provide the foundation for adapting to and optimizing our tomorrows.

New Knowledge

As we have repeatedly seen in the past, the introduction of new techniques of analysis result in new knowledge. For example, the electron microscope "saw" new information about bone morphology and the telescope "saw" errors in our thinking about the planets Pluto and Saturn. As we explored the world of kinanthropometry, we came to realize why tall golfers use the predominance of arm actions when they hit a golf ball and shorter golfers emphasize the actions of the trunk. We also see shot putters, especially shorter athletes, using a discus-style turn when putting the shot. New perspectives and greater interrelationships of a multiplicity of factors must be woven into existing knowledge. This we have tried to do in this volume.

Diversity

The amount of material is certainly more than might be discussed in one semester of class meetings. But students and teachers should not be hampered because of the size of this book. Books such as this one are resources to stimulate discussion among students and between students and teachers. The large amount of material is vital to enable students to learn the broad scope of biomechanics and all its applications. Our educational objective is to teach to the diversity of our students. Each student has unique prior experiences. Each has unique objectives and will select a vocational career that will require different aspects of biomechanics. Each student is also endowed with uniquely different cultural and familial backgrounds. With this book, we have tried to provide for the diversity and individuality of our readers. We hope it includes areas of study that will be exciting and motivating to every reader.

Suggestions on Using the Book

This book is designed to be nontraditional, although it can be used in a traditional manner. Since no two classes of students are alike, the order of presentation of material may differ from class to class. We envisage that graduate or second-course level students might wish to

start with Chapters 7 and 8 to study movement analysis. Some teachers may wish to begin with Chapter 24 as a motivating beginning; others will use it as the final session of a class to stimulate thinking for postcollege applications. An idea mentioned in one chapter may be further explored in one or more sections of the book. As the need arises, the student can explore the same concept from several perspectives, or choose to acquire only the basics. The teacher, therefore, can assign a portion of a chapter together with an application from another chapter, and recommend optional sections to read on the same general topic. It is not necessary to read the same number of pages or the same number of chapters for each successive class session. Some material is more difficult or less familiar than other material. Moreover, what is familiar to one student may not be familiar to another student.

Instructor's Manual

We would also mention that the instructor's manual is designed to provide hints for teachers in selecting appropriate key concepts, discussion topics, objectives, evaluation materials, and mini-laboratory experiences. The latter include mathematical problem-solving tasks. Some of the material is photocopy-ready for transparency displays on overhead projectors. The instructor's manual is a resource for the teachers to further enhance learning and provide additional experiences of biomechanical topics, emphasizing the problem-solving analysis approach.

Varied Presentations

The general format of the book is consistent throughout, but we believe that some variation in the presentation of material is refreshing to the student. Therefore, we have not followed a standardized style of writing. The freedom of presentation of ideas from new perspectives seems to be somewhat inconsistent, but we view it as providing the reader with one unique "feel" of each topic. This decision is congruous with the belief that change is inherently valuable for education and that the students of today are a diverse group.

Changes in This Edition

Adrian and Cooper acknowledge the pioneers' work, specifically that of Lawrence Morehouse and Ruth Glassow who wrote with us on previous editions of *Biomechanics of Human Movement*. Morehouse should be cited for his insight into the value of biomechanics as it related to sports. Glassow's pioneer work involved the synthesis of theory and application to the study of human movement. We are grateful for their outstanding foresights. We also are grateful for the contributions of those who contributed to the previous edition. We also acknowledge the many experts in biomechanics, teaching, coaching, therapy, anatomy, and related fields who have contributed to this edition.

Contributors are a Unique Source of Strength

One of the unique features of our book is the valuable insights and knowledge presented by our contributors. They have enabled us to continue to provide our readers with application concepts, knowledge, and issues in a wide spectrum of movement environments. We include a multitude of sports, activities of daily living, music and other arts, occupational tasks, rehabilitation, exercise, and developmental movement patterns. Thus, with this new edition, we have again presented a comprehensive textbook of biomechanics of human movement. This book continues to have the most complete description of analysis techniques, instrumentation systems, and methods of displaying and interpreting data in the field.

New Topics

New sports topics include soccer, team handball, and wrestling. Sections of many of the chapters have been expanded, and new research findings have replaced outdated material. We have particularly expanded the information on dance movements, dysfunctional patterns of disabled people, aging patterns, cycling, and exercise. Some sections have been rearranged and/or merged with others. All sections have been revised extensively.

Organization

The format has been redefined to include the highlighting of key concepts in each section and topics for discussion and movement pattern analysis. The material in the book's sections is consistent with Kinesiology Academy Guidelines, but goes far beyond these requirements.

The book consists of six parts:

Part I. Basic Biomechanical Concepts

Part II. Tools for Human Movement Analysis

Part III. Movements Across the Entire Spectrum of Life

Part IV. Sports Movements on Land

Part V. Sports Movements in Air, Ice, Snow, and Water Environments

Part VI. The Future

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