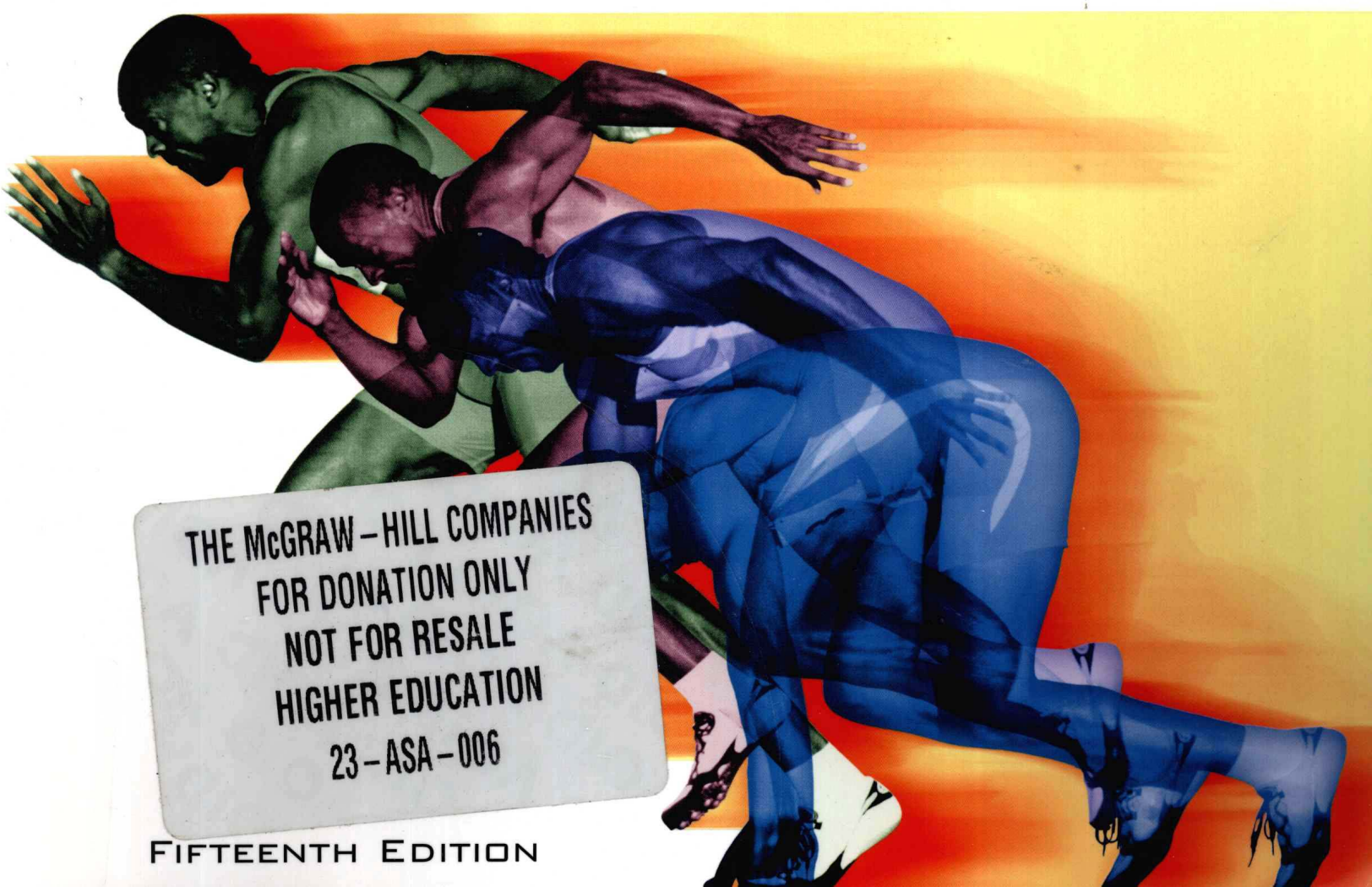
Manual of Structural Kinesiology

Clem W. Thompson

R.T. Floyd



Fifteenth Edition

Manual of Structural Kinesiology

R. T. Floyd EdD, ATC, CSCS

Director of Athletic Training and Sports Medicine
Professor of Physical Education and Athletic Training
Chair, Department of Physical Education and
Athletic Training
The University of West Alabama
(formerly Livingston University)
Livingston, Alabama

Clem W. Thompson Ph.D., F.A.C.S.M.

(deceased)
Professor Physical Education, Emeritus
Mankato State University
Mankato, Minnesota

FIFTEENTH EDITION

with 249 illustrations

Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis
Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City
Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto

The McGraw-Hill Companies

Mc Graw Hill **Higher Education**

MANUAL OF STRUCTURAL KINESIOLOGY, FIFTEENTH EDITION

Published by McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.

This book is printed on acid-free paper.

