Lecture Notes in Computational Vision and Biomechanics 29

Sofia Brandão
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Women's Health and Biomechanics

Where Medicine and Engineering Meet

Springer

Lecture Notes in Computational Vision and Biomechanics

Volume 29

The research related to the analysis of living structures (Biomechanics) has been a source of recent research in several distinct areas of science, for example, Mathematics, Mechanical Engineering, Physics, Informatics, Medicine and Sport. However, for its successful achievement, numerous research topics should be considered, such as image processing and analysis, geometric and numerical modelling, biomechanics, experimental analysis, mechanobiology and enhanced visualization, and their application to real cases must be developed and more investigation is needed. Additionally, enhanced hardware solutions and less invasive devices are demanded.

On the other hand, Image Analysis (Computational Vision) is used for the extraction of high level information from static images or dynamic image sequences. Examples of applications involving image analysis can be the study of motion of structures from image sequences, shape reconstruction from images, and medical diagnosis. As a multidisciplinary area, Computational Vision considers techniques and methods from other disciplines, such as Artificial Intelligence, Signal Processing, Mathematics, Physics and Informatics. Despite the many research projects in this area, more robust and efficient methods of Computational Imaging are still demanded in many application domains in Medicine, and their validation in real scenarios is matter of urgency.

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Foreword

This book relates to issues of Women's Health and Biomechanics. The book brings an interdisciplinary and multidisciplinary collaborative research to improve clinical outcomes in different aspects of women´s life. Experts from several fields contributed with a wide range of topics that affect women's health worldwide. The impact of the events occurring during the aging process in women's body and in its psychological and social impact is covered. This book included chapters related to physical activity or technologic platforms to fulfill well-being and to treat physical and psychological diseases, cancer-related mastectomy and its impact on body posture, breast reconstruction and implants, the biomechanics of pregnancy, the disorders of the pelvic floor (*postpartum*, due to age or among female athletes), sexual satisfaction and the quality of life in women with urinary incontinence, and its rehabilitation.

The chapters were elaborated considering the main body areas affected by the female life events, and, in this sense, this book gathers the major clinical and bioengineering perspectives from different professionals.

I hope the readers of this book will see the complex alterations which woman are subjected to during their life and will be able to use these concepts to understand the clinical and biomechanical practice and tools described here, and perhaps in a near future to apply them in subject-specific scenarios.

As one of the organizers of the related conference "International Conference on Clinical and BioEngineering for Women's Health (BioMedWomen)", that took place on June 20–23, 2015, in Porto, Portugal, which was the genesis for the present contribution, I would like to express my personal gratitude for the editors of this book and also to all authors for sharing their work and their knowledge in the context of the women's health and well-being.

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Isabel Maria Ramos, MD, Ph.D. received her MD degree from the Faculty of Medicine of the University of Oporto. She completed a fellowship at Yale University in 1989, and in the same year she received her Ph.D. from the University of Porto. Since 1990, she works in the Centro Hospitalar de São João-EPE, in Porto, as Director of the Radiology Department, and since 2007, she accumulates with the autonomous unit of management. She was Chairman of the Quality Programme of the Centro Hospitalar de S. João-EPE for 5 years and Chairman of the Administration Board in 2003 and 2004.

She is also Full Professor at the Faculty of Medicine of the University of Porto since 2001, besides of being in the past Chairman of the Faculty of Medicine Scientific Board and of the Postgraduate Institute. She is also a member of the Portuguese Medical Academy.

In the context of Radiology Societies, she was already (Vice-) and President of the Portuguese Society of Radiology, and a member of the Board (and President) of the Portuguese College of Radiology. From 1996 to 2000, she was a member of the Board of the European Association of Radiology Education Committee. She is also a Portuguese representative at Union Européenne des Médecins-Spécialistes (UEMS—Radiology) since 1995.

