

INTRODUCTION

THIS CHAPTER begins with a discussion indicating that much is unknown about low back pain causality, especially its relationship to work. This chapter is intended to calibrate readers' expectations so that they understand the difficulties in making definitive statements about low back pain causality due to work. Second, an argument is made for why we must view the body of knowledge as a series of puzzle pieces that must be put together to form a "picture" or system. This section indicates that this will be done in a relatively nontechnical manner and the audience for the book is identified. Third, a discussion indicates that there are several work (physical, psychosocial, and organizational) factors as well as nonwork (genetic) factors that constitute the "puzzle pieces." Workers are exposed to these factors regularly and the key to understanding is to determine how these factors interact and lead to back pain. Fourth, a high level conceptual model is proposed that suggests how physical and nonphysical work factors might interact with personal factors to affect the forces that are experienced by the spine subsequent back pain. Finally, the organization of the book is discussed and the reader is reminded that the book will provide a framework for how one should think about low back pain causality. The objective of the book is to place the reader in a position to reason through various workplace design issues as opposed to providing a "cookbook" formula for low back pain prevention.

What causes low back pain? Does work cause low back pain or would it occur regardless of work activities? No one knows the answers to these questions beyond a shadow of a doubt. I repeat, *no one knows for sure!* Numerous publications have attempted to explain various causes of back pain (referred to as causal pathways) including genetics, stability, acute trauma, repetitive stress to the tissue (cumulative trauma), aging, cardiovascular problems, psychological problems, organizational and social (psychosocial) problems, among others. However, no one has been able to *prove* or definitively *disprove* any of these theories. Realistically, the causal pathways are probably more complex than any single one of these pathways suggests. In all likelihood, there are probably numerous means by which low back pain can be initiated. Furthermore, one would expect that many of these pathways develop simultaneously and perhaps even interplay with each other.

The focus of this book concerns the many factors that can contribute to low back pain. However, this book is unique because it concentrates on the factors that *lead to* low back pain from a multidisciplinary and interdisciplinary perspective. While thousands of books have been written about the treatment of low back pain and how to manage back pain once it occurs, this book is different in that it is concerned with the ways in which back pain can be initiated and considers the factors that are within our control to minimize the risk of an initial or recurring back problem due to work-related factors.

Causality of health problems, such as low back pain, in real-life situations is extremely difficult to study and prove for a variety of experimental and ethical reasons. Some suggest that causality can be proven in what are referred to as *randomized controlled trials* such as what is done to test the efficacy of a new drug. In a typical randomized controlled trial, a population of people with an ailment is divided into different groups. Some are randomly given the drug of interest and others are randomly given a placebo. If the improvement rate among the “drug” group is statistically better compared to that of the “placebo” group, then the drug is deemed effective.

However, *causality* of a back disorder is very different from *treatment* of a low back disorder. Causality cannot be proven in the same way as the effectiveness of a drug can be proven. The literature over the past 50 years has suggested that many factors may influence low back pain. Therefore, it is difficult to isolate the issues that increase risk. In addition, contemporary studies are indicating that many of the categories of risk factors interact strongly. Thus, it becomes even more difficult to understand how these factors react in combination with each other. Furthermore, there are several scientific, practical, and ethical problems with applying such a model to low back causality and specifically to workplace interventions in the actual workplace. For example, almost everyone works, ages, and is exposed to a variety of forces through work, sports, accidents, and so on. It, therefore, becomes nearly impossible to compare people who are exposed to these multidimensional risk factors to those who are not, as would be necessary to prove causality in a randomized controlled trial. So how does one isolate the potential effect of forces resulting from work compared to spine forces resulting from other exposures? It becomes extremely difficult and, potentially, unethical to do so.

In addition, not many employers are willing to allow their facilities to be used in long-term studies of low back pain. The priority in industry is to make money. Very few industries are amenable to exposing part of their work force to different work risk conditions to prove a scientific point. Would you allow half of your employees to be exposed to suspected risk factors while not allowing the other half? Besides, word travels quickly in work environments, and psychological effects would quickly contaminate the study.