4 5 6 7 8 9 0 QPD/QPD 0 9 8 7 6 5

ISBN 0-07-255891-1

Vice president and editor-in-chief: *Thalia Dorwick*
Publisher: *Jane E. Karpacz*
Executive editor: *Vicki Malinee*
Developmental editor: *Lynda Huenefeld*
Senior marketing manager: *Pamela S. Cooper*
Project manager: *Richard H. Hecker*
Production supervisor: *Enboge Chong*
Media technology producer: *Lance Gerhart*
Designer: *George Kokkonas*
Art editor: *Emma Ghiselli*
Senior supplement producer: *David A. Welsh*
Compositor: *Interactive Composition Corporation*
Typeface: *10.5/12.5 Garamond*
Printer: *Quebecor World Dubuque, IA*

The credits section for this book begins on page 346 and is considered an extension of the copyright page.

Library of Congress Cataloging-in-Publication Data

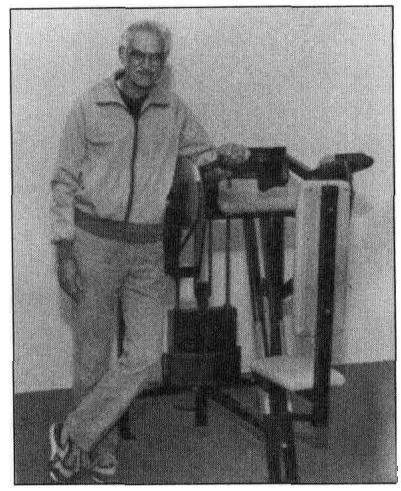
Floyd, R. T.
Manual of structural kinesiology / R. T. Floyd, Clem W. Thompson.-- 15th ed.
p. cm.
Includes index.
ISBN 0-07-255891-1 (alk. paper)
1. Kinesiology. 2. Human locomotion. 3. Muscles. I. Thompson, Clem W. II. Title.

QP303.T58 2004
612.7'6--dc21

2003045231

www.mhhe.com

Manual of Structural Kinesiology



Clem W. Thompson, Ph.D., F.A.C.S.M., who died in 1990, helped shape the field of physical education for his students and colleagues alike. Dr. Thompson wrote the fourth through the eleventh editions of *Manual of Structural Kinesiology*. He published many research papers, articles, and presentations, but he considered this book to be his most important professional accomplishment.

Dr. Thompson was a professor emeritus of physical education at Mankato State University in Mankato, Minnesota, where he served on the faculty for 25 years. He had taught at the University of Arkansas and Boston University before coming to MSU and retired from teaching in 1984. Dr. Thompson was a member of The American Alliance for Health, Physical Education, Recreation and Dance and served on various governing boards of the American Heart Association.

Dr. Thompson received his undergraduate degree from Knox College in Galesburg, Illinois, in 1938, his master's degree from the University of Illinois in 1941, and his doctorate from the University of Iowa in 1950.

Dr. Thompson was a pioneer in the campaign against smoking when it was more popular to smoke than to denounce it. He was a leader in the efforts to awaken Americans to the need to be healthy. His own outstanding personal example of physical fitness touched the lives of thousands of students and hundreds of his colleagues. His legacy of a commitment to a fit and healthy life will be perpetuated in the professional careers of them all.

To

my family,
Lisa, Robert Thomas, Jeanna, Rebecca, and Kate
who understand, support, and allow me to
pursue my profession

and to my parents,
Ruby and George Franklin,
who taught me the importance of a strong work ethic
with quality results

R.T.F.

Preface

In revising this edition I have attempted to further refine the chapters for consistency and to improve the overall completeness and accuracy of the text. As with previous revisions, I have attempted to maintain the successful presentation approach the late Dr. Clem Thompson established from 1961 through 1989. I first used this book as an undergraduate and later in my teaching over the years. Having developed great respect for this text and Dr. Thompson's style, it is my intention to continue to preserve the effectiveness of this time-honored text, while adding material pertinent to the professions working with today's ever-growing physically active population. Hopefully, I have maintained a clear, concise, and simple presentation method supplemented with applicable information gained through my career experiences.

This text, now in its 57th year, has undergone many revisions over the years. My goal continues to be to make the material as applicable as possible to everyday physical activity and to make it more understandable and easier to use for the student. With this in mind, numerous tables and illustrations have been added to this edition. I challenge kinesiology students and professionals to immediately apply the content of this text to physical activities with which they are individually familiar. I hope that the student will simultaneously palpate his or her own moving joints and contracting muscles to gain application. Concurrently, I encourage students to palpate the joints and muscles of fellow students to gain a better appreciation of the wide range of normal anatomy and, when possible, appreciate the variation from normal found in injured and pathological musculoskeletal anatomy.

Audience

This text is designed for students in an undergraduate structural kinesiology course after completing courses in human anatomy and physiology. While primarily utilized in physical education, exercise science, athletic training, physical therapy, and massage therapy curriculums, it is often used as a continuing reference by other clinicians and educators in addressing musculoskeletal concerns of the physically active. Applied kinesiologists, athletic trainers, athletic coaches, physical educators, physical therapists, health club instructors, strength and conditioning specialists, personal trainers, massage therapists, physicians, and others who are responsible for improving and maintaining the muscular strength, endurance, flexibility, and overall health of individuals will benefit from this text.

