

Brunnstrom's

Clinical Kinesiology

SIXTH EDITION



Peggy A. Houglum
Dolores B. Bertoti



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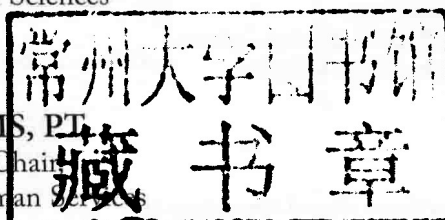
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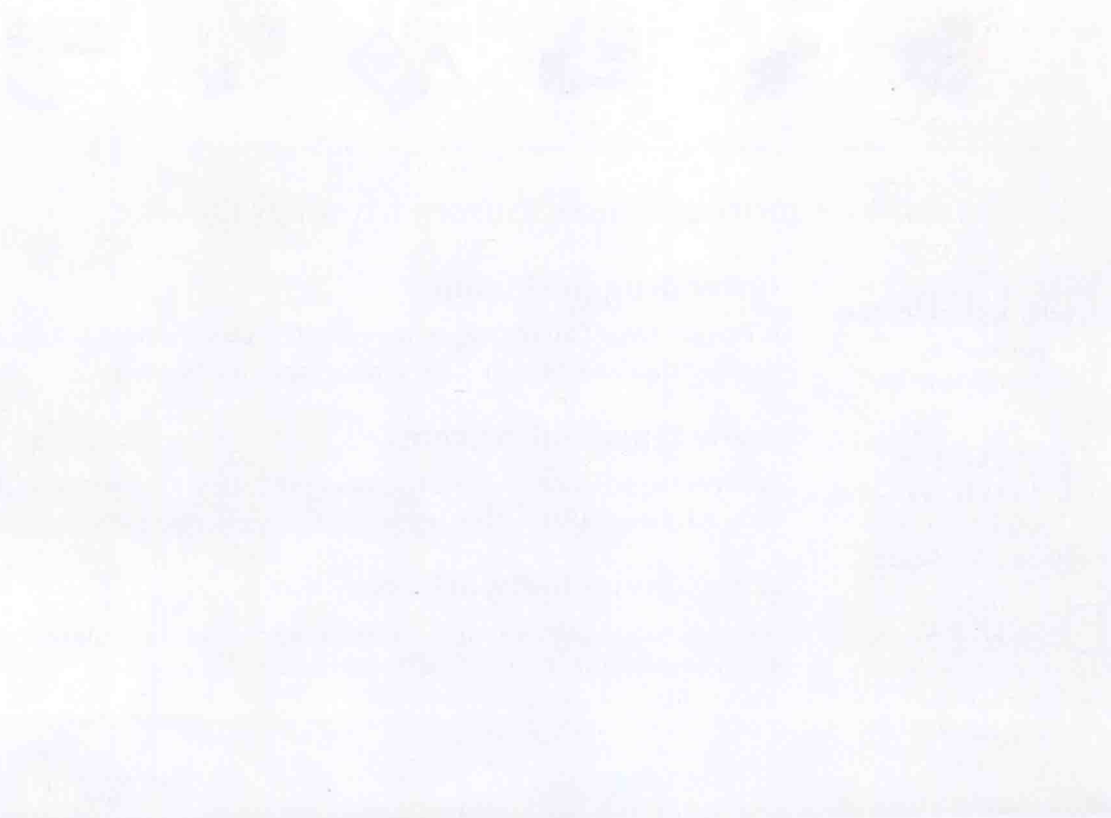
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*For Joel & Rita, Pam & Bob, Joan & Steve, Deanna & Dan: I am very
blessed to call you relatives and most grateful to call you friends.*

—Peg

*In celebration of 25 years as a Breast Cancer survivor, I joyfully dedicate
my work on this book in thanksgiving for the blessings in my life; my
loving family, Willy, Christopher, and Beth; and to Mom, who taught
all of my brothers and sisters and I the beauty of love for each other:
Jack, Carol, Mary, John, Vince, Karina, Andrew, Dien, Pat, Mary,
Michael, Mary Pat, Tim, Andrea, and Maureen.*

—Dolores

Preface

When Dolores and I were invited by F. A. Davis to rewrite *Brunnstrom's Clinical Kinesiology*, we were honored to be considered to undertake the project. In our own respective programs half a country apart, we each “grew up” with this text, as it was a required textbook for each of us in our professional education programs.

