



Respiratory Muscle Strength Training

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Front cover illustrations created by Maury Aaseng.

Typeset in 11/13 ITC Garamond by Achorn International
Printed in the United States of America by Integrated Books International

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Library of Congress Cataloging-in-Publication Data

Names: Sapienza, Christine M., editor. | Hoffman, Bari, editor.
Title: Respiratory muscle strength training / [edited by] Christine Sapienza, Bari Hoffman.
Description: San Diego, CA : Plural Publishing, Inc., [2021] | Includes bibliographical references and index.
Identifiers: LCCN 2020047735 | ISBN 9781635502572 (paperback) | ISBN 9781635502602 (ebook)
Subjects: MESH: Breathing Exercises—methods | Respiratory Muscles—physiology | Muscle Strength | Respiration Disorders—therapy
Classification: LCC RA782 | NLM WB 543 | DDC 613/.192—dc23
LC record available at <https://lccn.loc.gov/2020047735>





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§ Preface §

The intent of this clinical guide is to provide clinicians with background information regarding respiratory muscle strength training (RMST). Since the early 1970s, discussion of the benefits of RMST and its program protocols have filled our published literature. As a researcher I have been involved in testing RMST protocols in a variety of patient groups and was given opportunity to co-invent with my colleagues at the University of Florida, an expiratory pressure threshold trainer. Beyond those past experiences I have spent my entire career in higher education, where I have learned from my colleagues, both scholars and clinicians.

Now, my time is spent educating those interested in RMST, with the great fortune of having a substantial literature on RMST techniques to rely on. RMST is a program that uses devices to increase inspiratory or expiratory muscle strength.

This guidebook elucidates the RMST protocol through contributed case studies provided by well-known authors and clinicians using the protocols within the field of health care. I am extremely grateful that they shared their time and knowledge as contributors to this book. Their work is sure to continue as they help our field understand the outcomes for breathing, airway management, and speech/voice.

The American Speech-Language-Hearing Association recognizes the critical role of the speech-language pathologist in assessing and treating disorders of abnormal respiratory patterns and airway protection. These disorders cross into much of our patient care, whether it be acute or chronic, or whether treating primary versus secondary symptoms.

It is our hope that this book clarifies the principles and practices of RMST through the case studies, as well as answers frequently asked questions. It is our professional responsibility to distinguish between RMST protocols that have supporting outcome data and those that base outcome claims on anecdotal reports. The importance of how to use RMST for particular patient





x *Respiratory Muscle Strength Training*

populations requires consideration of the mechanisms of a patient's disease, as would be the case for any intervention strategy.

Note: The information and opinions provided in this book are believed to be accurate.





§ About the Editors §

Christine Sapienza, PhD, CCC-SLP, is currently provost at Jacksonville University and professor of the department of communication sciences and disorders at Jacksonville University (JU). After a 20-year career at the University of Florida, Dr. Sapienza joined JU to administer an inaugural master's program in speech-language pathology. She went on to serve 5 years as dean of the Brooks Rehabilitation College of Healthcare Sciences (BRCHS), setting a pace for the development and growth of the college. Under her leadership, the BRCHS became the largest and fastest-growing college at JU. Dr. Sapienza has a history of securing grants from the National Institutes of Health, the MJ Fox Foundation, and the Department of Veteran's Affairs.

A leading scholar in the discipline of speech-language pathology and rehabilitation, Dr. Sapienza has published more than 120 peer-reviewed articles, placing her among the most cited authors in her field with an overall scholar score of *outstanding*.

Known globally as the co-inventor of the expiratory muscle strength trainer (the EMST150), which is used by speech-language pathologists around the world, Dr. Sapienza continues to invent new devices to help deliver safe, quality patient care. She also has written best-selling textbooks and edited volumes that teach rehabilitation strategies to clinicians. Dr. Sapienza holds a PhD in speech science from the University at Buffalo, as well as master's and bachelor's degrees in communication sciences. Her areas of specialization include voice, respiratory muscle strength training, swallow function, and neurodegenerative diseases.