She is (co)-author of more than 200 papers published in Portuguese and international journals, nine chapters in Radiology books, and performed more than 300 lectures.

In 2016, she was awarded the medal of merit of the Portuguese Order of Physicians.

Sofia Brandão, RT, Ph.D. is a radiographer at the Centro Hospitalar de São João-EPE. She received her B.Sc. and Graduation in Radiological Sciences by the School of Allied Health Sciences of the Polytechnic Institute, a Postgraduate and Ph.D. in Biomedical Engineering by the Faculty of Engineering of the University of Porto, and her M.Sc. in Medical Informatics by the Faculty of Medicine of the University of Porto. For the past 13 years, she is an Assistant Professor at the CESPU, CRL—Advanced Institute of Health Sciences, in Porto. Her teaching activities are developed in different B.Sc. and Postgraduate courses of Health Sciences.

She is a member of the EFRS—European Federation of Radiographer Societies, and has participated for several times as invited speaker and moderator in the annual European Congress of Radiology (ECR) of the European Society of Radiology (ESR), and also on the Annual Congress of the European Society for Magnetic Resonance in Medicine and Biology (ESMRMB).

The main research interest is the field of magnetic resonance (MR) imaging applications, namely in brain, breast, and pelvic MR, and also pelvic MRI for computational modeling. She has participated in different Ph.D. and Postdoctoral Projects in the context of MRI protocol optimization and acquisition.

Sofia Brandão has received a Training Scholarship at the University Hospital of Tübingen, which is an International Reference Center of Siemens Medical Systems, in 2003, and several awards in national and international conferences. She has over 20 peer-reviewed publications and has participated in a book chapter. Furthermore, she has performed more than 30 talks on technical aspects of clinical MRI, as well as on imaging and computational analysis of the pelvic floor.

Teresa Mascarenhas Saraiva, MD, Ph.D. received her MD and her Ph.D. from the University of Porto. Since 1992 she works in the Department of Obstetrics and Gynecology of the Centro Hospitalar de São João-EPE, in Porto, and since 2006 and she is Head of Department and Associate Professor of the Faculty of Medicine of the University of Porto, respectively.

In the context of Professional and Scientific Societies, she was already the European Representative, member of the Scientific Board, and President of the International Urogynecological Association (IUGA), and was also a member of the Board of the European Urogynecological Association (EUGA). She was also founder of the Portuguese Section of Urogynecology of the Portuguese Society of Gynecology.

Professor Mascarenhas has developed relevant research work and has received several international and national awards. She is (co)-author of more than 200 publications, including book chapter and scientific papers in national or international journals, and has more than 400 conference presentations. She has also been (co-)supervisor of several M.Sc., Ph.D, and Postdoctoral theses in her research field, and is a member of the Editorial Board of two major International Journals in her area of expertise.

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She has over 30 peer-reviewed publications, has participated in a book chapter, and performed over 50 lectures regarding pelvic floor function and biomechanics. The focus of her 10-years research career has been on 3D pelvic floor structure and function, through computational modeling, especially in female athletes. She was the first to demonstrate the effect of a comprehensive pelvic floor muscles training program on urinary incontinence symptoms in sports women, as well as the differences in pelvic floor computational simulations between continent and incontinent athletes.

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Introduction

The definition of health, as described by the World Health Organization (WHO), includes physical, mental, and social well-being, and not just the absence of disease or infirmity. In this context, women experience unique health issues and concerns. The aging process of youth to old age, pregnancy, the bearing of children, as well as the hormonal changes in menopause, can lead to several pathologies such as breast cancer or pelvic floor dysfunction, and affect women worldwide.

Health care includes evaluating the psychological and social impacts that most clinical conditions imply. On the other hand, mental illness itself or chronic diseases can significantly reduce quality of life. Biochemical changes are well known and described in the diagnosis and treatment of physical distress due to aging or debilitating illness. Furthermore, psychological suffering—which can often cause hormonal alterations and even the alteration of neurotransmitters—may also constitute a health problem. Clinical and lifestyle changes such as physical activity or quality-of-life self-management can be supporting to the more classical medication prescription approach in such cases.