Similar problems also exist in drug treatment studies. Since few researchers are able to accurately and quantitatively measure the *extent* of low back pain, how does one assure that everyone starts the study at the same state of impairment? You cannot. Instead one must recruit very large populations of patients and hope that the samples are large enough so that low back pain severity is equally likely in each group. Finally, few physicians are willing to randomize treatments among their patients. Could you imagine going to your physician to have your back pain treated and then finding out that your treatment was part of a placebo group? Recently, a study randomized surgical treatment versus conservative treatment for back pain. Those patients who agreed to the randomization of treatment were enrolled in the “randomized” study where they did not become part of an “observational” group. Different effectiveness of surgery was reported depending upon group membership (1,2). However, it was clear that those in the observational group had much more severe pain than the randomized group. This study illustrates the difficulty with randomized controlled trials.

Hence, the traditional “rules” of science are difficult to apply in this complex, multidimensional problem we call low back pain in the “real-world” environment. Since low back pain is so complex, no one study will ever prove or disprove the causal pathway. Most individual studies simply explore one or, in rare cases, the interaction between two potential causal pathways. One way to gain faith in a causal mechanism is to repeat studies several times and observe whether the studies all arrive with the same conclusions. This way of thinking (looking for many studies arriving at the same

conclusion) is called looking at the *preponderance* of evidence. While a preponderance of evidence assures us that a risk factor is important, this type of rationale is often unable to assess and account for the interaction of various causal factors. A major tenet of statistical reasoning states that the interaction of causal factors can be far more powerful in determining the outcome than any single causal factors. In other words, it is common for factors to combine in unique ways and dictate the effects of causal factors. Therefore, instead of looking at low back pain causality from a singular, myopic viewpoint, we will examine the potential interactions in risk factors by examining the *pattern of evidence* associated with work-associated low back pain. It will try and build a case for how the multidimensional components of low back pain can interact and most likely influence low back pain risk.

My experience in low back pain and work comes from 25 years of research into low back biomechanics, experience examining hundreds of jobs associated with back pain, practical experience changing the jobs, and determining what works and why it works in reducing back pain risk at work, as well as personal experience with low back pain. Thus, this book is a practical explanation of the factors that influence the low back pain experience and a discussion of what tools and ability we have to influence a certain percentage of back pain that may be due to work.

The goal of this book is to provide the reader with a functional understating of how we think back pain is influenced by various work and nonwork factors. While various assessment tools will be discussed, it should be obvious that there are no “cookbook” solutions or “magic bullets.” However, if one has a reasonable understanding of the causal pathways involved with low back pain as well as an appreciation for how these pathways can be activated by various individual and workplace exposures, then one should be armed with the knowledge to assess a given work environment and prescribe effective interventions given the situation.

1.1 AUDIENCE FOR THE BOOK

This book is intended for a diverse audience. This book is intended to interpret the science in such a way that it is understandable for people of diverse backgrounds. The key to understanding low back pain causality is to understand how the various concepts fit together and interact as opposed to understanding the sophisticated scientific techniques that form the basis of the individual studies. These scientific techniques are simply tools to mine the knowledge that is inherent to the study. Thus, instead of delving into the minute details of the various studies, an attempt will be made to show how the major contributions of various studies fit together to form a pattern or picture of how low back pain might occur.

Hence, this book is intended for a broad audience consisting of anyone interested in low back pain causality. The book should be of interest to several groups including

1. those who either design work, dictate work processes and schedules, or perform the work that might lead to low back pain;
2. those who attempt to determine how return to work will influence the risk of low back pain recurrence or exacerbation;
3. those suffering from low back pain who are interested in the mechanisms behind low back pain; and
4. researchers who are interested in a more global view of how low back pain might be associated with work.

