BIOMECHANICS AND BIOLOGY OF MOVEMENT

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Biomechanics and Biology of Movement

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Human Kinetics

Library of Congress Cataloging-in-Publication Data

Biomechanics and biology of movement / [edited by] Benno M. Nigg, Brian R. MacIntosh, Joachim Mester.
p. cm.
Includes bibliographical references and index.
ISBN 0-7360-0331-2
1. Human mechanics. 2. Human locomotion. 3. Exercise--Physiological aspects. 4. Energy metabolism. I. Nigg, Benno Maurus. II. MacIntosh, Brian R., 1952- III. Mester, J. (Joachim)

QP303 .B56836 2000
612.7'6--dc21 99-059795

ISBN-10: 0-7360-0331-2
ISBN-13: 978-0-7360-0331-5

Acquisitions Editor: Loarn D. Robertson, PhD; **Managing Editor:** Cynthia McEntire; **Assistant Editor:** John Wentworth; **Copyeditor:** Judy Peterson; **Proofreader:** Pamela S. Johnson; **Indexer:** Marie Rizzo; **Permission Manager:** Cheri Banks; **Graphic Designer:** Nancy Rasmus; **Graphic Artist:** Kathleen Boudreau-Fuoss; **Cover Designer:** Jack W. Davis; **Printer:** Sheridan Books

Printed in the United States of America

10 9 8 7 6 5 4 3 2

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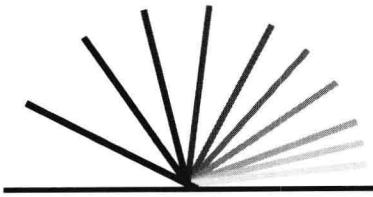

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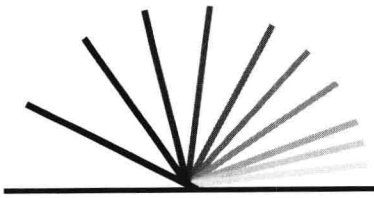

Introduction

B.M. Nigg, B.R. MacIntosh, and J. Mester

The life of an average member of civilized society has changed substantially over the last two centuries. About 100 to 200 years ago, most daily activities were associated with movement and physical activity. Today, at the beginning of the third millennium, most professional occupations are sedentary. Most people in the developed countries have minimal daily physical activity, and computers and television dominate the lives of many members of today's society. Most people have a substantial amount of leisure time available. Some use it for physical activities. They enjoy the outdoors or are engaged in daily workout routines. However, the majority of people in the developed countries are not physically fit. Many people are overweight and have only limited mobility. With the increasing life expectancy afforded by health care, mobility and longevity have become some of the most precious aspects of life. Thus, human movement, exercise, and sport have developed in the 20th century into important lifestyle options.

Parallel to this development, science that deals with human movement, exercise, and sport has become increasingly important. The number of scientists from many different disciplines concentrating on researching movement, exercise, and sport is still increasing. These scientists attempt to understand (a) the functioning of the human body as it relates to movement, exercise, and sport, (b) biological responses to force stimuli, (c) how to prolong mobility for all age groups, and (d) how to improve performance, whether in sport, in the work place, or during a walk. They work together to solve these important questions, which are relevant for the well-being of humankind.

Scientific disciplines dealing with human movement, exercise, and sport include anatomy, biochemistry, biomechanics, neurosciences, and physiology. Textbooks dealing with aspects of movement, exercise, and sport typically discuss discipline-related aspects. Titles such as *The Biomechanics of Sports Techniques* (Hay 1978), *The Physiology of Joints* (Kapandji 1970), *Functional Anatomy in Sports* (Weineck 1986), or *Biomechanics of Sports* (Vaughan 1989) are typical examples of such publications. They are discipline driven and lack approaches where the multidisciplinary question of interest drives the method(s) of inquiry. However, human life is not discipline oriented. Human life is exposed daily to practical questions, which ask for an answer. Topics that are important for movement, exercise, and sport include work and energy, balance and control of human movement, load and excessive load during movement and exercise, and fatigue during exercise.

Work and energy aspects are important for an athlete running a marathon, a soccer player participating in a three-week tournament, a mountaineer who wants to climb Mount Everest, or a speed skater attempting to break a world record. Additionally, work and energy questions are important for nonathletes interested in healthy nutrition as well as for people who want to maintain their health and achieve an adequate body weight. Furthermore, work and energy are equally important for a person with an artificial leg (e.g., a below-the-knee amputee) or an elderly person who wants to play her or his daily round of golf or to walk to maintain physical fitness. Work and energy questions are relevant to all sectors of the human population.