In the context of women's health, anamnesis (or medical history), clinical evaluation, and the choice of the most suited treatment options, whether conservative or surgical, is indeed the most common approach. In this context, to better understand the phenomena leading to the pathologic condition, diagnostic tools such as imaging techniques, imaging, or biomechanical-based computer analysis are often applied. Furthermore, medical devices or prostheses are currently available to be used during treatment, which means bringing different branches of Engineering to the Clinical environment in female health.

Having this in mind, our purpose is to present some of the aspects of women's health, some of which are clearly better understood and treated by bridging knowledge from Medicine and Engineering.

Section 1, entitled "Women's Health", emphasizes the psychological aspects of female health, such as those regarding the application of information technologies to monitor and assist women with chronic disease such as fibromyalgia (Chapter "Improving Women's Health via the Biopsychosocial Model: Fibromyalgia as a Case Study to Explore Opportunities for Engineering Applications") or the impact

of mental illness and the positive effect of physical activity programs in states of (post-natal) depression or eating disorders (Chapter "Physical Activity and Women's Mental Health"). Pain and reduction of quality of life are also often described in the elderly (female) population. It relates to deterioration of the musculoskeletal system leading to osteoarthritis in large joints such as hips, shoulders, and knees, mostly related to changes in the endocrine system, and also associated with the postmenopausal period. By investigating muscle architecture and properties by means of ultrasound (Chapter "The Role of Ultrasound Imaging of Musculotendinous Structures in the Elderly Population"), loss of muscle strength and functional decline can be assessed early, and the most suited geriatric rehabilitation programs can be developed.

Section 2, entitled "Bridging Clinical and Biomechanical Aspects of Breast Surgery", addresses the subjects of breast cancer diagnosis (Chapter "Diffusion-Weighted Breast Imaging: Beyond Morphology"), rehabilitation (Chapters "The Effects of Mastectomy and Breast Reconstruction on Body Posture and Biomechanical Aspects and The Role of Physiotherapy in Female Breast Cancer"), and surgical implants (Chapter "Breast Implants: Far Beyond Just Aesthetic Surgery"). Breast cancer is the most common cancer in women worldwide, with nearly 1.7 million new cases diagnosed in 2012. In Europe, Belgium had the highest rate of breast cancer, but also the highest proportion of 5-year survivors, followed by Denmark and France. An early and accurate diagnosis is a key factor, and Magnetic Resonance Imaging has proved to acquire information regarding microstructural complexity of both normal breast tissue and lesions non-invasively and with great accuracy (Chapter "Diffusion-Weighted Breast Imaging: Beyond Morphology"). After surgery, rehabilitation is usually performed, aiming for the promotion of health, improving wellness and quality of life in daily life activities (Chapter "The Role of Physiotherapy in Female Breast Cancer"). An important aspect to consider is the fact that there are adaptations of the musculoskeletal system related to mastectomy and breast implants. These biomechanical posture changes may provide relevant information for prescribing physical exercise and rehabilitation programs (Chapter "The Effects of Mastectomy and Breast Reconstruction on Body Posture and Biomechanical Aspects").

Breast implants are widely used in cancer patients after radical mastectomy or for breast augmentation purposes. Some adverse effects have been described, which is a major concern for patients, plastic surgeons, manufacturers, and regulatory agencies. There has to be certainty on the safety and compliance of the implants used. Detailed visual analysis and product testing provide important details, for example, on the mechanical properties of the materials inside the implant shell, and loads to which they may be subjected (Chapter "Breast Implants: Far Beyond Just Aesthetic Surgery").