1.2 APOLITICAL CAUSALITY ASSESSMENT

Besides being difficult to explore from a scientific inquiry perspective, the low back pain causality controversy is also clouded by political and monetary incentives. Low back pain can be very expensive and can cost companies and medical providers millions of dollars. Low back treatment is also big business with surgical supply companies charging huge amounts for equipment, implants, and treatment procedures for low back pain. Since large amounts of money are at stake, workers' compensation insurance and legal issues can become the objective of a workplace risk assessment instead of attempts to resolve and mediate the risk of low back pain associated with a job task. In addition, once monetary incentives are in place, compensation rather than resolution of the back pain can become the objective (3,4). This makes some suspicious that those suffering from low back pain are malingering or striving for secondary (often monetary) gain. The suspicious nature of a work investigation can further escalate the level of distrust among the worker and further magnify the emotional component of the pain and serve to further enhance the pain. Hence, the low back pain business is costly for all involved.

The costly nature of the work-related low back pain environment provides an opportunity for low back pain experts to cash in on their opinions. Experts claiming that the work task was a likely cause of a low back disorder can secure a lifetime settlement for a worker. Likewise, experts who contend that there is no relationship between work and low back pain can potentially save a company millions of dollars in workers' compensation costs. Either way, when large sums of money are involved there are always incentives for bias on the part of the experts. In addition, national politics have also been entangled in the debate. Large corporations and unions have a great deal of money at stake and both groups place political pressure on elected representatives to "spin" the science in a direction that benefits their cause. Thus, rulemaking is often influenced by politics more than scientific integrity (5).

This book will strive to set aside political and monetary incentives, cut through the literature base that is motivated by such concerns, and provide a realistic view of how the various bodies of knowledge regarding low back pain causality might fit together to form a logical explanation of how low back pain occurs under work conditions. As we will soon see, there is evidence to support the contention that there are numerous pathways to low back pain. The work task might be simply the initiating event in a long chain of events leading to low back pain and the work can either mediate or enhance the problem.

1.3 A SYSTEMS VIEW OF LOW BACK PAIN CAUSALITY

While many of the studies that form the underlying logic in this book involve complex methodologies and techniques, the basic concepts underlying the ideas are fairly straightforward. The point of the book is to show how various influences or risk factors might be considered collectively, or in combination, to influence the risk of low back pain at work. The idea here is to assess how the multiple dimensions of risk can interact and combine to set the stage for low back pain to occur. One can consider this type of thinking as a jigsaw puzzle with the different pieces of the puzzle representing the different aspects of risk. When pieces of the puzzle are viewed in their correct orientation and in perspective, the overall picture, or in this case, causality pathway becomes clearer. It is the goal of this book to show how the pieces of the puzzle or the *pattern of evidence* fit together so that we might better understand low back pain causality at work.

1.4 THE REALITY OF WORK

To be realistic, the pattern of evidence associated with exposure to physical work must consider not only the effects of exposure to physical work characteristics also the effects of many other factors that might exacerbate or mediate the influence of physical work characteristics. The effects of exposure to the organizational stress issues associated with work as well as the unique characteristics of the individual worker and their individual response to physical and psychological stresses should be considered. This book is about considering how these factors can interact in a systematic manner.

Individual characteristics of the worker may mediate or accentuate the intensity of the load imposed upon a tissue due to work and may also play a role in how the worker's tissues are able to tolerate the tissue load. To make matters worse, it is possible that this relationship can change over time. Age, conditioning, genetics, lifestyle habits, psychological state, personality, and the current state of tissue degeneration can all influence the rate at which tissue is stressed and how the body tissues handle the stress. The ability of the body to induce forces upon a tissue as well as the ability of the body to withstand tissue load have all been well documented in the literature (6), but their interactive influence of loads in combination with psychological stress and individual variation in responses has not been well documented in the literature and is not well understood.

The influence of time can also profoundly affect the influence of physical loads imposed on the body. The ability of the body to withstand physical loading can change dramatically over time. Cumulative loading and adaptation to loading can alter our interpretation of risk depending upon the magnitude of the accumulated load, the temporal nature of the cumulative exposure, and the ability of the body to compensate for the tissue insult.

