

**CRAM'S  
INTRODUCTION TO**

# **Surface Electromyography**

**SECOND EDITION**

Edited by

**ELEANOR CRISWELL, EdD**

**Director, Novato Institute for Somatic Research and Training  
Professor Emeritus, Sonoma State University**



**JONES AND BARTLETT PUBLISHERS**

*Sudbury, Massachusetts*

**BOSTON TORONTO LONDON SINGAPORE**

*World Headquarters*

Jones and Bartlett Publishers  
40 Tall Pine Drive  
Sudbury, MA 01776  
978-443-5000  
info@jbpub.com  
www.jbpub.com

Jones and Bartlett Publishers  
Canada  
6339 Ormindale Way  
Mississauga, Ontario L5V 1J2  
Canada

Jones and Bartlett Publishers  
International  
Barb House, Barb Mews  
London W6 7PA  
United Kingdom

Jones and Bartlett's books and products are available through most bookstores and online booksellers. To contact Jones and Bartlett Publishers directly, call 800-832-0034, fax 978-443-8000, or visit our website, [www.jbpub.com](http://www.jbpub.com).

Substantial discounts on bulk quantities of Jones and Bartlett's publications are available to corporations, professional associations, and other qualified organizations. For details and specific discount information, contact the special sales department at Jones and Bartlett via the above contact information or send an email to [specialsales@jbpub.com](mailto:specialsales@jbpub.com).

Copyright © 2011 by Jones and Bartlett Publishers, LLC

All rights reserved. No part of the material protected by this copyright may be reproduced or utilized in any form, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without written permission from the copyright owner.

The authors, editor, and publisher have made every effort to provide accurate information. However, they are not responsible for errors, omissions, or for any outcomes related to the use of the contents of this book and take no responsibility for the use of the products and procedures described. Treatments and side effects described in this book may not be applicable to all people; likewise, some people may require a dose or experience a side effect that is not described herein. Drugs and medical devices are discussed that may have limited availability controlled by the Food and Drug Administration (FDA) for use only in a research study or clinical trial. Research, clinical practice, and government regulations often change the accepted standard in this field. When consideration is being given to use of any drug in the clinical setting, the health care provider or reader is responsible for determining FDA status of the drug, reading the package insert, and reviewing prescribing information for the most up-to-date recommendations on dose, precautions, and contraindications, and determining the appropriate usage for the product. This is especially important in the case of drugs that are new or seldom used.

**Production Credits**

Publisher: David Cella  
Associate Editor: Maro Gartside  
Production Director: Amy Rose  
Associate Production Editor: Julia Waugaman  
Marketing Manager: Grace Richards  
Manufacturing and Inventory Control Supervisor: Amy Bacus  
Composition: Cape Cod Compositors, Inc.  
Cover and Title Page Design: Scott Moden  
Photo Research and Permissions Manager: Kimberly Potvin  
Assistant Photo Researcher: Emily Howard  
Cover Image: © gulsev/Shutterstock, Inc.  
Printing and Binding: Malloy Incorporated  
Cover Printing: Malloy Incorporated

**Library of Congress Cataloging-in-Publication Data**

Criswell, Eleanor.

Cram's introduction to surface electromyography / by Eleanor Criswell.—2nd ed.  
p. ; cm.

Rev. ed. of: Introduction to surface electromyography / Jeffrey R. Cram. 1998.

Includes bibliographical references and index.

ISBN-13: 978-0-7637-3274-5 (pbk.)

ISBN-10: 0-7637-3274-5 (pbk.)

1. Electromyography. I. Cram, Jeffrey R. Introduction to surface electromyography. II. Title. III. Title:

Introduction to surface electromyography.

[DNLM: 1. Electromyography. WE 500 C933c 2011]