Although the world of fiction contains several classical novels, from *Oliver Twist* to *Catcher in the Rye*, there are very few textbooks, especially in the health professions, that withstand the test of time and fall within the category of “classics.” However, *Brunnstrom's Clinical Kinesiology* is, indeed, one such textbook. The mere fact that it is celebrating its Golden Anniversary year of publication is evidence of its stand-alone presence in the world of health care. It was originally written by Signe Brunnstrom when there were few textbooks in kinesiology and little research on the topic. Her text began as a teaching manual for her students at Columbia University and evolved into a book through a grant from the Office of Vocational Rehabilitation. It was her desire to provide kinesiological information from a clinical perspective to assist professionals in their own performance in the field of rehabilitation.

Her desire to meet the needs of professionals in rehabilitation continues to be met today in this new and updated version of her original textbook. We have included information based on new evidence, applications based on new techniques, and chapters based on new knowledge to expand Brunnstrom's original text to move her original idea of providing clinical applications of kinesiology to rehabilitation into the 21st century.

Dolores and I first met when we spent an intensive and productive weekend together developing a proposal for this immense project. We instantly hit it off and have been on the same wavelength throughout the past 4 years as this project has moved from vision to reality.

Our goal for this revision has been to keep the classic Brunnstrom touch in this text while moving its

information into the 21st century. We also wanted to maintain Brunnstrom's idea of this text as a book of useful information that aids students and clinicians in their understanding of body movement and its application in the clinical world. If there is one criticism of many of today's kinesiology texts, it is that much of the information includes biomechanical calculations and engineering perspectives rather than a clinical perspective. Although there are individuals who prefer to include these calculations and information, there are also many who find such information unnecessary for students becoming health care professionals.

Therefore, we have preserved Signe Brunnstrom's perspective of approaching kinesiology from a clinical perspective throughout this text. We have included only essential calculations when they are necessary, as the goal of this text is to provide clinical applications of kinesiology rather than biomechanics. For this reason, you will find this text thinner than other kinesiology texts. The kinesiology presented in this book is pertinent to those individuals who perform as health care providers for individuals in need of rehabilitation treatments, prevention techniques, and corrective exercises.

It has been 50 years since Signe Brunnstrom's first edition was published and students began learning from her wealth of information. The fact that this text continues to contribute to the education of health care students today speaks to the scholarship, foresight, and richness that Signe Brunnstrom infused within it 50 years ago. She appreciated the unique simplicity of the body with its complexity of movement and wanted other clinicians to share in her appreciation of how wondrously it works. We do, too, and hope that this edition provides you with the enrichment and appreciation of body motion the way Signe Brunnstrom's early editions did for us. We will let you decide if we have accomplished this goal.

Peggy A. Houghlum
Dolores B. Bertoti

Biographical Sketch of Signe Brunnstrom, 1898–1988

Anna Signe Sofia Brunnstrom was born at Karlberg Castle (the Swedish Military Academy) in Stockholm, Sweden, on January 1, 1898. She was the second daughter of Captain Edvin Brunnstrom and his wife Hedwig. She died in Darien Convalescent Center in Darien, Connecticut, on February 21, 1988. During the 90 years of her life, she served in many capacities. She was a master clinician, scholar, translator, researcher, educator, author, lecturer, mentor, traveller, and humanitarian. Her reputation as a physical therapist was known worldwide.

At age 16, she entered Uppsala College, where she studied sciences, history, geography, and gymnastics. In 1917, she passed the required examination to enter the Royal Institute for Gymnastics in Stockholm. The Institute was founded by fencing master Per Henrik Ling in 1813. Ling developed a system of medical gymnastics, called "Swedish exercises" that spread across Europe and later into the United States. His exercises were unusual at the time because hands-on resistance or assistance was applied by the therapist. Ling's techniques became the foundation for many of the treatment approaches that Miss Brunnstrom would use in her future work. At the Institute, she excelled in calisthenics and graduated on May 30, 1919, with the title of "Gymnastikdirektor."

In 1920, Miss Brunnstrom went to Berne, Switzerland, to work with a physical therapist. A year later, she established her own "Sjuggymnastik Institute" in Lucerne. There she gained a reputation as a therapist treating disabled children with scoliosis and poliomyelitis. She also established an evening program for working women in need of remedial exercise.