Factors such as physical factors, psychosocial factors, and organizational factors can all play a role in defining risk. Traditionally, it has been the physical workplace factors that have been explored and associated with increased tissue loading, particularly when the biomechanical characteristics of the work were properly and specifically addressed (6). However, there continues to be controversy as to the contributions of psychosocial factors and organizational factors. Some have argued that increases in low back pain reporting can be explained through work dissatisfaction, organizational factors, or the availability of compensation (7). However, most studies have not considered the explanatory power of these factors relative to that of the load–tolerance relationship. Some of the classic psychosocial studies, when re-examined, have been found to explain a very small percentage of variability in low back pain reporting (8). Analyses have shown that when biomechanical evaluations are considered collectively along with psychosocial evaluations, the explanatory power associated with the psychosocial studies is greatly reduced (9). More recent findings have also shown that psychosocial factors have an interactive effect with biomechanical loading (10) and that individual factors, such as personality, can explain much of the variation in the magnitude of the loading forces experienced across individuals (11).

Collectively, this pattern of evidence suggests that no single factor fully explains the presence or absence of cumulative trauma and its association with low back pain. Furthermore, it is also clear that researchers often find only what they are looking for. If one does not bother to properly measure the influence of a potential risk factor, they certainly will not find a significant association with that factor, and they are therefore, not justified in suggesting there is no causality associated with a factor they did not properly explore.

Traditionally, the literature has taken the approach of examining single-risk factors *in isolation*, in trying to explain back pain. Large bodies of literature exist that argue for the

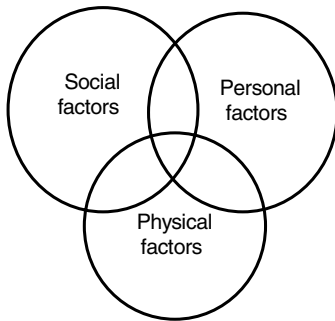


Figure 1.1 Interaction between various dimensions of risk factors contributing to cumulative trauma and low back pain.

influence of each type of risk factor independently. However, if we consider the components of the system, it is likely that physical factors, individual characteristics, organizational factors, and psychosocial factors *all* influence the load–tolerance relationship that is at the core of cumulative trauma. The evidence suggests that cumulative exposure to loads when combined with other risk factors can contribute to low back disorders above and beyond the influence of aging or genetics alone. However, the magnitude of the effect of cumulative trauma above and beyond aging and genetics is not well understood. In addition, it is not known how cumulative trauma responds in conjunction with other risk factors.

The pattern of evidence suggests that we must consider how the *system* behaves in order to appreciate the influence of any one or any combination of risk factors in the etiology of low back pain. Instead of continuing to explore low back pain causality within the confines of specific disciplines (e.g., biomechanics, psychosocial, physiology, genetics, etc.), we must more fully explore the interactions between these disciplines as proposed in Fig. 1.1. The pattern of evidence suggests that the explanatory power inherent to the interaction between these disciplines may very well overpower the influence of any main effects. Thus, in order to understand the amount of variability that is accounted for by any one of the risk factors we must also understand the nature of the interactions between the risk factors. The research community has already begun to quantify the degree of interaction between many of these risk factors, yet much more work is required before we fully understand these interactions. These interactions represent the current research “gaps” as well as opportunities for future research direction.

When considering the pattern of evidence for low back pain, if all the components of plausibility are considered in perspective, a picture emerges that logically supports the relative influence of various risk factors associated with the etiology of low back disorder.