Section 3, entitled "The Biomechanics of the Reproductive Period", focuses common conditions associated with pregnancy and childbirth. During this period, body composition and posture change significantly, and one can define an anthropometric profile specific of this stage of a woman's life. Chapter "Anthropometrics and Ergonomics in Pregnant Women" discusses practicing good

ergonomics at home and in the workplace, which will provide comfort and improve women's health throughout this period. During pregnancy, the abdomen becomes larger, the curvature of the lumbar spine increases, and the gait changes. The changes seen in step width are thought to reflect mechanical rather than functional adaptation to increase stability, which is discussed in Chapter "Increased Step Width during Walking as Pregnancy Progresses: Functional or Mechanical Adaptation?".

Another important issue in this period is the well-known *diastasis recti abdominis*, which develops during pregnancy and may be present during the first weeks after childbirth. The prevalence and risk factors for development of this condition are still under study. In Chapter "Diastasis Recti during Pregnancy and Postpartum ", the authors discuss the application of early diagnosis by means of ultrasound as an easy way to plan an effective exercise program to reduce the *inter rectus distance*. Another frequent condition in *postpartum* is pelvic floor dysfunction, namely urinary incontinence. This may result from changes in the connective tissue due to hormonal changes or direct muscle damage during the traumatic event of vaginal childbirth. For that purpose, computational modeling has been used to study the biomechanics of the pelvic floor. Several subject-specific factors have to be taken into account. Structural congruence between shape and position of the fetal head at delivery with the women's pelvic girdle and pelvic floor muscles' shape is important, but also the soft tissue properties, and damage analysis during the different stages of vaginal delivery. These inputs are significant to understand the pathophysiology of the resultant functional damage (Chapter "Biomechanical Analysis of the Damage in the Pelvic Floor Muscles During Childbirth").

Pelvic floor dysfunction is indeed one of the most prevalent conditions during women's life. Hence, we gave it a great deal of attention and detail in the present book. In this particular field, much experimental, clinical, and mechanical research has been carried out in different branches of the subject. From *postmortem* tissue experimental tests, computational simulation, to elaborating and testing the most suited surgical materials, much effort has been made to understand the underlying conditions that promote developing pelvic floor dysfunction. Sections 4 and 5 focus on different aspects of studying pelvic floor dysfunction.

Section 4 entitled "Clinical Approach on the Female Pelvic Floor" was thought to emphasize clinical evaluation of the pelvic floor muscles and the impact of urinary incontinence in quality of life. Not only elderly or parous women suffer from urinary incontinence but also female athletes are at risk. Exercise-induced urinary incontinence is not yet fully understood, but it is thought to result not only from sports practice itself but also from individual factors. Chapter "Pelvic Floor in Female Athletes: From Function to Dysfunction" reviews these issues and sheds light on the impact of urinary incontinence on the quality of life of young athletes, and on the relevance of developing effective preventive physiotherapy. When evaluating the function of the pelvic floor muscles, measuring vaginal squeeze pressure is a means for assessing muscle strength. Chapter "Towards the Development of a Vaginal Finger-cot Device for Measuring Pelvic Floor Muscles Strength" presents a customized adjustable vaginal finger-cot device that

can be used to provide biofeedback and motivate women during the rehabilitation protocol. In this same context, Chapter "Physiotherapeutic Diagnostic Process for Female Urinary Incontinence" describes the rationale and the steps of a clinical pelvic diagnostic process for female urinary incontinence toward an adequate pelvic physiotherapy evaluation and treatment.

The impact of urinary incontinence on women's quality of life has to be thought. The psychological impact in her well-being, coping mechanism and sexual life are important factors to account to when developing the rehabilitation process itself, as well as health promotion strategies, as explained in the Chapter "Psychological Morbidity, Sexual Satisfaction, Coping, and Quality of Life in Women with Urinary Incontinence in Rehabilitation Treatment".