She left Switzerland in 1927 and travelled to New York City, where she accepted a position in exercise therapy at the Hospital for the Ruptured and Crippled (later to be renamed the Hospital for Special Surgery). Fourteen Scandinavians worked in the physiotherapy

department, and Miss Brunnstrom became the person to whom they all looked for advice as a generous and patient friend. To make ends meet during the depression years, Miss Brunnstrom became a physical training instructor in the gymnasium of the Metropolitan Life Insurance Company. There she applied her ideas about physical education for working women and started special remedial exercise classes. She worked for Metropolitan on and off for 20 years and also offered "Swedish massage" to private patients, received referrals from physicians, and taught exercise classes at New York University.

In 1931, Miss Brunnstrom was admitted to Barnard College, where she took nine credits in chemistry and three credits in English. Recognizing that she could successfully handle American university work, she then enrolled at New York University, where as a part-time student she earned a Master's degree in physical education and a Master of Arts degree in education.

On November 26, 1934, at age 36, Anna Signe Sofia Brunnstrom became a citizen of the United States of America and officially had her name changed to Signe Brunnstrom.

Only 6 years after she came to New York, her first article in English, "Faulty Weight Bearing with Special Reference to Position of the Thigh and Foot" (*Physiother. Rev.* 15 [3], 1935), was published. This article was the forerunner of 22 clinical articles; several book chapters; three voluminous research reports; numerous abstracts and book reviews (including many translations of classic European work); several films; and three major textbooks on prosthetic training, kinesiology, and hemiplegia movement therapy. She also read and translated the works of major European and American scientists and brought them to the kinesiology literature. These scientists included Blix, Borelli, Bethe and Franke, Braune and Fisher, Elfman, Duchenne, Fick, Inman, Marey, Magus, and the Weber brothers.

Signe Brunnstrom remains one of the most productive contributors to the body of physical therapy knowledge. Through her students and writings, she has left a great legacy to practicing physical and occupational therapists.

In 1938, Miss Brunnstrom was appointed an instructor of therapeutic exercise at New York University. She taught there until 1942 and later in 1948, when she joined the faculty of the Institute for Rehabilitation Medicine as a research associate working on a suction socket study sponsored by the Veterans Administration and NYU.

In the spring of 1941, with the United States still not drawn into World War II, Miss Brunnstrom applied through the American Red Cross to serve as a civilian physical therapist in a military hospital. She was assigned to the physical therapy department at Sheppard Field, Texas, with the Army Air Corps. She left Texas 2 years later, hoping to enlist in the US Army Medical Specialist Corps, but was refused because of her age (she was 45). She then enlisted in the US Navy, and in 1943 reported to the Navy Hospital at Mare Island, California, as the officer in charge of physical therapy. It was there, while working with a young naval medical officer, Dr. Henry Kessler, that she made major contributions to the rehabilitation of amputees. After the war, Dr. Kessler founded the well-known Kessler Institute of Rehabilitation in West Orange, New Jersey. Miss Brunnstrom was discharged from the Navy in 1946 with the rank of lieutenant.

After the war, Miss Brunnstrom participated in prosthetic research at the University of California and New York University. In addition, she was Director of Professional Education at the Kessler Institute. She was also a clinical consultant at the Burke Foundation in White Plains, New York, the New York State

Rehabilitation Hospital at West Haverstraw, and the Veterans Administration; she was also a visiting instructor at Stanford University in California. In 1951, she was awarded a Fulbright Lectureship to Greece, where she worked on developing a school of physical therapy and trained aides to carry out amputee exercise programs. Throughout this time, Miss Brunnstrom was in great demand to conduct continuing education courses, seminars, and workshops.

From 1955 through 1971, one of Miss Brunnstrom's many professional activities was teaching kinesiology to physical and occupational therapy students at the College of Physicians and Surgeons, Columbia University, New York. A teaching grant from the US Office of Vocational Rehabilitation enabled her to prepare a laboratory manual for the students. The manual was developed into the textbook *Clinical Kinesiology*, which was published in 1962. This was the first American kinesiology text to be written for physical and occupational therapy students. Before this time, most kinesiology textbooks were oriented to physical education and athletic activities.

Signe Brunnstrom received numerous honors and awards, including the US Navy Medal of Merit in 1945, the Marian Williams Research Award presented by the American Physical Therapy Association (APTA) in 1965, the University Citation of the State University of New York at Buffalo (equivalent to an honorary doctorate) in 1973, and an appointment to honorary membership in the Union of Swedish Physical Therapists in 1974. In 1987, the Board of Directors of APTA renamed the Award for Excellence in Clinical Teaching in her honor. The award is now known as the Signe Brunnstrom Award for Excellence in Clinical Teaching.