Bari Hoffman, PhD, CCC-SLP is professor and associate dean for clinical affairs in the College of Health Professions and Sciences at the University of Central Florida. She also serves as director of the Center for Voice Care and Swallowing Disorders at the Ear, Nose, Throat, and Plastic Surgery Associates. She has worked clinically in this setting for more than 20 years treating individuals with voice and upper-airway disorders specializing in pediatric, professional, and neurogenic





populations, along with individuals undergoing treatment for head and neck cancer. Dr. Hoffman received her doctoral degree from the University of Florida in 2001. Her current research involves studying novel treatment technologies and biomechanical mechanisms for disorders of laryngeal function while defining the high impact on quality-of-life factors. She implements 3-D computer modeling of upper and lower airway function, coping strategies of individuals with dysphonia, and respiratory muscle strength paradigms in a variety of patient groups. Dr. Hoffman has a significant record of peer-reviewed publication and authorship of two other textbooks: *Voice Disorders, Fourth Edition* and *Cases in Head and Neck Cancer: A Multidisciplinary Approach*. She actively lectures nationally and internationally on these topics. In recognition of her contributions to teaching, research, and service, she has received numerous awards within her university, state, and national association.

Note: Dr. Sapienza holds no ownership rights to the EMST150 device.





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This book is dedicated to our patients who have sought treatment for their disease and to all of our colleagues who are contributing to the understanding of RMST devices and RMST protocols.







§ 1 §

Respiratory Anatomy and Physiology

Christine Sapienza

To help guide your patient with the process of respiratory muscle strength training RMST, a review of respiratory anatomy and physiology is critical so that you can systematically manage the patient's deficits or symptoms.

Often, patients complain of symptoms related to breathing. These symptoms can originate in the respiratory structures (i.e., lung disease) or can present because of respiratory muscle weakness or motor incoordination. Respiration is complex and is centrally driven by multiple structures, one of which is the brain stem, where the respiratory central pattern generator is located.

WHAT IS RESPIRATION?

Respiration is the recognized term for the exchange of oxygen from the environment for carbon dioxide from the body's cells. Each respiratory breath consists of an inspiratory and expiratory cycle. Inspiration is life sustaining, bringing to the airways the main gas of oxygen, which keeps our body cells vital. Expiration is the act of expelling air out of the lungs, allowing for the release of carbon dioxide, which is considered the waste gas



produced when carbon is combined with oxygen as part of the body's energy-making processes.

Structures Involved in Respiration

The Lungs

The lungs are elastic tissue that inflate and deflate and, as a result of the inflation and deflation, move air. Anatomically, there are three lobes on the right lung and two lobes on the left lung. The right lung is larger than the left lung to make room for the heart (Figure 1-1).

The Trachea

The trachea is a cartilaginous structure that allows air to pass from the nose and mouth into the lungs. It is made up of 16 cartilaginous rings. The larynx sits on top of the uppermost tracheal ring. Anatomically, it lies in part of the neck and part of the chest cavity.

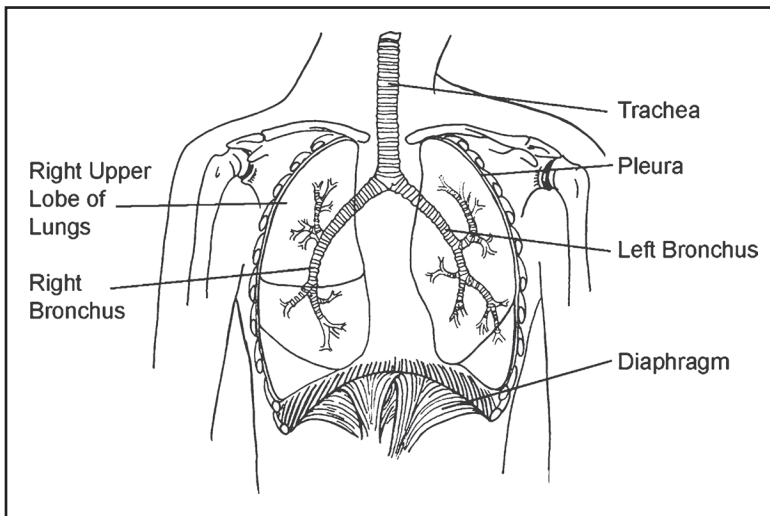


Figure 1-1. Lower airway and right and left lungs.