With the tremendous growth in the number of participants in an ever-increasing spectrum of physical activity, it is imperative that medical, health, and education professionals involved in providing instruction and information to the physically active be correct in and accountable for the teachings that they provide. The variety of exercise machines, techniques, strengthening and flexibility programs, and training programs is continuously expanding and changing, but the musculoskeletal system is constant in its design and architecture. Regardless of the goals sought or the approaches used in exercise activity, the human body is the basic ingredient and must be thoroughly understood and considered to maximize performance capabilities and minimize undesirable results. Most advances in exercise science continue to result from a better understanding of the body and how it functions. I believe that an individual in this field can never learn enough about the structure and function of the human body.

Those who are charged with the responsibility of providing instruction to the physically active will find this text a helpful and valuable resource in what I hope is their never-ending quest for knowledge and understanding of human movement.

New to this edition

Major changes to this edition include the replacement of several illustrations and the addition of others, as well as numerous tables added in each chapter. Content relative to understanding the structure and function of bones, joints, muscles, and nerves and their individual and combined contribution to human movement has been expanded.

Chapter 1, "Foundations of Structural Kinesiology," has been divided into two chapters. Chapter 1 retains the foundations related to bones and joints, with additions regarding bony features, bone growth, bone markings, bone properties, and joint movements, including discussion related to physiological movements and accessory motions. The new Chapter 2, "Neuromuscular Fundamentals," contains the previous edition's information on neuromuscular function, with substantial additions regarding muscle nomenclature, muscle shape and fiber arrangement, muscle tissue properties, determination of muscle action, lines of pull, neural control of voluntary movement, proprioception and kinesthesis, muscle length–tension and muscle force–velocity relationships, and angle of pull. Chapter 12 from the previous edition, "Basic Biomechanical Factors and Concepts," has been moved to Chapter 3 to allow coverage of these important concepts prior to addressing the muscles of each joint in the subsequent chapters. Some concepts has been expanded, including types of machines found in the body, friction, and mechanical loading basics. In the eight chapters that address specific body parts, tables have been added to clearly detail the origin, insertion, action, plane of motion, palpation, and innervation for each muscle. All palpations have been carefully reviewed and revised, with an emphasis placed on combining movement with palpation in many cases. Illustrations detailing the ranges of motion have been added, as well as a section on the nerves involved, with related illustrations. Chapter 5, "The Shoulder Joint," and Chapter 9, "The Hip and Pelvic Girdle," now have illustrations to depict the ligaments of the glenohumeral and acetabularfemoral joints, respectively. The movement analysis examples in Chapters 8 and 13 have been reworked, with the analyses broken down by phases and placed in tables for clearer understanding.

The Glossary has been essentially doubled in volume and contains well over 100 terms new to this edition. The definitions of several other terms have been revised. Finally, the listings of web sites included at the end of each chapter have been updated. A third appendix has been added to include a listing of the more commonly used exercises for strengthening selected muscles.

Ancillaries

Image Presentation CD-ROM
ISBN 0-07-284288-1
The Image Presentation CD-ROM is an electronic library of visual resources. The CD-ROM comprises images from the text displayed in PowerPoint, which allows the user to view, sort, search, use, and print catalog images. It also includes a complete, ready-to-use PowerPoint presentation, which allows users to play chapter-specific slide shows.

Online Learning Center
www.mhhe.com/floyd15e
The Online Learning Center to accompany this text offers a number of additional resources for both students and instructors. Visit this website to find useful materials such as these:

For the instructor:
- Downloadable PowerPoint presentations
- Interactive web activities
- Chapter-specific interactive animations
- Links to professional resources
- PowerWeb access

For the student:
- Self-scoring chapter quizzes
- Anatomy flashcards and crossword puzzles for learning key terms and their definitions
- Chapter-specific interactive animations
- Learning objectives
- Interactive labeling activities
- PowerWeb access

PowerWeb
PowerWeb is a reservoir of course-specific articles and current events. Students can access PowerWeb articles to take a self-scoring quiz, complete an interactive exercise, click through an interactive glossary, or check the daily news. An expert in each discipline analyzes the day's news to show students how it relates to their field of study. PowerWeb articles are available on the Online Learning Center that accompanies this text.

Acknowledgments

I am very appreciative of the excellent comments, ideas, and suggestions provided by the ten reviewers. These reviews have been an extremely helpful guide in this revision. These reviewers are

Rebekah Bower
Wright State University

Salome Brooks
Sacred Heart University

Laura Clark
Western Illinois University

Mike Daniel
Texas A&M University, Kingsville

Erika Goodwin
Wilmington College

J. Ty Hopkins
Illinois State University

Dean Jacks
Winston-Salem State University

Mike Lester
Idaho State University

Kenneth Sarubbi
DePaul University

Vassilios Vardaxis
Indiana University

I would also like to thank Brad Montgomery, MAT, ATC; Karen Straub, MS, ATC; and the kinesiology/athletic training students of The University of West Alabama for their advice and input throughout this revision. Their assistance and suggestions have been most helpful. I also acknowledge Mr. John Hood and Mrs. Lisa Floyd of Birmingham and Livingston, Alabama, respectively, for the fine photographs. Special thanks to Mrs. Linda Kimbrough of Birmingham, Alabama, for her superb illustrations and insight. I appreciate the models for the photographs: Mr. David Whitaker, Miss Kala Peak, Mr. Marcus Shapiro, Mrs. Zina Pruitt, and Mr. Darrell Locket. My thanks also go to Lynda Huenefeld, Carlotta Seely, Vicki Malinee, and Rick Hecker of the McGraw-Hill staff, who have been most helpful in their assistance and suggestions in preparing the manuscript for publication.