Balance and control of movement are important for many sport activities such as balance beam exercises in gymnastics, shooting, somersaulting and twisting in trampolining, and activities on the trapeze. However, balance and control are equally important for children as they learn to move correctly and control their movements and for elderly people who may experience impaired control. Impaired mobility can result in exclusion from a large segment of life activities and people so affected will experience a decrease in the quality of life.

Excessive load during sport and exercise is specifically important for competitive sport activities. Injuries resulting from excessive repetitive forces are speculated to be the cause of early arthritis and disability. Therefore, it is important to understand the factors contributing to excessive loading and the strategies that can be used to avoid inappropriate

loading situations. Furthermore, it is important to understand when a load on the musculoskeletal system is beneficial and contributes to the development of strong and healthy biological structures.

Fatigue is a consequence of repeated use of muscles or other tissues and limits the duration a given activity can be performed. Fatigue may be the limiting factor, which when minimized permits winning or when evident results in losing a competition. Fatigue may impair mobility or general physical capability during daily activities. Furthermore, fatigue may be a contributing factor to the development of acute or chronic injuries. The ability to assess the presence and magnitude of fatigue becomes an important objective in the quest to understand the circumstances and consequences associated with muscle fatigue. Fatigue is also important in the work place and in daily leisure activities. If fatigue can be reduced, work performance may improve or leisure activities may become more enjoyable.

These questions and problems cannot be solved with the methods and approaches of only one scientific discipline. To understand the effects of excessive load, for instance, one needs contributions from biomechanics, biochemistry, and neuroscience. Answering questions related to fatigue requires contributions from physiology, biochemistry, neuroscience, and muscle mechanics. Balance and control questions can be answered only with contributions from neuroscience, biomechanics, anatomy, and physiology. Work and energy questions require contributions from physiology, biochemistry, biomechanics, and thermomechanics. Consequently, when studying movement, exercise, and sport-related questions one should attempt to understand the many facets contributing to the question and synthesize them into a comprehensive analysis.

The editors of this book identified the primary biological and physical knowledge associated with work and energy, balance and motor control, load and excessive load, and fatigue. The editors defined the important components for each topic and invited world-renowned experts in these areas to contribute from their viewpoint and wealth of understanding to the identified topic. Thus, the different sections of this book attempt to discuss important questions using input from the many disciplines of movement, exercise, and sport sciences that belong to the physical and biological sciences. The authors of the various chapters are experts in their fields. To integrate the presented knowledge, the editors added a synthesis to each topic. The contributions were organized in the form of a concise and comprehensive textbook in the hope that this text may provide a new approach to the exciting field of movement, exercise, and sport sciences.

The book is aimed at students and professionals working in kinesiology (e.g., biomechanics, physiology, physiotherapy, athletic therapy, and ergonomics). Readers who already have a basic knowledge of biology, physiology, and biomechanics will obtain the greatest benefits from the use of this text. Thus, the book is expected to be used for advanced undergraduate or early graduate level courses. Furthermore, the book will be a useful resource for research-oriented undergraduate and graduate students.

Each part starts with selected historical highlights for the interested reader. However, the book can be used without reading these historical highlights. This initial section is followed by basic and applied discussions of the topic of interest, followed by a synthesis of the discussed topic. Each part ends with a summary and a list of the most important definitions used. The reader is not expected to read through these definitions. They are collected to provide the reader a place to quickly find definitions if needed. Furthermore, the reader of this book is not required to use all the chapters. It is possible to choose a selection of contributions to a given topic and to make this selection based on the basic knowledge and the specific interest of the reader or student.

Over the last two decades the quality of students in kinesiology and the exercise sciences has improved substantially. Their expertise in biological and mechanical methods has vastly improved. In many universities, students in kinesiology and exercise sciences are among those with the highest entrance averages of all university faculties. The field of kinesiology is expanding and proves to be attractive for many brilliant young students and scientists. A strong indication for this development in kinesiology and the general field of exercise sciences is the establishment of the IOC Olympic Prize, a research award of $500,000 (U.S.) given for excellence in research on movement, exercise, and sport. It illustrates that intellectual leaders of human society are convinced that science dealing with movement, exercise, and sport is extremely important and should be recognized. This book takes this phenomenon into account. The concepts are presented in a relatively simple way. However, readers will be challenged with the intellectual depth achieved in each section of the text.

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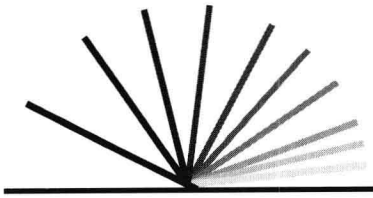

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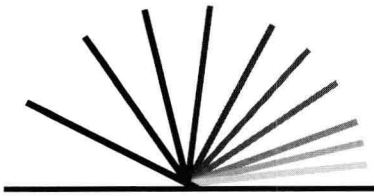

PART I

Work and Energy