RC77.5.C73 2011

616.7'407547—dc22

2009042383

6048

Printed in the United States of America

14 13 12 11 10 9 8 7 6 5 4 3 2 1

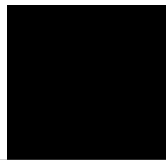
In memoriam

Jeffrey R. Cram

March 30, 1949 – March 2, 2005

Dedicated to Shannon, Heidi, and Maya





---

# Brief Contents

<b>PART I</b>	THE BASICS OF SURFACE ELECTROMYOGRAPHY . . . . .	I
Chapter 1	Introduction . . . . .	3
Chapter 2	Anatomy and Physiology . . . . .	9
Chapter 3	Instrumentation . . . . .	35
Chapter 4	Electrodes and Site Selection Strategies . . . . .	65
Chapter 5	General Assessment Considerations . . . . .	75
Chapter 6	Static Assessment and Clinical Protocol . . . . .	89
Chapter 7	Emotional Assessment and Clinical Protocol . . . . .	115
Chapter 8	Dynamic Assessment . . . . .	123
Chapter 9	Treatment Considerations and Protocols . . . . .	141
Chapter 10	Documentation . . . . .	163
<b>PART II</b>	SURFACE ELECTROMYOGRAPHY: PAST, PRESENT, AND FUTURE . . . . .	173
Chapter 11	The History of Muscle Dysfunction and Surface Electromyography . . . . .	175
Chapter 12	Somatics and Surface Electromyography . . . . .	191
Chapter 13	Electromyographic Assessment of Female Pelvic Floor Disorders . . . . .	203
Chapter 14	Surface Electromyography Past, Present, and Future . . . . .	231
Chapter 15	Conclusion . . . . .	243
<b>PART III</b>	ATLAS FOR ELECTRODE PLACEMENT . . . . .	245
Chapter 16	Electrode Atlas Overview . . . . .	247
Chapter 17	Electrode Placements . . . . .	257

<b>APPENDIX A</b>	GLOSSARY .....	385
<b>APPENDIX B</b>	ANSWERS TO CHAPTER QUESTIONS .....	391
<b>INDEX</b>	.....	393



# Contents

<b>FOREWORD TO THE FIRST EDITION</b> .....	xiii
<b>PREFACE</b> .....	xv
<b>PREFACE TO THE FIRST EDITION</b> .....	xix
<b>CONTRIBUTING AUTHORS</b> .....	xxi
<b>PART I THE BASICS OF SURFACE ELECTROMYOGRAPHY</b> .....	I
<i>Jeffrey R. Cram and Glenn S. Kasman</i>	
<b>Chapter 1 Introduction</b> .....	3
The History of Surface Electromyography .....	3
The Advantages and Disadvantages of Surface Electromyography .....	5
References .....	7
<b>Chapter 2 Anatomy and Physiology</b> .....	9
Basic Overview of the Neuromuscular System .....	9
Muscle Fibers and How They Work .....	12
Sensory Motor Integration .....	17
Nervous System Control .....	20
The Motor Unit .....	27
Motor Unit Recruitment Patterns .....	28
Factors That Affect Muscle Tension or Force .....	28
References .....	31
Chapter Questions .....	32
<b>Chapter 3 Instrumentation</b> .....	35
Introduction .....	35
The Source of the Electromyographic Signal .....	35
Impedance .....	37

	Differential Amplification and Common Mode Rejection . . . . .	39
	Filtering the Electromyographic Signal . . . . .	41
	Spectral Analysis, Fatigue, and Band Pass Filters . . . . .	42
	Types of Surface Electromyography Visual Displays . . . . .	43
	Quantification of the Surface Electromyographic Signal . . . . .	47
	Comparison of Quantified Surface Electromyography Values Across Instruments . . . . .	48
	Comparison of Quantified Surface Electromyography Values Across Muscles and Individuals . . . . .	49
	Amplitude Probability Distribution Function . . . . .	51
	Auditory Displays . . . . .	53
	Issues Regarding Noise and Artifact . . . . .	54
	How to Check Specifications of Surface Electromyographic Instruments . . . . .	57
	References . . . . .	62
	Chapter Questions . . . . .	62
<b>Chapter 4</b>	<b>Electrodes and Site Selection Strategies . . . . .</b>	<b>65</b>
	Electrode Selection . . . . .	65
	Electrode Leads and Cables . . . . .	69
	Site Preparation . . . . .	69
	Strategies for Electrode Placement . . . . .	70
	References . . . . .	73
	Chapter Questions . . . . .	73
<b>Chapter 5</b>	<b>General Assessment Considerations . . . . .</b>	<b>75</b>
	Factors That Affect Interpretation . . . . .	75
	Surface Electromyography and Clinical Syndromes . . . . .	80
	Assessment/Treatment Link: An Upper Quarter Example . . . . .	83
	Conclusion . . . . .	86
	References . . . . .	87
	Chapter Questions . . . . .	88
<b>Chapter 6</b>	<b>Static Assessment and Clinical Protocol . . . . .</b>	<b>89</b>
	Static Assessment . . . . .	89
	Normative Data . . . . .	90
	Within-Patient Analysis . . . . .	92
	Sensitivity and Specificity . . . . .	94
	Reliability . . . . .	95
	Stability of the Signal . . . . .	95
	Interpretation of Static Findings . . . . .	96
	Headache Example . . . . .	97
	Low-Back Pain Example . . . . .	98
	The Clinical Procedure Associated With the Static Assessment . . . . .	100
	Normative Data Comparison Considerations . . . . .	103
	Locations of Scan Sites and Interpretation for Each Site . . . . .	103
	References . . . . .	113
	Chapter Questions . . . . .	114
<b>Chapter 7</b>	<b>Emotional Assessment and Clinical Protocol . . . . .</b>	<b>115</b>
	Muscles and Emotional Display . . . . .	115
	The Facial Muscles . . . . .	115
	The Trunk Muscles . . . . .	116
	Relationship of Emotional Arousal to Muscle Activation . . . . .	117