R.T. Floyd

Contents

Chapter 1

Foundations of Structural Kinesiology

Objectives

- To review the anatomy of the skeletal system
- To review and understand the terminology used to describe body part locations, reference positions, and anatomical directions
- To review the planes of motion and their respective axes of rotation in relation to human movement
- To describe and understand the various types of bones and joints in the human body and their characteristics
- To describe and demonstrate the joint movements

Online Learning Center Resources

Visit *Manual of Structural Kinesiology's* Online Learning Center at **www.mhhe.com/floyd15e** for additional information and study material for this chapter, including:

- *Self-grading quizzes*
- *Anatomy flashcards*
- *Animations*

Structural kinesiology is the study of muscles as they are involved in the science of movement. Both skeletal and muscular structures are involved. Bones are different sizes and shapes—particularly at the joints, which allow or limit movement. Muscles vary greatly in size, shape, and structure from one part of the body to another.

More than 600 muscles are found in the human body. In this book, an emphasis is placed on the larger muscles that are primarily involved in movement of the joints. Details related to many of the small muscles located in the hands, feet, and spinal column are provided to a lesser degree.

However, anatomists, coaches, strength and conditioning specialists, personal trainers, nurses, physical educators, physical therapists, physicians, athletic trainers, massage therapists, and others in health-related fields should have an adequate knowledge and understanding of all the large muscle groups, so they can teach others how to strengthen, improve, and maintain these parts of the human body. This knowledge forms the basis of the exercise programs that should be followed to strengthen and maintain all of the muscles. In most cases, exercises that involve the larger primary movers also involve the smaller muscles.

Fewer than 100 of the largest and most important muscles, primary movers, are considered in this text. Some small muscles in the human body, such as the multifidus, plantaris, scalenus, and serratus posterior, are omitted, since they are exercised with other, larger primary movers. In addition, most small muscles of the hands and feet are not given the full attention provided to the larger muscles. Many small muscles of the spinal column are not considered in full detail.

Chapter 1

Kinesiology students frequently become so engrossed in learning individual muscles that they lose sight of the total muscular system. They miss the "big picture"—that muscle groups move joints in given movements necessary for bodily movement and skilled performance. Although it is vital to learn the small details of muscle attachments, it is even more critical to be able to apply the information to real-life situations. Once the information can be applied in a useful manner, the specific details are usually much easier to understand and appreciate.

Skeletal systems

Fig. 1.1 shows anterior and posterior views of the skeletal system. Two hundred six bones make up the skeletal system, which provides support and protection for other systems of the body and provides for attachments of the muscles to the bones by which movement is produced. Additional skeletal functions are mineral storage and hemopoiesis, which involves blood cell formation in the red bone marrow. The skeleton may be divided into the appendicular and the axial skeleton. The

