

# Perceived Exertion Laboratory Manual



Luke Haile • Michael Gallagher, Jr.  
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# Perceived Exertion Laboratory Manual

From Standard Practice to Contemporary  
Application

 Springer

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*I dedicate this book to a few very important people in my life. First, to my parents, for always pushing me to do my best while pursuing my dreams every step of the way. Second, to the teachers who had the most profound influence on me throughout my education: Greg Laubach, Joseph Andreacci, Robert Robertson, and Fredric Goss. Each of them showed me how to be an educator, researcher, and advisor by being an all-around good man. Third, to my wife, Amanda, and son, Samuel, for being my unending motivation to live with purpose and passion.*

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*I dedicate this book to my family, friends, teachers, and students. Each of them continually challenges me to be the best version of myself; as a son, a brother, a colleague, and as a mentor. I would not be where I am today without their love and support.*

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*To my wife Margaret, whose sage advice and sound judgment have supported me throughout my professional career.*

RJR



# Preface

This unique laboratory manual contains a series of conceptually linked research paradigms that are based on an empirical framework for tailoring individualized exercise programs to client perceptions and behaviors. The various laboratory experiments are teaching tools that analyze perceptual and psychosocial variables that influence participation in physical activities, describe methods for assessing these factors in clients, examine guidelines for exercise prescription and program evaluation, and feature practical applications of current research. The rationale underlying each of the experiments is based on a combination of scientific findings and psychological insights that will teach students and practitioners how to create effective strategies for increasing physical activity in clients at various stages of health and illness. The manual is formatted such that the experiments can be performed individually or sequentially in groups of two or more depending on the extent of the knowledge base that informs the learning experience.

In the late 1950s and early 1960s, research was conducted by Swedish psychologist Gunnar Borg, together with medical doctor and clinical physiologist Hans Dahlstrom, that explored psychophysics and perception in the context of sports and occupational endeavors. Borg's 1962 monograph of his doctoral dissertation research, *Physical Performance and Perceived Exertion*, introduced the field of perceived exertion to the world. Bruce Noble invited Borg to visit the University of Pittsburgh in the fall of 1967, marking the beginning of perceived exertion research in the United States. The following spring of 1968, Borg continued his trip with a short drive Northeast to the Pennsylvania State University, where he visited Ellsworth Buskirk, James Skinner, and Oded Bar-Or. The visit culminated with the American College of Sports Medicine annual meeting, which was held in State College, Pennsylvania. The presentations made at this conference, most notably by Borg, Noble, and Michael Sherman, were the first broad exposure of perceived exertion research to an audience of United States exercise scientists.

In 1973, Borg made a second visit to the University of Pittsburgh to continue his work with Noble and his doctoral students, Robert Robertson, Kent Pandolf, and Enzo Cafarelli. During this trip to the United States, Borg also visited the University of Wisconsin to collaborate with William Morgan. These five scientists Noble,

Robertson, Pandolf, Cafarelli, and Morgan began the proliferation of perceived exertion research throughout the United States and other parts of the world. Most exercise scientists conducting perceived exertion research today can be linked to one of these researchers through their scientific genealogy, connecting student to mentor back through the generations.

In 1996, almost 30 years after Borg's first visit to the University of Pittsburgh, Noble and Robertson published a book entitled *Perceived Exertion*. This was the first all-encompassing synthesis of the burgeoning field of perceived exertion. It provided both an empirical and theoretical resource for researchers and clinicians. The text included a historical review, from the roots of modern psychology to the advancement of psychophysical scaling and the development of the field by Borg. It described the development, administration, and experimental use of Borg's rating of perceived exertion (RPE) scale and discussed the theoretical models developed to explain how psychophysiological signals mediate the intensity of exertional ratings. Great detail is devoted to both specific and broad explanations for the involvement of the physiological (i.e., respiratory-metabolic and peripheral mediators) and psychological inputs to the effort sense, whether conscious or unconsciously monitored. In addition, the text includes a summary of research involving the use of RPE for exercise testing and prescription by both the exercise leader and client.