The last part of the book relates to the "Biomechanical Analysis of the Female Pelvic Floor" (Section 5). Until now, significant advances have been made to characterize biomechanical properties of pelvic floor structures to identify possible mechanisms that contribute to developing pelvic floor dysfunctions. Several studies have been performed to improve and to identify the most suited constitutive models for the pelvic floor muscles. While Chapter "Computational Analysis of Pelvic Floor Dysfunction" presents an integrated discussion of the constitutive model based on the tissue constituents, fiber, and ground substance, Chapter "Searching for the Tissue Mechanical Properties in Pelvic Floor Dysfunction by Computational Modeling" presents a method that allows estimating the most suited material constants for the pelvic floor muscles for a subject-specific using input information for the computational simulations acquired non-invasively: the inverse finite element analysis. Accordingly, we expect that this book section can clarify and help future researches to choose the best constitutive model and understand this complex condition.

We would like to recognize the effort and time spent by the authors to these manuscripts, as well as acknowledge serenity for the comments of the editors and for the valuable work performed. We also would like to thank the editorial team of Springer, who carefully worked hard on every detail. Finally, we hope our book will help all readers to understand or improve their skills to assist women's health.

Part I
Women's Health

Improving Women's Health via the Biopsychosocial Model: Fibromyalgia as a Case Study to Explore Opportunities for Engineering Applications

Heather Lynn Rogers

Abstract The biopsychosocial model of health provides a framework to assess and/or treat various medical disorders and is the most heuristic approach to managing chronic pain. Fibromyalgia (FM) is a chronic pain disorder primarily affecting women characterized by widespread musculoskeletal pain, abnormal pain processing, sleep disturbance, fatigue, and often cognitive difficulties and psychological distress. Evidence-based management guidelines in different countries recommend biopsychosocial, lifestyle-oriented intervention to include exercise, cognitive-behavioral therapy, and multicomponent intervention. State-of-the-art evaluation and treatment approaches in FM illustrate the application of the biopsychosocial model to improve women's health. Engineering applications are beginning to be developed, that, within the context of this model, have the potential to further advance management of the disorder and improve quality of life for those (primarily women) who suffer from it. Users of existing online multicomponent treatment module platforms experience improved pain and physical functioning. Those who use FM symptom tracking systems report improvements in a number of debilitating core FM symptoms beyond pain and physical function. Areas of engineering application showing particular promise include advances in gaming using commercially available motion-controlled video games, mobile activity and symptom data collection with or without feedback via smartphone devices, and integration of these technologies with clinical oversight.

Keywords Biopsychosocial model · Evidence-based guidelines
Fibromyalgia · Engineering/IT applications · Quality of life

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Highlights

- Fibromyalgia (FM) is a chronic pain disorder primarily affecting women and evidence-based guidelines recommend biopsychosocial, lifestyle-oriented intervention for management of the disorder.
- Existing engineering applications have been developed that have demonstrated the potential to further advance self-management of the disorder and improve quality of life for those (primarily women) who suffer from it.
- Specifically, users of existing online multicomponent treatment module platforms experience improved pain and physical functioning and those who use FM symptom tracking systems report improvements in a number of debilitating core FM symptoms beyond pain and physical function.
- Areas of engineering application showing particular promise include advances in gaming using commercially available motion-controlled video games, mobile activity and symptom data collection with or without feedback via smartphone devices, and integration of these technologies with clinical oversight.

1 Introduction

Since 1948, the World Health Organization (WHO) has defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" [1]. The biopsychosocial model [2] provides an appropriate framework to promote general health/well-being. This biopsychosocial model is now a widely accepted approach to the assessment and/or treatment of many disorders in various medical subspecialties. In particular, in the case of chronic pain conditions, the biopsychosocial model is now viewed as the most heuristic approach to management [3].

This chapter has five objectives:

(1) To describe the biopsychosocial model
(2) To place the biopsychosocial model in the context of the history of Western Medicine
(3) To apply the biopsychosocial model to the evaluation and treatment Fibromyalgia (FM), a chronic pain disorder primarily affecting women,
(4) To review examples and evidence-based benefits of engineering/information technology (IT) applications in the management of FM, and
(5) To highlight new developments in engineering/IT to assist those with FM.