1.5 HOW MIGHT THE DIFFERENT ASPECTS OF WORK BE ASSOCIATED WITH BACK PAIN

How could a conceptual model be developed that can integrate the different bodies of literature associated with low back pain occurrences? This issue was debated by the National Research Council and the Institute of Medicine within the National Academy of Sciences in two studies exploring the work relatedness of musculoskeletal disorders (6,12). In these studies, the literature was thoroughly evaluated and explored and a unifying model was developed based upon the interaction of potential causal factors suggested by Fig. 1.1. This model is further expanded in Fig. 1.2. This model suggests a pain pathway that is shown in the right hand box labeled “PERSON” in Fig. 1.2. The PERSON box indicates the possible

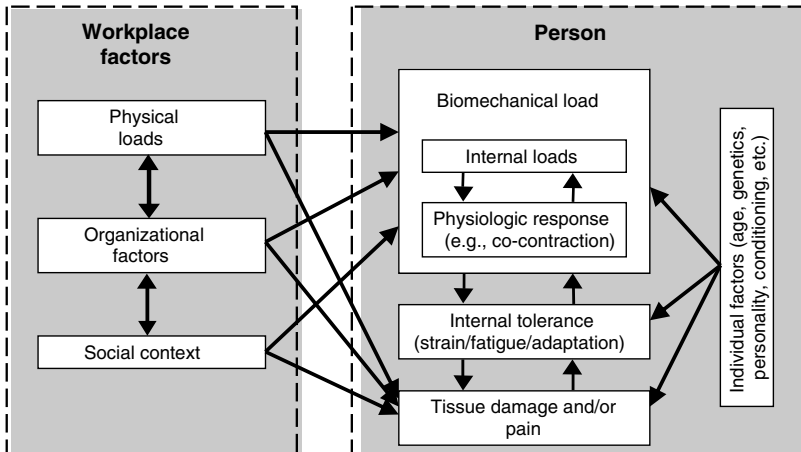


Figure 1.2 Conceptual model relating potential workplace risk factors to the development of low back pain. (Adapted from reference 12).

work-related pathways and processes that could occur within the person including the biomechanical load–tolerance relationship and the factors that may mediate this relationship (e.g., individual factors and adaptation). This pathway suggests that at the heart of this system, work-related low back pain must be initiated by a biomechanical response (forces) to one of many (physical, psychological, psychosocial, etc.) conditions found in the workplace that is capable of exceeding a tissue tolerance. The biomechanical load “box” indicates that physical force and motion factors must be of sufficient magnitude to cause the body to develop sufficient internal (to the body) forces upon the spinal tissues. These can often be magnified by muscle coactivation, hence, biomechanical analyses must be sensitive enough to consider this means of loading in order to accurately consider work-related spinal tissue loading.

Forces or loads imposed on the back are compared to internal (tissue) tolerances within the back. Tolerances can take many forms in this model including tolerances relative to the structural strength of the tissues including endplate strength, disc fiber strength, ligament strength, muscle tolerance, and so on that result in tissue strain. Another form of tolerance that must be considered is biochemical tolerance. Structural tolerances are most likely preceded by biochemical reactions. For example, cytokines are strong initiators of inflammatory responses that can be upregulated by repetitive insult to a tissue. In addition, as we will see, these responses can be mediated or exacerbated by physiologic adaptation, former experiences that alter muscle recruitment, and cognitive factors. Hence, “internal tolerance” in this model can include many forms of tolerance.

The next block in this sequence suggests that pain can result from these tolerances being exceeded. The inflammatory responses, tissue damage, and so on can lead to pain-sensitive tissues (nociceptors) being activated, which initiates the sequence of pain. It should also be noted that arrows flow in both directions in these last two boxes. This indicates that the individual tolerances and pain experiences can be either exacerbated once exposed or may help adaptation. In either case, significant feedback loops can complicate the sequence of events.

The model in Fig. 1.2 shows that the pain pathway just described can also be influenced by the specific characteristics and conditions of the individual. These conditions and characteristics include genetic factors, personality, physical capacity and conditioning,

psychological state, biochemical response, cardiovascular response, and so on. There is strong evidence that individual factors can mediate the response of each of the components in this pain sequence.

The dotted box in the left-hand portion of the figure indicates the potential influences of the workplace. These include physical factors, organizational factors, and social influences. Note that each of these factors has the potential to influence each component of the low back pain pathway sequence and can interact with individual factors.