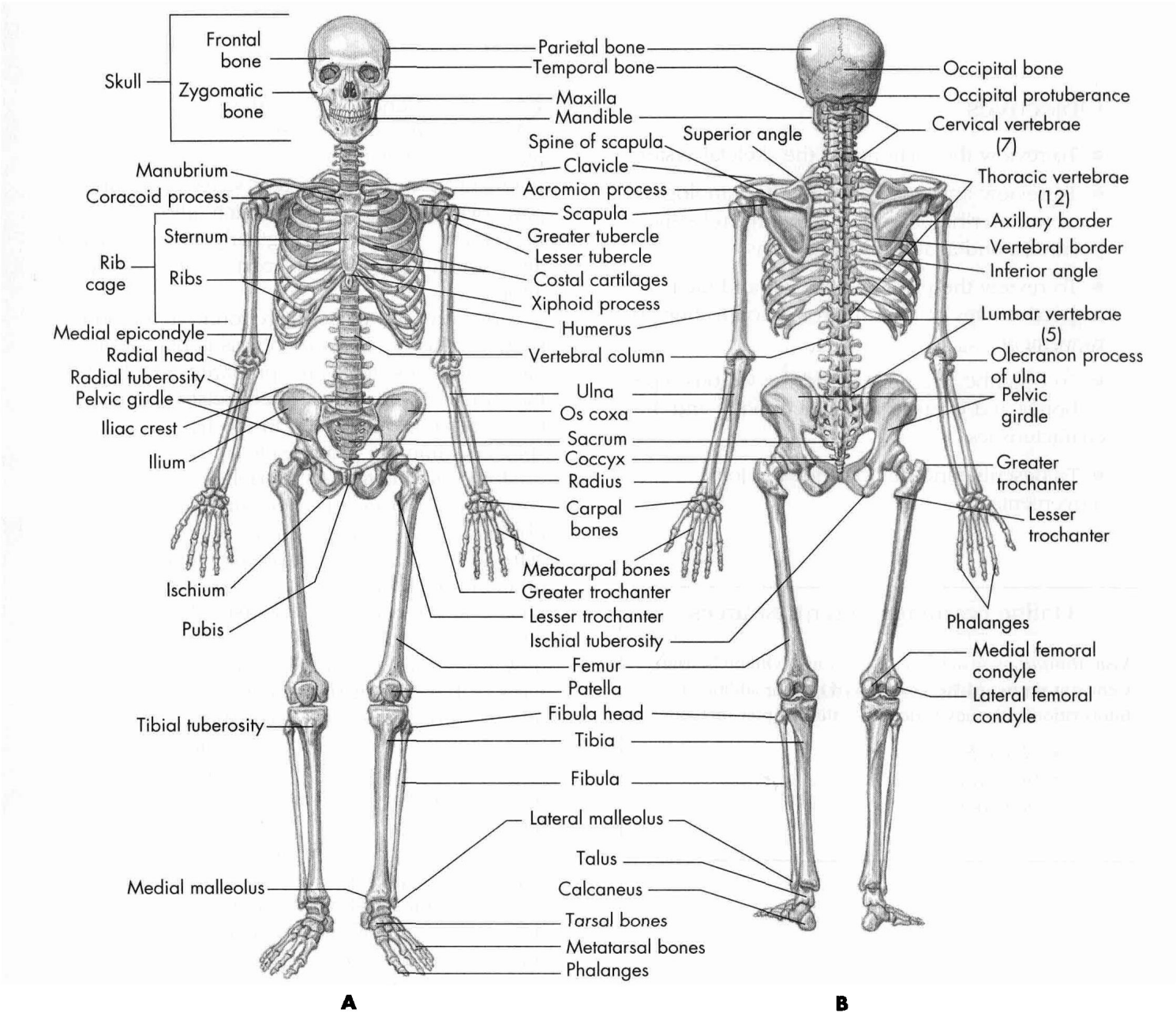


FIG. 1.1 • Skeleton. **A,** Anterior view; **B,** posterior view.

Modified from Van De Graaff KM: *Human anatomy,* ed 5, New York, 2000, McGraw-Hill.

appendicular skeleton is composed of the appendages, or the upper and lower extremities, and the shoulder and pelvic girdles, while the axial skeleton consists of the skull, vertebral column, ribs, and sternum. Most students who take this course will have had a course in human anatomy, but a brief review is desirable before beginning the study of kinesiology. Other chapters provide additional information and more detailed illustrations of specific bones.

Reference positions

It is crucial for kinesiology students to begin with a reference point in order to better understand the musculoskeletal system, its planes of motion, joint classification, and joint movement terminology. Two reference positions may be used as a basis from which to describe joint movements. The *anatomical position* is the most widely used and accurate for all aspects of the body. Fig. 1.2 demonstrates this reference position, with the subject standing in an upright posture, facing straight ahead, feet parallel and close, and palms facing forward. The *fundamental position* is essentially the same as the anatomical position, except that the arms are at the sides and facing the body.

Anatomical directional terminology FIG. 1.2

Anterior

In front or in the front part

Anteroinferior

In front and below

Anterolateral

In front and to the outside

Anteromedial

In front and toward the inner side or midline

Anteroposterior

Relating to both front and rear

Anterosuperior

In front and above

Caudal

Below in relation to another structure; inferior

Cephalic

Above in relation to another structure; higher, superior

Contralateral

Pertaining or relating to the opposite side

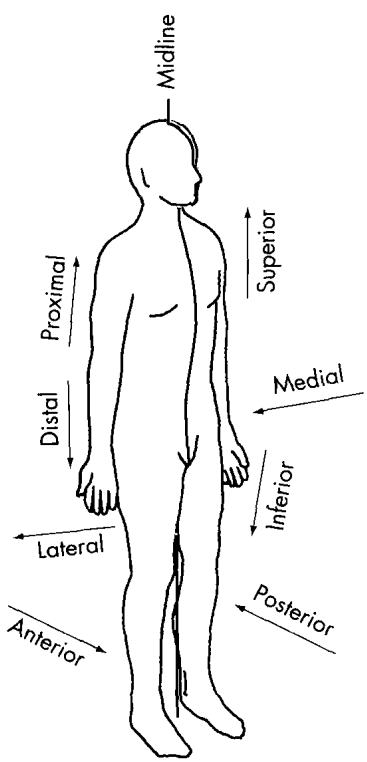


FIG. 1.2 • Anatomical position and Anatomical directions. Anatomical directions refer to the position of one body part in relation to another.

From Prentice WE: *Arnheim's principles of athletic training*, ed 11, New York, 2003, McGraw-Hill.