The Bronchi

Two main bronchi branch off of the trachea, one going to each lung (Figure 1–2). Smaller branches from the bronchi continue to divide, and are known as *secondary bronchi*. There are three secondary bronchi supplying the right lung and two secondary bronchi supplying the left lung. Bronchioles are the smallest branches stemming from the secondary bronchi and lead to the alveoli where gas exchange occurs allowing air to enter into the blood. Alveoli are tiny air sacs, and each of us has hundreds to millions of alveoli in our lungs. The exchange of oxygen and carbon dioxide takes place in the alveoli.

The Thorax

The thorax is the chest cavity that surrounds and protects the lungs as well as the heart and other respiratory structures such as the bronchial tree. The thorax is made up of the ribs and muscles, and its most inferior aspect is the diaphragm.

The Ribs

There are 12 pairs of ribs. Ribs 1 through 7 are called the *true ribs* and ribs 8 through 10 are called the *false ribs*. Ribs 11 and 12 are called *floating ribs* because they do not attach to the sternum like ribs 1 through 10 do. The lungs are attached to the inside

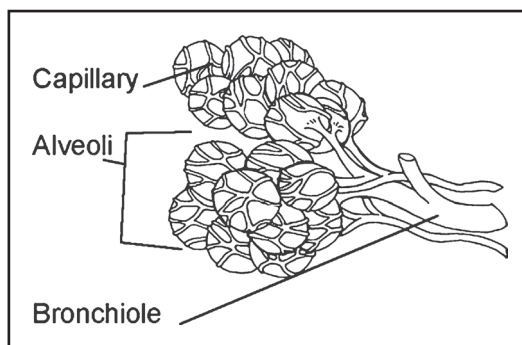


Figure 1–2. Final branches of the respiratory tree where primary gas exchange occurs.

of the ribs by pleura, a thin lining that covers the outside of the lungs (visceral pleura) and the inside of the rib cage (parietal pleura).

The Diaphragm

The diaphragm anatomically separates the chest from the abdomen. It is the major muscle of inspiration. At rest, the diaphragm sits in a dome-shaped position; when it contracts during inspiration, it moves downward and flattens, enlarging the chest cavity. As the diaphragm moves downward, the force is transferred to the lower ribs, moving them outward. This happens because, as the diaphragm contracts, it is opposed by the passive properties of the abdominal wall, the tone of its muscles, and the inertia of the abdominal contents. When this occurs, the intra-abdominal pressure rises and the lower rib cage expands (Goldman, Rose, Morgan, & Denison, 1986). This in turn enlarges the thoracic

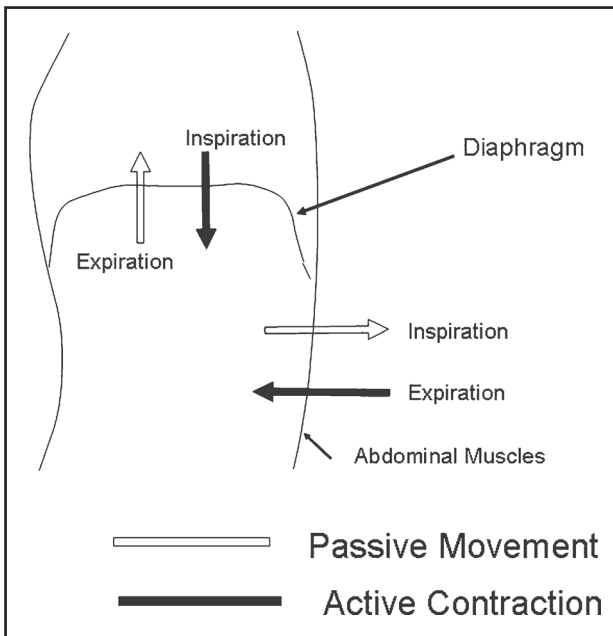


Figure 1-3. Direction of thoracic cavity movement with inspiration and expiration.