	Reliability of Stress Profiling . . . . .	118
	The Stress Profiling Protocol . . . . .	118
	Patterns of Activation and Recovery . . . . .	119
	References . . . . .	121
	Chapter Questions . . . . .	122
<b>Chapter 8</b>	<b>Dynamic Assessment . . . . .</b>	<b>123</b>
	Dynamic Evaluation of the Neuromuscular System . . . . .	123
	The “Tonic Baseline” Amplitude . . . . .	125
	Recovery of Baseline Levels Following Movement . . . . .	125
	Assessment of Trigger Points . . . . .	125
	Range of Motion . . . . .	126
	Issues Pertaining to the Work Peak . . . . .	126
	Issues Pertaining to Temporal Factors . . . . .	128
	The Issue of Rest . . . . .	131
	Reliability of Dynamic Surface Electromyography Assessments . . . . .	134
	Assessment of the Pelvic Floor . . . . .	137
	References . . . . .	139
	Chapter Questions . . . . .	140
<b>Chapter 9</b>	<b>Treatment Considerations and Protocols . . . . .</b>	<b>141</b>
	An Overview of Treatment . . . . .	141
	Dynamic Relaxation Strategies . . . . .	150
	Surface Electromyographic Feedback and Neuromuscular Reeducation . . . . .	153
	Surface Electromyographic Feedback: Development of Recruitment and Timing Synergies . . . . .	155
	An Example Involving the Cervical Muscles . . . . .	158
	Summary for Uptraining . . . . .	158
	Pelvic Floor Considerations . . . . .	160
	References . . . . .	160
	Chapter Questions . . . . .	161
<b>Chapter 10</b>	<b>Documentation . . . . .</b>	<b>163</b>
	Basic Documentation . . . . .	163
	Assessment Considerations . . . . .	164
	Treatment Considerations . . . . .	166
	Documentation as an Outcome Measure . . . . .	167
	Relationship of Surface Electromyography to Other Measures . . . . .	167
	Comprehensive List of Elements to Document . . . . .	167
	Issues Pertaining to Third-Party Reimbursement . . . . .	168
	References . . . . .	169
	Suggested Readings . . . . .	169
	Chapter Questions . . . . .	170
<b>PART II</b>	<b>SURFACE ELECTROMYOGRAPHY: PAST, PRESENT, AND FUTURE . . . . .</b>	<b>173</b>
<b>Chapter 11</b>	<b>The History of Muscle Dysfunction and Surface Electromyography . . . . .</b>	<b>175</b>
	<i>Jeffrey R. Cram and Maya Durie</i>	
	Tissue-Related Issues . . . . .	175
	The Psychologic and Emotional Level . . . . .	177
	Sensory Motor Aspects: Movement-Oriented Approaches and Rehabilitation . . . . .	179
	Biomechanics and the Role of Posture . . . . .	182