Deep
Beneath or below the surface; used to describe relative depth or location of muscles or tissue

Distal
Situated away from the center or midline of the body, or away from the point of origin

Dorsal
Relating to the back; posterior

Inferior
(infra) Below in relation to another structure; caudal

Inferolateral
Below and to the outside

Inferomedial
Below and toward the midline or inside

Ipsilateral
On the same side

Lateral
On or to the side; outside, farther from the median or midsagittal plane

Medial
Relating to the middle or center; nearer to the medial or midsagittal plane

Palmar
Relating to the palm or volar aspect of the hand

Posterior
Behind, in back, or in the rear

Posteroinferior
Behind and below; in back and below

Posterolateral
Behind and to one side, specifically to the outside

Posteromedial
Behind and to the inner side

Posterosuperior
Behind and at the upper part

Prone
Face downward position of the body; stomach lying

Proximal
Nearest the trunk or the point of origin

Superficial
Near the surface; used to describe relative depth or location of muscles or tissue

Superior
(supra) Above in relation to another structure; higher, cephalic

Superolateral
Above and to the outside

Superomedial
Above and toward the midline or inside

Supine
Lying on the back; face upward position of the body

Ventral
Relating to the belly or abdomen

Volar
Relating to palm of the hand or sole of the foot

Planes of motion

When studying the various joints of the body and analyzing their movements, it is helpful to characterize them according to specific planes of motion (Fig. 1.3). A plane of motion may be defined as an imaginary two-dimensional surface through which a limb or body segment is moved.

There are three specific, or *cardinal,* planes of motion in which the various joint movements can be classified. The specific planes that divide the body exactly into two halves are often referred to as cardinal planes. There are an infinite number of planes within each half that are parallel to the cardinal planes. This is best understood in the following examples of movements in the sagittal plane. Sit-ups involve the spine, and as a result, are performed in the cardinal sagittal plane, which is also known as the *midsagittal* plane. Biceps curls and knee extensions are performed in *parasagittal* planes, which are parallel to the midsagittal plane. Even though these examples are not in the cardinal plane, they are thought of as movements in the sagittal plane.

Although each specific joint movement can be classified as being in one of the three planes of motion, our movements are usually not totally in one specific plane, but occur as a combination of motions from more than one plane. These movements from the combined planes may be described as occurring in diagonal, or oblique, planes of motion.

Sagittal, anteroposterior, or AP plane

The sagittal, anteroposterior, or AP plane bisects the body from front to back, dividing it into right and left symmetrical halves. Generally, flexion and extension movements such as biceps curls, knee extensions, and sit-ups occur in this plane.