—Jay Schleichkorn, PhD, PT

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There are many people who have been invaluable to me throughout this project. I would be remiss if I did not recognize them. First, I must thank Dolores Bertoti for agreeing to co-author this text with me; she and I have seen this text's potential from the start and have approached its development and completion with the same vision throughout the process. It has been a pleasure to work with my new friend. A special thank you goes to members of Duquesne University's Rangos School of Health Sciences. Members of the school are a close community of professionals who are not only colleagues but also friends; without their direct or indirect contributions, this book could not have been written. Within the university, I am most grateful to Dr. Greg Frazer, Rangos School Dean, who always supports his faculty in our endeavors, and Provost Pearson, who supports and encourages all university faculty. A very special thank you is owed to my Department Chair, Dr. Paula Turocy, and my colleague Dr. Jason Scibek, who took over my teaching load, burdening themselves with an unusual overload so I could take a sabbatical to finish this text. Susan Venditti, our Administrative Assistant, has always "had my back"; she is a professional's professional and assisted me in more ways than I can count, even when I wasn't present in the department. Dr. Christopher Carcia, PT, created an outstanding spine chapter, made a great contribution to the hip and pelvis chapter, and is responsible for the fine ancillaries that accompany this text. Dr. Ingrid Provident, OTR/L, the author of the hand and wrist chapter and the chapter on kinesiology applications of the upper extremity in ADLs, made complex topics easily understandable. Jennifer Pine, Developmental Editor, deserves special recognition for her patience with me and Dolores for our never-ending, "Just one more change" requests, for her yeoman's attention to detail that caught our omissions, and for her exceptional ability to maintain an even keel when I am sure all she wanted to do was strangle one or both of us. Pete Houdak and Bonnie Virag, two Duquesne University students, spent hours posing as models during a nearly week-long photo shoot; thanks to them for donating their bodies to this text. Members of Graphic World Inc. put together the final product. Two members finalized this edition: Rose Boul, Senior Art Coordinator, and Grace Onderlinde, Production Editor,

provided needed persistence, perseverance, and patience in the creation of what you now hold in your hands. Liz Schaeffer, Developmental Editor and Electronic Products Coordinator for F. A. Davis, managed, directed, and coordinated with wonderful clarity and vision the creation and production of the fine digital resources that accompany this text. We believe that these resources are a marvelous and unique complement to the text, which provides students with alternatives to understanding what could otherwise be difficult concepts to grasp. Putting together a textbook requires much more than authors with an idea. An entire legion of qualified experts is necessary; we believe that we have, among the throng that has participated in this project, some of the very best.

From Dolores Bertoti:

This work would not have been possible without the support of so many friends and colleagues. I am appreciative of the support from both the administration and my fellow faculty and students at Alvernia University, including a reduction in teaching during the semester when I was buried deep in the research and writing process. My academic dean, Dr. Karen Thacker, never missed an opportunity to ask me how the book was coming, and she shared in my professional excitement throughout the long process. I am especially grateful to my faculty colleagues in Athletic Training who proof-read and offered me feedback when the chapters were being developed: Dr. Tom Porrazzo, Dr. Kim Stoudt, and Mr. Jay Mensinger. I would also like to acknowledge the invaluable insights my Kinesiology students offered as they read and reacted to portions of the text; they are who I wrote this book for and are my biggest support. I had images of their eager faces before me during the days of seemingly endless writing; they truly motivated me. Two students traveled to Duquesne to participate in the photo shoot, Courtney Renshaw and Mike Lloyd; Chris Burkert helped me out locally with additional photos. Our developmental editor, Jennifer Pine, was an absolute pleasure to work with and I am grateful for her continual encouragement and kind "nudging" to meet deadlines. Most importantly, I am honored to have had the opportunity to work with Peg Houghlum on this text. She is an amazing scholar and surely a champion in the field. I truly have been privileged to work with her.

Introduction

This book is written with a strong clinical base and perspective. The minimal biomechanical elements in this book are included only to allow an understanding of the clinical importance of these applications. The book is written with the intent of direct application of information to clinical, functional, and practical use. To that end, throughout the chapters there are *Practice Points*. These are special inserts that are related to the topic at hand and provide special clinical insight, information, or application of the topic discussed. The experience of the authors enables these “tidbits” of clinical reality to bring meaning to the information presented. The start of each chapter presents a *Clinical Scenario*. These clinical scenarios are again addressed at the end of the chapter, after the reader has acquired insight and information that assists him or her in realizing the significance of the scenario. Clinical relevance of information is repeated throughout the chapters to encourage students to see why it is important to know and understand the concepts presented throughout the text. The end of each chapter includes two types of exercises: discussion questions and lab activities. The discussion questions are thought-provoking as well as reminders of the more important take-home points of the chapter. The lab activities may be performed in small groups or individually and are intended to apply hands-on elements of the lessons within the chapter.