Electrode Atlases . . . . .	183
A Brief History of Electricity and SEMG Instrumentation . . . . .	184
Conclusion . . . . .	185
References . . . . .	185
Chapter Questions . . . . .	188
<b>Chapter 12 Somatics and Surface Electromyography . . . . .</b>	<b>191</b>
<i>Eleanor Criswell</i>	
What Is Somatics? . . . . .	191
SEMG Monitoring and Somatics . . . . .	195
SEMG Feedback as a Somatics Discipline . . . . .	197
Somatic Exercises and SEMG . . . . .	199
What Is Needed for the Practice of Somatics and SEMG? . . . . .	200
Surface EMG and Somatic Psychotherapy . . . . .	200
Conclusion . . . . .	201
References . . . . .	201
Chapter Questions . . . . .	202
<b>Chapter 13 Electromyographic Assessment of Female Pelvic Floor Disorders . . . . .</b>	<b>203</b>
<i>Marek Jantos</i>	
Introduction . . . . .	203
Pelvic Floor Anatomy and Physiology . . . . .	203
Pelvic Floor Microscopic Anatomy . . . . .	207
Urogenital Pain . . . . .	207
Urinary Incontinence . . . . .	217
Sexual Dysfunction . . . . .	220
Responsibility and Competence in Treating Pelvic Disorders . . . . .	223
References . . . . .	224
Chapter Questions . . . . .	228
<b>Chapter 14 Surface Electromyography Past, Present, and Future . . . . .</b>	<b>231</b>
<i>Eleanor Criswell</i>	
SEMG Past . . . . .	231
SEMG Present . . . . .	239
SEMG Future . . . . .	240
Conclusion . . . . .	241
References . . . . .	241
<b>Chapter 15 Conclusion . . . . .</b>	<b>243</b>
References . . . . .	244
<b>PART III ATLAS FOR ELECTRODE PLACEMENT . . . . .</b>	<b>245</b>
<i>Jeffrey R. Cram and Glenn S. Kasman with Jonathan Holtz</i>	
<b>Chapter 16 Electrode Atlas Overview . . . . .</b>	<b>247</b>
Introduction . . . . .	247
Information Contained in the Electrode Atlas . . . . .	248
Reference Planes and Movement Descriptions . . . . .	250
References . . . . .	256
<b>Chapter 17 Electrode Placements . . . . .</b>	<b>257</b>
Frontal (Wide) Placement . . . . .	257
Temporal/Mastoid (Wide) Placement . . . . .	258
Temporal/Masseter (Wide) Placement . . . . .	260

Temporal/Suprahyoid (Wide) Placement . . . . .	262
Suprahyoid Placement . . . . .	262
Cervical Trapezius (Wide) Placement . . . . .	265
Upper Trapezius (Wide) Placement . . . . .	268
Anterior Temporalis Placement . . . . .	269
Masseter Placement . . . . .	271
Cheek (Zygomaticus) Placement . . . . .	271
Orbicularis Oculi Placement . . . . .	273
Buccinator Placement . . . . .	274
Frontalis (Narrow) Placement . . . . .	276
Corrugator Placement . . . . .	277
Sternocleidomastoid (SCM) Placement . . . . .	279
Scalene (Anterior) Placement . . . . .	282
Midcervical (C-4) Paraspinal Placement . . . . .	285
Cervical Dorsal (Wide) Placement . . . . .	287
Upper Trapezius (Narrow) Placement . . . . .	289
Interscapular (Middle Trapezius) Placement . . . . .	292
Lower Interscapular (Lower Trapezius) Placement . . . . .	293
Serratus Anterior (Lower Fibers) Placement . . . . .	297
Suprascapular Fossa (Upper Trapezius/Supraspinatus) Placement . . . . .	299
Infraspinatus Placement . . . . .	302
Anterior Deltoid Placement . . . . .	303
Middle Deltoid Placement . . . . .	305
Posterior Deltoid Placement . . . . .	306
Pectoralis Major (Clavicular and Sternal) Placement . . . . .	307
Wrist-to-Wrist (Wide) Placement . . . . .	309
Forearm Flexor/Extensor (Wide) Placement . . . . .	311
Forearm Extensor Bundle (Wide) Placement . . . . .	312
Forearm Flexor Bundle (Wide) Placement . . . . .	314
Biceps–Brachium Placement . . . . .	315
Triceps Placement . . . . .	319
Brachioradialis Placement . . . . .	321
Ventral Forearm (Pronator Teres) Placement . . . . .	323
Extensor Carpi Ulnaris Placement . . . . .	324
Extensor Carpi Radialis (Longus and Brevis) Placement . . . . .	325
Extensor Digitorum Placement . . . . .	327
Flexor Carpi Radialis and Palmaris Longus Placement . . . . .	328
Flexor Carpi Ulnaris Placement . . . . .	331
Flexor Digitorum Superficialis Placement . . . . .	332
Abductor Pollicis Longus and Extensor Pollicis Brevis Placement . . . . .	334
First Dorsal Interosseus Placement . . . . .	335
Flexor Pollicis Brevis Placement . . . . .	335
Abductor Pollicis Brevis Placement . . . . .	336
Dorsal Lumbar (Wide) Placement . . . . .	337
T-12 Paraspinal Placement . . . . .	338
Latissimus Dorsi Placement . . . . .	341
Low-Back (Erector Spinae) Placement at L-3 . . . . .	342
Lateral Low-Back (Quadratus Lumborum and External Obliques) Placement . . . . .	345
Rectus Abdominis Placement . . . . .	348
External Abdominal Oblique Placement . . . . .	349