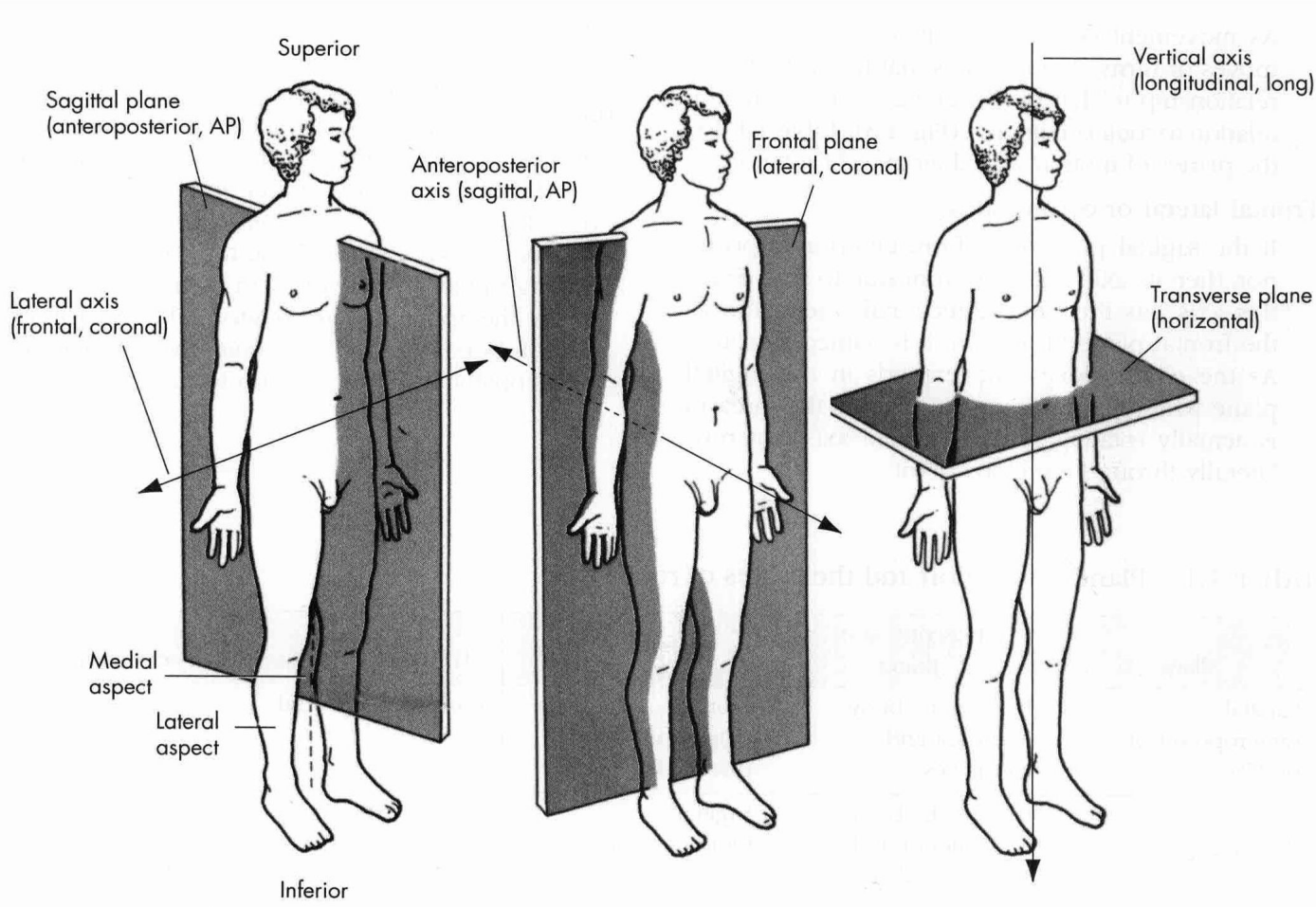


FIG. 1.3 • Planes of motion and axes of rotation.

Modified from Booher JM, Thibodeau GA: *Athletic injury assessment,* ed 4, New York, 2000, McGraw-Hill.

Frontal, lateral, or coronal plane

The frontal plane, also known as the lateral or coronal plane, bisects the body laterally from side to side, dividing it into front and back halves. Abduction and adduction movements such as jumping jacks and spinal lateral flexion occur in this plane.

Transverse or horizontal plane

The transverse plane divides the body horizontally into superior and inferior halves. Generally, rotational movements such as pronation, supination, and spinal rotation occur in this plane.

Diagonal or oblique plane

The diagonal or oblique plane is a combination of more than one plane. In reality, most of our movements in sporting activities fall somewhere less than parallel or perpendicular to the previously described planes and occur in a diagonal plane.

Axes of rotation

As movement occurs in a given plane, the joint moves or turns about an axis that has a 90-degree relationship to that plane. The axes are named in relation to their orientation (Fig. 1.3). Table 1.1 lists the planes of motion with their axes of rotation.

Frontal, lateral, or coronal axis

If the sagittal plane runs from anterior to posterior, then its axis must run from side to side. Since this axis has the same directional orientation as the frontal plane of motion, it is named similarly. As the elbow flexes and extends in the sagittal plane when performing a biceps curl, the forearm is actually rotating about a frontal axis that runs laterally through the elbow joint.

Sagittal or anteroposterior axis

Movement occurring in the frontal plane rotates about a sagittal axis. This sagittal axis has the same directional orientation as the sagittal plane of motion and runs from front to back at a right angle to the frontal plane of motion. As the hip abducts and adducts during jumping jacks, the femur rotates about an axis that runs front to back through the hip joint.

Vertical or longitudinal axis

The vertical axis, also known as the longitudinal or long axis, runs straight down through the top of the head and is at a right angle to the transverse plane of motion. As the head rotates or turns from left to right when indicating disapproval, the skull and cervical vertebrae are rotating around an axis that runs down through the spinal column.

Osteology

The adult skeleton, consisting of approximately 206 bones, may be divided into the axial skeleton and the appendicular skeleton. The axial skeleton contains 80 bones, which include the skull, spinal column, sternum, and ribs. The appendicular skeleton contains 126 bones, which include all of the bones of the upper and lower extremities. The pelvis is sometimes classified as being part of the axial skeleton due to its importance in linking the axial skeleton with the lower extremities of the appendicular skeleton. The exact number of bones as well as their specific features occasionally vary from person to person.

TABLE 1.1 • **Planes of motion and their axes of rotation**

Plane	Description of plane	Axis of rotation	Description of axis	Common movements
Sagittal (anteroposterior or AP)	Divides the body into right and left halves	Frontal (lateral or coronal) (medial-lateral)	Runs medial/lateral	Flexion, extension
Frontal (lateral or coronal)	Divides the body into anterior and posterior halves	Sagittal (anteroposterior or AP)	Runs anterior/ posterior	Abduction, adduction
Transverse (horizontal)	Divides the body into superior and inferior halves	Vertical (longitudinal or long)	Runs superior/inferior	Internal rotation, external rotation

Skeletal functions

The skeleton has five major functions:

1. protection of vital soft tissues such as the heart, lungs, and brain
2. support to maintain posture
3. movement by serving as points of attachment for muscles and acting as levers
4. storage for minerals such as calcium and phosphorus
5. hemopoiesis, which is the process of blood formation that occurs in the red bone marrow located in the vertebral bodies, femur, humerus, ribs, and sternum.

Types of bones

Bones vary greatly in shape and size, but can be categorized in five major categories (Fig. 1.4).