2 The Biopsychosocial Model

In 1977, George Engel published a seminal paper, "The Need for a New Medical Model: A Challenge for Biomedicine" [2], in which he critiques the biomedical model prevalent at the time. He describes the requirements of a new medical model to account for disease as a human experience, and proposes a biopsychosocial model as a "blueprint for research, a framework for teaching, and a design for action in the real world of health care" [2, p. 135]. Engel proposes a new dynamic and interactional medical paradigm that broadened the scope of the clinician's focus in diagnosing and treating disease. As a consequence, he expands the domain of medical knowledge to address the needs of each individual patient.

Borrell-Carrio, Suchman, and Epstein [4] summarize the key tenants of Engle's Biopsychosocial Model:

(1) Illness results from the interaction of several diverse causes, including those at the molecular, individual, and social levels. A biochemical alteration does not necessarily translate directly into an illness, and psychological alterations may, under certain circumstances, manifest as illnesses or forms of suffering that constitute health problems, including, at times, biochemical correlates.
(2) Psychosocial factors influence the susceptibility, severity, and course of illness, as well as the effect of treatment.
(3) Determining the biological cause does not necessarily infer meaning to the patient. Furthermore, the success of the most biological treatments is influenced by psychosocial factors, e.g., the so-called placebo effect.
(4) The patient-physician relationship influences medical outcomes, at minimum as a result of its influence on adherence to the selected treatment.
(5) Adopting a sick role is not necessarily associated with a biological cause

Engel identified weaknesses in the biomedical model and defined a multidisciplinary approach to treating illness known as the "Biopsychosocial Model." This model proposes that a combination of factors play a significant role in human functioning in the context of disease—not only the biological factors in the biomedical model of illness, but psychological (which includes thoughts, emotions, and behaviors) and social (socioeconomical, socio-environmental, and cultural) factors as well [5]. In summary, the main distinction between the biomedical model and the biopsychosocial model is the full integration of "psychosocial" factors. These psychosocial factors are the same health determinants that contribute to the development and progression of many noncommunicable, or lifestyle, diseases involving all of the body's systems (e.g., coronary heart disease, musculoskeletal disorders, Type 2 diabetes, cancer, asthma, Alzheimer's disease). In fact, studies have shown that when physicians address the patient's lifestyle and environmental context via use of the biopsychosocial model, they are more likely to provide more psychosocial advice/interventions and prescribe fewer medications, with an increase in patient-reported satisfaction [6].

3 A Brief History of Western Medicine

An examination of the history of Western medicine's conceptualizations regarding the mind-body relationship in health and disease elucidates how the biopsychosocial model integrates factors that have been considered to be influential at various points in time. It is possible to argue that the biopsychosocial model brings Western medicine full circle to where it began with the ancient Greeks. In brief, in the early days of medicine, illness was almost always explained in spiritual terms. Hippocrates, often recognized as the father of Western medicine, proposed a new paradigm in which natural, not supernatural, explanations of illness were sought. Because dissection of human cadavers was forbidden on religious grounds, Hippocrates and Aristotle relied on logic and philosophy to explain disease. Centuries later, Galen, a Roman anatomist, studied pigs and integrated the role of personality in illness. Hippocratic-Galenic medicine hypothesized a "Holism." Under this view, there was a synergistic and individual relationship between a person's body, mind, personality, and the outside world. These factors are postulated as integrated and inseparable [7].