Ankle-to-Ankle (Wide) Placement . . . . .	351
Gluteus Maximus Placement . . . . .	353
Gluteus Medius Placement . . . . .	356
Tensor Fasciae Latae Placement . . . . .	358
Femoral Triangle (Iliopsoas) Placement . . . . .	360
Hip Flexor (Sartorius) Placement . . . . .	361
Rectus Femoris Placement . . . . .	363
Vastus Lateralis Placement . . . . .	365
Vastus Medialis (Oblique) Placement . . . . .	366
Hip Adductor (Adductor Longus/Gracilis) Placement . . . . .	367
Medial and Lateral Hamstring Placement . . . . .	369
Ankle Dorsiflexor (Tibialis Anterior) Placement . . . . .	371
Gastrocnemius Placement . . . . .	374
Soleus Placement . . . . .	374
Extensor Digitorum Brevis Placement . . . . .	376
Perivaginal and Perirectal Placement . . . . .	377
References . . . . .	379
Chapter Questions . . . . .	381
<b>Appendix A Glossary . . . . .</b>	<b>385</b>
<b>Appendix B Answers to Chapter Questions. . . . .</b>	<b>391</b>
<b>INDEX . . . . .</b>	<b>393</b>



---

## Foreword to the First Edition

The privilege of reading the manuscript of a book by distinguished authors before its publication is always a thrilling experience. When the material is as sparkling as in this book, one feels truly privileged and honored to be asked to write the foreword. This is a fine book that will meet the needs of many scientists and clinicians in a wide range of specialties. Both those who directly employ surface electromyography for any purpose and those who have to understand its consequences will be ever grateful to the authors.

This book is written in an astute style that clearly informs *all* readers, even such as this grizzled veteran. Only after a while will the novice reader awaken to the fact that, *mirabile dicitur*, a profound learning experience has happened without the use of a computer or TV screen. Few scientific or clinical books today succeed in this game of seizing and holding the reader's interest in spite of the level of sophistication of either the reader or the subject matter.

Not only are the style and organization complete and well integrated, the choices of words and phrases are friendly and beckoning without annoying those readers who are more comfortable with scientific and clinical jargon. In this book, a spade is called a spade, but it is a shiny, well-used spade and not an “automated excavating system” used by over-anointed writers.

To summarize, it is simple and accurate to say this is a very fine book and I am happy to have read it before its birth. Moreover, I expect to refer to it *ad lib* after publication and to recommend it to others.

John V. Basmajian, DC, MD, FRCP, FRCPS  
Professor Emeritus  
McMaster University  
Hamilton, Canada





## Preface

*The muscles of the body are critical to almost every form of human behavior. In fact, without muscle activity there would be no observable behavior or skilled actions that we come to expect in behavior.*<sup>1</sup> (p. 229)

*[Surface electromyography] is a very interesting area in which to work, because the same end organ (the muscle) is under the command of three masters: gravity (posture), emotions, and movement.*<sup>2</sup> (p. xiii)

What is surface electromyography? Surface electromyography (SEMG) is a field specializing in the use of electronic devices to measure the energy of the muscles, to analyze the data, and to display the results. Surface electromyography rests on the practitioner's understanding of anatomy, physiology, and the instrumentation. It is an example of applied psychophysiology: the use of psychophysiological knowledge and skills in the evaluation and treatment or training of individuals presenting with psychophysiological complaints or goals. Surface electromyography is a multidisciplinary field that encompasses contributions from electronics, medicine, anatomy, physiology, psychology, psychophysiology, physical therapy, occupational therapy, ergonomics, and so forth.

Surface EMG has many applications, including assessment, treatment planning, evaluation of progress and outcomes, rehabilitation, worksite ergonomic design, sports training, and research. This technology helps differentiate between beliefs about muscle function and actual function, and is used in evaluation and rehabilitation. Surface electromyography is used with patients and clients by physical therapists, occupational therapists, psychologists, dental professionals, biofeedback trainers, stress management consultants, corporate safety consultants, sports psychologists, arts medicine practitioners, ergonomics consultants, and somatics

educators/practitioners, among others. The feedback provided by this technique works best when combined with other therapies. Regardless of how SEMG is being used, a solid foundation in the principles of SEMG is necessary to be effective.

There were 14 chapters in the first edition of this book; there are 17 chapters in this second edition. In the second edition, 13 of the original chapters, the SEMG atlas, and the appendices remain. Chapter 14, "Surface Electromyography Past, Present, and Future," has been rewritten to reflect progress in the field. New chapters by Jeffrey R. Cram, Maya Durie, Eleanor Criswell, and Marek Jantos have been added as well. An emphasis on somatics has been included in the second edition at Jeffrey Cram's request.