In 2004, Robertson published a book entitled *Perceived Exertion for Practitioners: Rating Effort with the OMNI Picture System*. In contrast to Noble and Robertson's *Perceived Exertion*, this book was written as a practical guide for health-fitness, clinical and therapeutic professionals that can also be applied to sports medicine, physical education, and coaching. It explains how to use RPE scales to assess physical fitness and to prescribe and regulate exercise intensity for individuals of varied fitness level and clinical status. In addition, the text introduces and explains the rationale behind the OMNI Scale of Perceived Exertion, developed as a more easily understood alternative to the Borg Scale, especially when used with children. The book details the use of the OMNI Scale for exercise testing and programming for a wide variety of exercise types and settings.

This book, entitled *Perceived Exertion Laboratory Manual: From Standard Practice to Contemporary Application*, serves as the third installment of works by Robert Robertson. It is authored along with two of his doctoral students, Luke Haile and Michael Gallagher. As this book comes to press, we are approaching the 50th year of perceived exertion research in the United States.

This book serves a number of purposes that are shared with Robertson's previous books. *Perceived Exertion Laboratory Manual* includes updated summaries of the research for multiple areas within the field of perceived exertion. These varied content areas pertain to exercise assessment, prescription, and program monitoring that are linked to underlying psychophysical and physiological rationale. However, these reviews are written not only for researchers and clinicians but also for educators and exercise science students alike. *Perceived Exertion Laboratory Manual* includes structured experiments that yield practical explanations for the use of RPE scales in both teaching laboratories and field-based physical fitness assessments, as well as their use for exercise prescription and intensity self-regulation. A unique



feature of the manual is that these explanations are provided in the format of detailed exercise experiments with both a literature review and step-by-step methods for administration in a research and/or educational setting.

Unique to *Perceived Exertion Laboratory Manual* is the inclusion of full chapters devoted to the constructs of *exercise-induced muscle pain* and the *affective response to exercise*. Although there are many perceptual and psychosocial variables that may play a role in mediating the perceived exertion response to exercise, research has paid special attention to these two, studied both individually and together with perceived exertion. Therefore, following an introductory chapter, Part I of this book (Chaps. 2–4) is devoted to three principal variables: perceived exertion, exercise-induced muscle pain, and the affective response to exercise. All three of these constructs can be easily used to develop effective and cost-efficient strategies to promote the adoption and maintenance of physical activity by healthy and clinical populations. Each chapter in Part I includes a brief historical review and conceptual framework for the constructs and the scales used to measure them during exercise.

Parts II and III present the conceptual framework and methodology for a series of laboratory exercise experiments to study perceived exertion, the principle variable used for the development of each experimental design. The authors chose this presentation style to align with the literature. The field of perceived exertion was conceived by Borg nearly 30 years prior to studies of pain and affective responses to exercise were seen in the literature. Consequently, many of the research models used to study pain and affect during exercise were developed through research conducted on the perceived exertion response. Each chapter in these two parts includes detailed methodology to examine exertional perceptions during aerobic exercise (treadmill exercise and/or cycle ergometry) and resistance exercise (where appropriate).

Part II (Chaps. 5–8) is devoted to the use of perceived exertion during exercise assessment. Chapter 5 presents laboratory experiments that examine perceived exertion scaling procedures, the mastery of which is a prerequisite to understanding the use of perceived exertion during exercise for individuals of varying characteristics. The experiment in Chap. 6 covers the use of perceived exertion scales during graded exercise testing, i.e., perceptual estimation protocols. This includes procedures for both maximal oxygen consumption ( $\text{VO}_2\text{max}$ ) and one-repetition maximum (1RM) assessments, which are the primary methods for the determination of RPE scale validity. Chapter 7 presents an experiment that focuses on the determination of a target RPE for use during exercise intensity self-regulation. The experiment in Chap. 8 examines the use of RPE to predict both  $\text{VO}_2\text{max}$  and 1RM.