In the Middle Ages, the Catholic Church became a powerful political and social force. The "mind-body issue" was deemed religious and investigations into human anatomy were not allowed. Later in the 1500s, physicians were allowed to dissect executed criminals. Hence, structures that could only be imagined prior could be now manipulated to reveal clues about their function. By the mid-1600s, physicians began to view human physiology as the mechanized interaction of organs. Growth in medical technology played a key role in reductionist perspective in Western Medicine. For instance, the microscope revolutionized biology and was used as a tool to study not just simple organisms but also the disease process. The etiology of disease could be tied to distinct anatomical locations [7]. At the same time, during the Renaissance, Descartes popularized the belief of "Dualism"—a distinction between mind and body. Descartes' dualism separated the mind (soul), which was left to the Church, from the body, which was now available for physicians and scientists to study in this reductionist and mechanical manner.

In the eighteenth century, with the Industrial Revolution, it was possible to observe a shift from a purely mechanistic view of health to a more integrative view of health within the context of one's environment. Then, the nineteenth–twentieth century was characterized by a shift back to reductionism in order to understand illnesses at the time with the largest impact on public health (e.g., infectious diseases) and treat their mechanisms of action. In the twenty-first century, chronic illnesses are now the primary causes of mortality. As espoused by the biopsychosocial model, the mind-body interaction approach to the study and treatment of chronic illnesses is an integration of the holistic approach to early medicine with modern reductionist understanding of disease processes.

4 Fibromyalgia Evaluation and Treatment—Applying the Biopsychosocial Model in the Twenty-First Century

Fibromyalgia (FM), also known as Fibromyalgia Syndrome (FMS), is a chronic pain disorder that has a debilitating impact on women's health. FM is a condition characterized by widespread musculoskeletal pain that is accompanied by abnormal pain processing, sleep disturbance, fatigue, and often cognitive difficulties and psychological distress. Its etiology is unknown [8]. The disorder typically affects women 40–55 years of age, has a female-to-male ratio of 9-to-1, and can affect up to 5% of the population [9]. Considerable quantitative (e.g., Gonzalez et al. [10]) and qualitative (e.g., Arnold et al. [11]) research has documented the important impact that FM has on quality of life. Negative impact on social function includes social isolation and interference with family relationships, friendships, activities of daily living, leisure activities, and physical activity. Negative professional impact, such as the loss of career or inability to advance in careers or education, has also been reported.

The need for biopsychosocial assessment of FM has become even more apparent with the American College of Rheumatology (ACR) 2010 revised criteria for diagnosing FM [12] which are focused on patient perception of pain in 19 specific locations (known as the Widespread Pain Index; WPI) and six self-administered symptoms questionnaires to assess sleep difficulty, fatigue, headache, depression, abdominal pain, and poor cognitive status (known as the Symptom Severity Score; SSS).

As a multidimensional disorder, it is not surprising that multicomponent interventions involving a biopsychosocial perspective are the recommended treatment for FM. Evidence-based management guidelines have been developed by various associations in different countries, for instance, in Canada in 2012, by the Association of the Scientific Medical Societies (AMWF) in Germany in 2008 and the American Pain Society in 2005. Most recently, in 2016, the original 2007 European League Against Rheumatism (EULAR) recommendations for managing fibromyalgia were updated. Exercise was given a "strong" therapy-based recommendation based on meta-analyses. Although other therapies had "weak" evidence according to meta-analyses, expert opinion suggests a staged, individualized approach to FM treatment. Intervention was to begin with patient education and a focus on non-pharmacological therapies. If the individual does not respond to this management of FM, three additional therapies in the following order were recommended: (1) Psychological therapies to improve mood disorders and unhelpful coping strategies, (2) Pharmacotherapy to manage of severe pain or sleep disturbance, and/or (3) A multimodal rehabilitation program to address severe disability [13]. In general, guidelines from the United States, Europe, and Canada coincide in recommending aerobic exercise, cognitive-behavioral therapy, and multicomponent intervention as first-line therapies. There is also some agreement among experts regarding the need for a stepwise approach to the management of FM with an emphasis on longer term self-management of this incurable condition that provokes considerable suffering.