dimension, creating an inspiratory maneuver. When you are quietly breathing, your diaphragm is doing all of the work. When the brain stem sends messages to the breathing muscles to contract, the diaphragm is pulled downward, enlarging the space filled by the lungs. This creates a temporary partial vacuum into which air rushes, inflating and expanding the lungs. When the diaphragm relaxes, the lung space is reduced, pushing air out. Unfortunately, serious life-threatening conditions result when there is impairment to the diaphragm. For example, when the upper cervical spinal cord is damaged in spinal cord injury cases such as Christopher Reeve's, the damage to the cervical spinal cord impacts breathing ability because the neural signals that drive rhythmic breathing are removed and the diaphragm muscle is paralyzed (Figures 1–3 and 1–4).

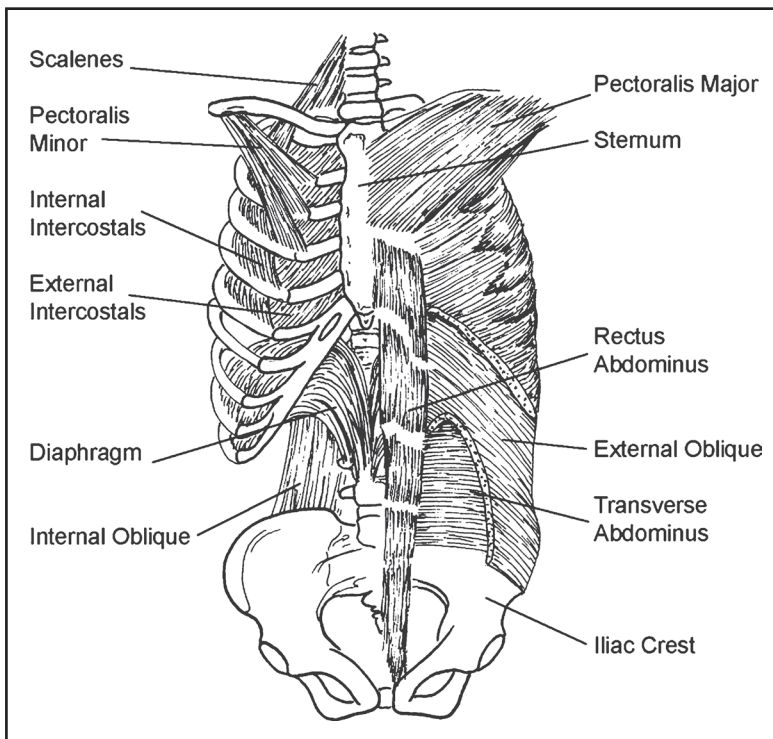


Figure 1–4. The abdominal musculature and supporting structures.



The Abdominal Wall

The abdominal wall is a layered structure made up of central and lateral muscles that arise from the ribs and the pelvic girdle. It has passive and active properties that are described in more detail below. During passive expiration, the abdominal wall draws in, and during effortful tasks such as coughing, sneezing, and certain voicing tasks, the abdominal muscles contract to compress the abdominal contents. This, in turn, increases the intra-abdominal pressures. This compression also is important for other functions such as defecation, childbirth, and cough production.

Sternum

The sternum has three processes that attach to respiratory muscles such as the diaphragm and intercostal muscles. The first seven ribs are attached to the sternum. The three processes include the manubrium, body, and xiphoid process. The manubrium appears as a handle and attaches to ribs 1 and 2, the corpus is the body of the sternum and attaches to ribs 2 through 7, and the xiphoid process is the smallest of the three parts and partially attaches to many muscles including some of the abdominal wall muscles.

The Clavicle

The clavicle is commonly known as the *collarbone*, and the two bones of the clavicle extend from the manubrium. The clavicle attaches to certain respiratory muscles such as the trapezius, pectoralis major, and sternocleidomastoid.

Respiratory Physiology: Driving Forces of the Respiratory System

The process of moving air requires a driving force. The force is the pressure difference between the alveolar pressure (i.e., pressure within the alveoli) and the atmospheric pressure (Figures 1–5 and 1–6). Alveolar pressure typically is referenced with respect to atmospheric pressure, and atmospheric pressure is always set to zero. When alveolar pressure is above atmospheric pressure, it is