Part I provides information on the basics of surface electromyography, including the history of SEMG; the advantages and disadvantages of SEMG; anatomy and physiology; instrumentation; electrodes and site selection strategies; general assessment considerations; static assessment and clinical protocol; emotional assessment and clinical protocol; dynamic assessment; treatment considerations and protocols; and documentation. Part II features chapters titled "The History of Muscle Dysfunction and Surface Electromyography" by Jeffrey R. Cram and Maya Durie, "Somatics and Surface Electromyography" by Eleanor Criswell,

“Electromyographic Assessment of Female Pelvic Floor Disorders” by Marek Jantos, “Surface Electromyography Past, Present, and Future” by Eleanor Criswell, and the conclusion. Part III features the Atlas for Electrode Placement developed by Jeffrey R. Cram and Glenn S. Kasman with Jonathan Holtz, the electrode atlas overview, and electrode placements for key muscles. An expanded glossary of terms appears at the back of the book; the answers to the chapter questions can also be found there.

The cornerstone of this book remains the electrode atlas found in Part III. “Knowing the map of the territory—where to place the surface electromyography (SEMG) electrodes and what to expect to see during a given movement—will greatly assist the practitioner in understanding the energy that the muscle gives off.”<sup>2</sup>(p. xiii) The atlas of electrode placement covers 69 electrode placement sites. Along with illustrations showing electrode placement sites, information is provided about each muscle in question: its action or purpose, clinical uses (such as for specific presenting complaints), origin and insertions of the muscle, innervation of the muscle (nerve supply to the muscle), as well as information on joint considerations, location of electrodes, behavioral tests to determine the type of placement (general or specific), the accuracy of the electrode placement, comments about the tracings, volume conduction, other sites of interest, possible artifacts, and benchmark measures. Surface EMG tracings, photographs, tables, graphs, and drawings throughout the book demonstrate the concepts under discussion. The discoveries by Cram, Kasman, and others are highly useful gems scattered throughout the book.

Since the first edition of this book was published, a tremendous amount of research has been conducted using surface EMG. This research has taken place all over the world (see Chapter 14). In these studies, many aspects of human behavior have been assessed using SEMG, including work performance, sports performance, rehabilitation, and movement analysis. The second edition reflects that research.

Who can benefit from *Cram’s Introduction to Surface Electromyography*? Designed to introduce the reader to the principles and practices of SEMG, this book is suited to both beginners in the field—upper-division university students, master’s and PhD students, beginning professionals, and educated laypersons—and advanced professionals who want to deepen their SEMG knowledge. This book will prove useful for physical therapists, occupational therapists, biofeedback trainers, behavioral

medicine practitioners, psychologists, dentists, chiropractors, biomedical engineers, exercise physiologists, and complementary and alternative medicine practitioners. The reader who learns more about SEMG will be more effective in his or her work.

Physical and occupational therapists will benefit greatly from SEMG objective measures that can show chronic muscle contractions, postural difficulties, inadequate activation of muscles, and the like. They have a great need for such data in their assessments, evaluations of patient progress, and discharge planning. In situations where objective data are highly valued, such as with third-party payers, SEMG recordings are invaluable. Nevertheless, the information in this book is useful regardless of whether the reader plans to use SEMG directly or indirectly in his or her work. This modality is an important means of gathering data about human functioning: it offers a clear measure of the mind-body connection. The SEMG data are particularly understandable because people are used to contracting muscles to engage in movements to achieve their goals. For this reason, SEMG is finding a home in mind-body medicine.

Surface electromyography is valuable for somatics educators of all disciplines who seek a deeper understanding of the mind-body connection, for the training of somatics practitioners/educators, and as a means of enhancing the effectiveness of the somatics approaches. For somatics educators using SEMG, it is valuable to see what is happening inside the client during somatics practices; for SEMG biofeedback practitioners, it is valuable to use the somatics disciplines to complement the adjunctive procedures, such as progressive relaxation, that are typically employed.

Although the use of SEMG equipment can be learned through manuals and online instructions, the reader is strongly urged to get thorough training in the use of SEMG through an established training program with highly trained, experienced SEMG professionals in the field. Certification by the Biofeedback Certification Institute of America in general biofeedback, which includes SEMG, is important for using this technology in a clinical setting.

Accuracy in SEMG recordings is essential. The old computer-related saying, “Garbage in, garbage out,” is very apt here. In other words, if the recordings are not accurate, the data will not be accurate. Reliability and validity of the data are always important. Inaccurate data are always worse than worthless, because the practitioner and the patient may draw conclusions from the data that are not warranted. Accuracy is particularly



important in SEMG research. Research design and description of the procedures, equipment, data gathered, conclusions, and so forth need to allow for replication. This book provides detailed step-by-step methods for ensuring accurate SEMG recordings.