Long bones

Composed of a long cylindrical shaft with relatively wide, protruding ends; serve as levers. The shaft contains the medullary canal. Examples include phalanges, metatarsals, metacarpals, tibia, fibula, femur, radius, ulna, and humerus.

Short bones

Small, cube-shaped, solid bones that usually have a proportionally large articular surface in order to articulate with more than one bone. Short bones provide some shock absorption and include the carpals and tarsals.

Flat bones

Usually having a curved surface and varying from thick (where tendons attach) to very thin. Flat bones generally provide protection and include the ilium, ribs, sternum, clavicle, and scapula.

Irregular bones

Irregular shaped bones serving a variety of purposes and including the bones throughout the entire spine and the ischium, pubis, and maxilla.

Sesamoid bones

Small bones embedded within the tendon of a musculotendinous unit that provide protection as well as improve the mechanical advantage of musculotendinous units. In addition to the patella, there are small sesamoid bones within the flexor tendons of the great toe and the thumb.

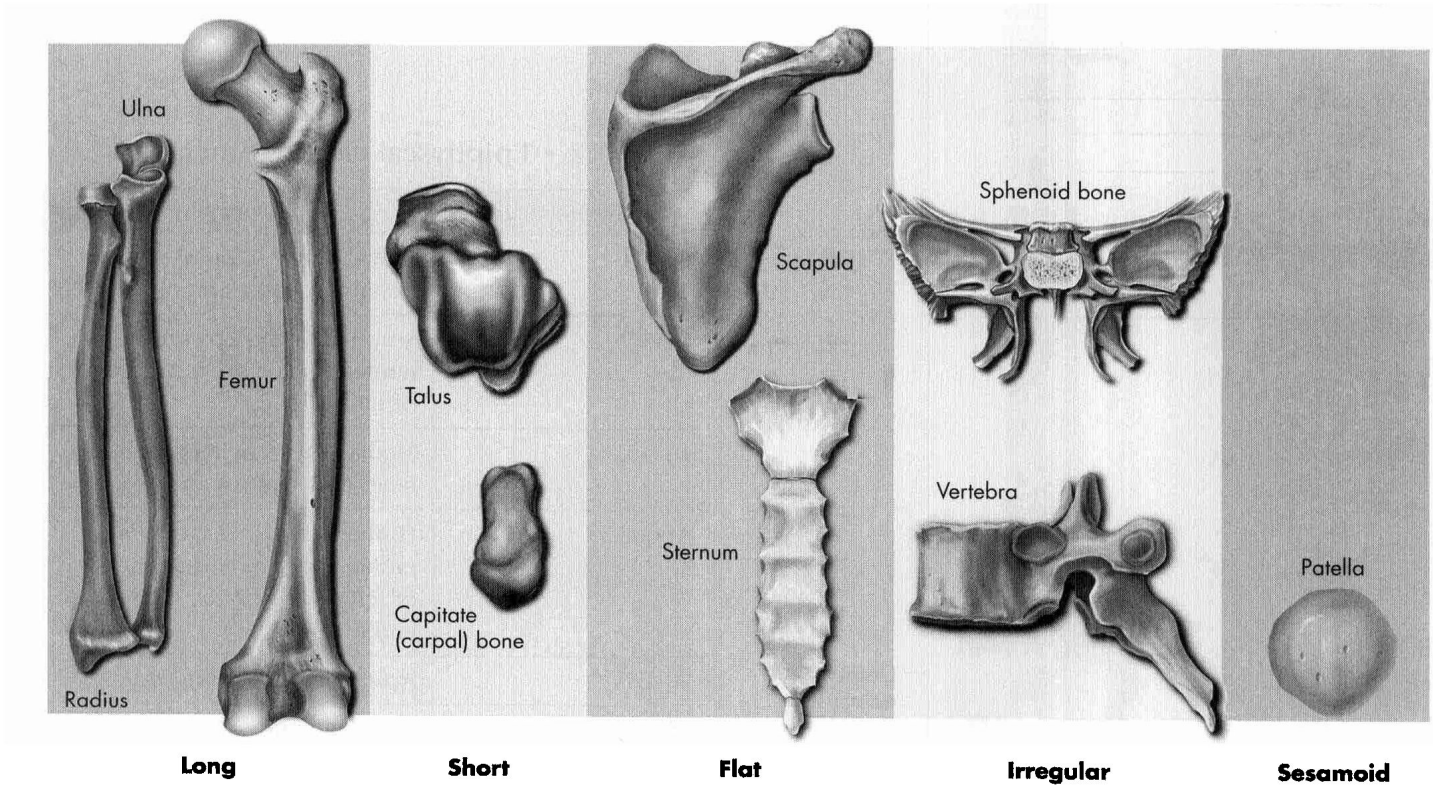


FIG. 1.4 • Classification of bones by shape.

Modified from Booher JM, Thibodeau GA: *Athletic injury assessment*, ed 4, New York, 2000, McGraw-Hill and Shier D, Blutler J, Lewis R: *Hole's Human anatomy & physiology*, ed 9, New York, 2002, McGraw-Hill.