The information derived from the experiments presented in Chaps. 5 and 6 is a necessary prerequisite to the use of RPE in any type of exercise test or prescription scenario. However, Chap. 7 begins the presentation of content and laboratory methods that are only appropriate in specific situations. Therefore, Chaps. 7 and 8, as well as each chapter in Part III of the book, contain case studies providing an example of an individual for which the methods presented in the laboratory experiment would be appropriate.

Part III (Chaps. 9–13) presents experiments that use perceived exertion for exercise prescription and program evaluation. The experiment in Chap. 9 employs a perceptual estimation-production paradigm for exercise intensity self-regulation. This paradigm is a staple for most perceived exertion research involving exercise intensity regulation pacing strategies for sport performance. Chapter 10 builds upon this through an experiment that examines aerobic interval exercise, a form of exercise intensity modulation that is growing in popularity. The experiment in Chap. 11 takes the paradigm one step further by determining the just noticeable difference (JND) in perceived exertion. This experiment presents the JND as a measure of perceptual acuity with application towards the study of pacing strategy during endurance exercise performance. The experiment in Chap. 12 compares self-selected and imposed exercise intensities, an important consideration prior to exercise intensity prescription especially for novice exercisers. Chapter 13 is the final segment of Part III and includes an experiment that evaluates “off-stimulus” measurements of perceived exertion, predicted RPE and session RPE, which are assessed prior to exercise or following exercise, respectively.

As noted above, the laboratory experiments that are described in Parts II and III focus solely on the measurement and prescriptive application of perceived exertion. Part IV brings focuses on the research variables pain and affect; both of which can be examined independently or in concert with perceived exertion. Chapter 14 presents a series of brief literature summaries (power reviews) that explain how research models initially intended to examine perceived exertion can also be applied to the study of pain and affective responses to exercise. Then, Chaps. 15–17 highlight topics that are of growing interest in the current literature, with a focus on the interplay between exertion, pain, and affect. These applied perceptual and psychosocial research topics include the effects of caffeine, carbohydrate ingestion, and music on the perceived exertion, pain, and affective responses to exercise performance.

This fourth and final section of the book illustrates the direction in which perceived exertion research has been traveling, especially over the past 15 years. Investigations involving exercise performance and adherence to physical activity programs have taken a multidisciplinary approach, with theoretical and empirical roots embedded in the disciplines of physiology and psychology. Recent research has examined many psychoperceptual variables in addition to perceived exertion, pain, and affect. The conceptual models and research methodology necessary to study these three variables, along with mediating physiological variables, provide the health-fitness professional with a solid foundation for exercise assessment and prescription with the goal of promoting the adoption of long-term physical activity participation.

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# List of Abbreviations

1RM	One-repetition maximum
AR	Affective response
AT	Anaerobic threshold
ATP	Adenosine triphosphate
BP	Blood pressure
CERT	Children's effort rating table
EDI	Exercise discomfort index
FS	Feeling Scale
GXT	Graded exercise test
HR	Heart rate
HR-VT	Heart rate corresponding to the ventilatory threshold
JND	Just noticeable difference
LT	Lactate threshold
PA	Physical activity
PACES	Physical Activity Enjoyment Scale
PAE	Physical activity enjoyment
PO	Power output
POmax	Maximal power output
POpeak	Peak power output
RPE	Rating(s) of perceived exertion
RPE-A	Differentiated rating of perceived exertion for the arms
RPE-AM	Differentiated rating of perceived exertion for the active muscle
RPE-C	Differentiated rating of perceived exertion for the chest/breathing
RPE-L	Differentiated rating of perceived exertion for the legs
RPE-O	Undifferentiated rating of perceived exertion for the overall/total body
RPE-VT	Rating of perceived exertion corresponding to the ventilatory threshold
VCO <sub>2</sub>	Volume of carbon dioxide production
V <sub>E</sub>	Pulmonary (minute) ventilation

VO <sub>2</sub>	Volume of oxygen consumption/uptake
VO <sub>2</sub> max	Maximal oxygen consumption/uptake, maximal aerobic power
VO <sub>2</sub> peak	Peak oxygen consumption/uptake, peak aerobic power
VT	Ventilatory threshold