The reader already knowledgeable about SEMG may want to read those sections that are most relevant to his or her needs first; those new to the field may wish to start at the beginning. Another approach is to begin with the instrumentation chapter, practice using the equipment, and then go on to acquire more detailed knowledge from the chapters devoted to anatomy and physiology, neurophysiology, and the like over time, reading the rest of the chapters in Part I and referring to Part III as needed. For continued SEMG study, a variety of professional training programs and university-based programs include SEMG as part of their general biofeedback offerings. (Contact the Association of Applied Psychophysiology and Biofeedback [AAPB] and the Biofeedback Certification Institute of America [BCIA] for information about relevant programs.)

The term *patient* is used throughout this book, except in Chapter 12, because SEMG is most commonly used in rehabilitation and other medical settings. The term *client* is used in the “Somatics and Surface Electromyography” chapter because in the somatics world the participant is called a client and the practitioner is called an educator or practitioner. Somatics is a client-centered educational process. Many biofeedback (SEMG) settings are client centered as well.

The SEMG field continues to have enormous potential. The professionals and organizations that serve it continue to expand the knowledge, skills, and application areas through professional meetings, journals, seminars, conferences, and networking. For example, SEMG research has appeared in more than 42 journals worldwide in the last 10 years. Key organizations in the field are the Association for Applied Psychophysiology and Biofeedback (AAPB) (the Surface EMG Society of North America is now the Surface EMG division of AAPB), the Biofeedback Foundation of Europe, and the International Society of Electrophysiological Kinesiology (ISEK) (formerly the International Society of Electromyography and Kinesiology).

Surface electromyography is an exciting and growing field with huge potential for teaching people how to grow healthily; age successfully; take care of neuromuscular complaints that develop over time due to accident, injury, illness, repetitive use, and the like; and actualize more of their somatic potential for optimal

performance. Manufacturers of SEMG equipment can be found throughout the world. Research, clinical applications, and new technology are all fostering the growth of this field. Neuroimaging in relationship to motor performance is a valuable development in the understanding of SEMG. Telemetry systems and other technological innovations will continue to expand what is possible with SEMG and its contribution to enhanced human functioning.

## ACKNOWLEDGMENTS

---

I would like to acknowledge and offer my deep thanks to the following individuals: Marsha Calhoun, the copy editor for the second edition, whose work on this edition was invaluable; Wendell Hanna, for her research assistance; Satri Pencak, for assistance with the Hanna photograph; Jeffrey Cram, Glenn Kasman, and Jonathan Holtz for their fine earlier edition; Jeffrey Cram for his invitation to bring somatics into this edition and finally to assume editorship; Shannon Cram, Heidi Cram, and Maya Durie for their help and encouragement; Allegra Hiner and Sam Hiner, key staff members, and Phil Shenk and Susan Koenig, Hanna Somatic Education Core Teachers of the Novato Institute for Somatic Research and Training, for their ongoing support; my advisors Richard Stone, Belinda Scrimenti, and Neil Russack; Charles Merrill, Stephen Sideroff, Jone Bondoc, Elaine Leeder, Dennis and Deborah Reis, and Kara Knack for their friendship and encouragement; our care team of Marianne Locke, Jerry Moore, Conrad Knudsen, Marsha Harrison, and Lyman Spencer; my long-time colleagues at the Biofeedback Society of California, the Association for Applied Psychophysiology and Biofeedback, and the Biofeedback Certification Institute of America; Steve Wall and Katee Wynia of the Bio Research Institute for our many years of shared biofeedback explorations at Sonoma State University (SSU) and beyond; the students in the Professional Biofeedback Training Sequence at SSU over the past 25 years from whom I learned so much; the chair, Gerrmann Olson, and faculty and staff of the Psychology Department at SSU for their appreciation and support of the biofeedback program over the years; and the staff from Jones and Bartlett Publishers, especially Maro Gartside, Julia Waugaman, and Teresa Reilly, for their understanding and able assistance. Above all, I would like to thank my husband, Pernell Roberts, for his deep understanding and caring.

## REFERENCES

---

1. Andreassi JL. *Psychophysiology: Human Behavior and Physiological Response*. 5th ed. Mahwah, NJ: Lawrence Erlbaum Associates; 2007.
2. Cram JR, Kasman GS. *Introduction to Surface Electromyography*. Gaithersburg, MD: Aspen; 1998.