Since this is likely an introductory text for individuals seeking to eventually move into biomechanics, we have introduced mathematical formulas and concepts in English, not metric, values. We realize that most professional publications require metric values, but since many students have yet to progress in their careers to realize the significance or size of the numbers in terms of force or applications made either to or by the body, we prefer to put these formulas in the more familiar terms of the English measurement system.

Information in this text is divided into four units. Each unit contains specific information that falls under the umbrella of a single element within kinesiology. Kinesiology is broken down into these units to allow the reader to build on the information obtained in one unit to better understand the next, successive unit. The first unit is basic to understanding the other units of the book. It deals with the basic information that is relevant to the understanding of how the body functions from a

kinesiological perspective. Chapter 1 provides information on the basic structure and function of joints and muscles as well as planes and directions of motion. Chapter 2 involves the physical concepts that produce forces and torque, create levers, and how these impact body movement. Although it discusses physics concepts, it does so with a clinical approach, placing little emphasis on the mathematical methodology and more emphasis on the functional application. To provide a total perspective on body movement, Chapter 3 includes information on muscles and how they are constructed, how they function neurologically, and how they utilize energy for motion. Motor control and the body's ability to function dynamically through the interaction of multiple systems are presented. Chapter 4 is the final chapter of this unit, and it presents the various types of muscle contractions and how their functions change during motion. Whereas Chapter 3 discusses muscle function from a neurological approach, Chapter 4 discusses muscle's mechanical features, how changing length of muscle and altering angles of joints changes a muscle's ability to perform. It also looks at the main physical factors that determine muscle strength.

The second and third units utilize information from the first unit to develop a clinical understanding of how the body performs from a kinesiological perspective. These two units are divided into upper and lower extremities with the axial skeleton placed between them. Each of these chapters within these two units approaches its specific body segment in similar fashion: The bones and joints are presented and followed by a review of the muscles. Once this basic information is provided, how the segment functions is addressed, providing details that are unique for each body segment. Chapter 5 presents information on the shoulder complex. Chapter 6 delves into the elbow and forearm. Chapter 7 is written by an occupational therapist and deals with the complexities of the wrist and hand. Chapter 8 provides information on the axial skeleton and is written by a physical therapist with expertise on the spine. Chapters 9, 10, and 11 provide information on the hip, knee, and foot and ankle, respectively.

Unit 4, the final section of this text, puts all of the information in the previous three units into practical application for activities from those we perform on a daily basis to specific sport and leisure activities.

It provides the reader with application of the concepts introduced in the first unit and combines them with information about the specific body segments provided in the second and third units to create a total picture of kinesiology. Most clinicians are required to utilize their kinesiological knowledge to provide appropriate plans of care for the individuals they treat. After separating kinesiology into small tidbits to allow the reader to grasp the information, this last unit puts it all together to create the complete picture of what kinesiology is and how it is used in health care. Chapter 12 presents information on posture, stance, and gait. Topics include the joint motions, muscle activity, and forces seen in normal gait; the development and changes that occur in normal gait; and pathological gaits commonly seen clinically. It also goes beyond walking gait and analyzes running gait. Chapter 13 provides kinesiological analysis of activities of daily living. Sequences of movement, joint requirements, and muscle activity are analyzed for daily activities such as moving around on the floor, moving from sitting to standing, and lifting; analyses of

examples of work and household tasks are also provided. Chapter 14, written by an occupational therapist, provides special attention to upper extremity tasks and their analysis. Upper extremity tasks in this chapter are divided into tasks of the shoulder girdle, elbow, forearm, and wrist to provide the reader with in-depth analysis of common activities performed by these joints. Analysis of sports movements is the topic of Chapter 15. Sports are divided into competitive and recreational sports and are all commonly occurring activities at all levels of competition and within the greatest age range of participants.

As was mentioned, this book takes a strong clinical approach to kinesiology. It is not a biomechanics book, but a kinesiology text that presents information that is directly applicable to the concerns, needs, and functions of clinicians. It is meant to serve the purpose of providing present and future clinicians with the ability to appreciate human motion, understand relevant kinesiological application, and produce successful treatment results.

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