# Preface to the First Edition

The cornerstone of this book is the electrode atlas found in Part II. Knowing the map of the territory—where to place the surface electromyography (SEMG) electrodes and what to expect to see during a given movement—will greatly assist the practitioner in understanding the energy that the muscle gives off. Indeed, many times during the collection of tracings for a particular set of muscles, I found myself and others asking, “What happens if we do *x*?” Then we tried *x* and were either pleasantly surprised or confused and disappointed. Sometimes the system worked as we had been told it would by others. Sometimes it was far too complex to see what we expected to see, given the simple tools and procedures we were using. Capturing a valid SEMG tracing is sometimes associated with a subtle event. For example, I was duly impressed by the changes in recruitment patterns as we instituted small postural or positional requirements on the limbs or torso. To this day, I remember my amazement at how a simple sternal lift could facilitate the recruitment of lower trapezius. There are literally dozens of gems like this sprinkled throughout this book. The tracings in this book illustrate what can be seen using the SEMG technology. We hope that they stimulate the reader’s curiosity and that readers explore the movement of their own patients while measuring muscle energy patterns.

The static and dynamic assessment chapters provide the background and protocols in detail for almost all of

the current assessment procedures. This is a very interesting area in which to work, because the same end organ (the muscle) is under the command of three masters: gravity (posture), emotions, and movement. Muscle scanning is a method for assessing the neuromuscular aspects of posture; stress profiling is the method to quantify the emotional component; dynamic SEMG procedures provide the basis for assessing movement. Practitioners need to think in this three-dimensional manner if they want to find successful solutions when something goes wrong.

Part I reviews the basic tenets of the treatment of musculoskeletal and pain-related disorders and provides a few examples of these approaches. Additional information is found in the companion book *Clinical Applications in Surface Electromyography: Chronic Musculoskeletal Pain*. I highly recommend that readers study this very scholarly, yet pragmatic review of what we know about the use of SEMG in treating a variety of conditions.

History, anatomy, physiology, and instrumentation are the foundations upon which the clinical practice of SEMG rests. Every practitioner who uses electromyography should have a sound understanding of what is behind the SEMG screen displays. Chapters 1 through 3 provide this information in an easy-to-understand fashion. For those who are new to the area of SEMG and are just learning the jargon, we have included a glossary

(Appendix A) to provide definitions of some of the basic concepts.

Surface EMG is seen as an emerging technology. We have just begun to scratch the surface of its clinical potential. Chapter 11 provides some glimpses into where SEMG may be moving as it unfolds.

As is true for all manuscripts, literally hundreds of people have helped bring this book into print. The greatest contributors to this book were the many students in my workshops, whose curiosity and enthusiasm led me to seek out the “essence” of a given muscle, for a given movement, while exploring electrode placement strategies. Four of these students became dear friends, colleagues, and eventually my teachers. Will Taylor, Stu Donaldson, Jonathan Holtz, and Glenn Kasman helped to create the boundaries and channels into which this introductory volume on SEMG flowed, but it was Glenn Kasman’s commitment to work on this book that set it in motion. And, once under way, it was the substantive

editing of Steven Wolf that provided the basis for course corrections, and the buff and polish of Glenn Kasman, Blair Schular, Diana Huff, and Maya Cram that made it intelligible.

Many people made the tracings for the electrode atlas possible. With minds like those of Glenn Kasman and Jonathan Holtz, the power and beauty of SEMG recordings began to emerge as we intensively studied a few individuals. Some of those individuals, who spent hours or days with us and allowed us to place electrodes here and there while we asked them to move this way or that, deserve special recognition. Specifically, the efforts of David Rommen, Dennis Harmoo, Mark Woodburn, Carrie Hall, Paula Holtz, and Maya Cram helped to make the atlas possible. Finally, this book has hundreds of graphics contained within its pages. Many of these were created by Bella and Dave Bingham and Heidi Cram.

*Jeffrey R. Cram, PhD*



---

## Contributing Authors

**Jeffrey R. Cram, PhD**

Director, Sierra Health Institute  
President, Clinical Resources  
Nevada City, California

**Maya Durie, MEd, CMT**

Massage Therapist and Movement Educator  
Mill Valley, California

**Jonathan Holtz, MA, PT**

Santa Cruz, California

**Marek Jantos, PhD**

Director of the Behavioural Medicine Institute  
Adelaide, Australia

**Glenn S. Kasman, MS, PT, FACHE**

Vice President of Professional Services and Business  
Development  
MultiCare Good Samaritan Hospital  
Puyallup, Washington