This model is the governing concept behind this book's logic. The chapters that follow review the pattern of evidence that supports this means of considering low back pain causality and work. While this model suggests many complex interactions through the various "arrows," one should not be overly concerned if this system of interactions is not clear at this stage. This book will expand upon many of these interactions and demonstrate how many of these factors can influence the system of factors that can influence low back pain perception. The important thing to realize at this stage is that there are a variety of work and nonwork factors that can play a role via this web of influences.

1.6 ORGANIZATION OF THE BOOK

The goal of this book is to explain the potential avenues of low back pain and show how they could be related to work exposure. Our knowledge of low back pain has advanced rapidly over the past several decades. It is unlikely that the major cause of most modern work related low back pain is simply lifting a load that is too heavy, which causes a structure to break. While it is possible, for the majority of workers, this is probably not the mechanism of pain for most work-related low back pain. The literature now suggests that there are numerous, more complex, potential pathways of pain that may be associated with work tasks.

In order to effectively assess and design workplaces that minimize low back pain risk, one must be armed with an underpinning of causal mechanism logic so that one could understand the initiators of sequences of events that can lead to persistent low back pain. Therefore, instead of simply listing the numerous pathways to low back pain, it is important to develop an appreciation of how these pathways might interact with the physical and social work environments as well as with the individual attributes of the worker. Hence, we are talking about a *system*. It would be easy to simply list a set of rules of dos and don'ts for work. However, invariably, one will quickly run into a situation that has not been described in the "list" and in reality the work situation would probably contain several different trade-offs between risk factors. This situation would lead to a conclusion that one should automate the process. Automation is costly and is often not effective from a production efficiency standpoint. However, if one has an understanding of the spectrum of underlying mechanisms involved in low back pain, it is more likely that one can reason through the work situation and devise a feasible intervention to minimize the pain. Therefore, this book will attempt to lay the ground work for a systems approach to understanding the causes and pathways of low back pain.

Given these goals, this book is organized in a manner that will provide the basis of understanding in the spectrum of topics that are important to understanding work-related low back pain. While each chapter is designed to be relatively independent so that it can be read by itself, maximum understanding will be gained if one considers each chapter in the context of the entire system and, thus, it is recommended that one read the entire book and build the knowledge base as one progresses from chapter to chapter.

Chapter 2 reviews the magnitude of the low back pain problem and explores factors that may contribute to low back pain from an observational (as opposed to causal) standpoint. The

chapter reviews statistics (in terms of magnitude, trends, and costs) indicating the extent to which back pain impacts society. The chapter also reviews the epidemiologic (surveillance) findings to suggest the degree to which physical, psychosocial, and individual risk factors have been associated with low back pain. Epidemiology is the science of observing trends in the workplace. It has the advantage of going beyond theoretical relationships and can show that if certain conditions are present, the probability for low back pain increases. Hence, strong relationships can be found. The disadvantage of epidemiology is that it is often difficult to isolate a specific risk factor of interest and it is often difficult to study interactions between potential risk factors. In addition, the measurement tools used in epidemiologic research are often fairly imprecise. Nonetheless, epidemiology can be a useful tool for identifying historic trends in the workplace. However, as with all scientific approaches, one must consider the limitations of the tools and view the information in perspective.

Chapter 3 will present the basics of anatomy of the low back in a functional manner. Anatomy is presented along with a description of why the anatomy is important to the functioning of the back and spine. An appreciation for anatomy is essential for the understanding of which structures could be involved in the various pathways of injury. Along the same lines, Chapter 4 reviews the mechanisms of pain transmission in the human body. The goal is to help the reader understand that pain perception is influenced not only by physical loading but also by prior (cognitive) experiences. This chapter will show how pain occurs and the roles that physical load and memory play in the pain experience. The influence of biomechanical loads imposed upon tissues and biochemical reactions is discussed in terms of their ability to initiate pain perception.

Based upon the previous three chapters, Chapter 5 articulates the various pain pathways that are possible as a function of work exposure. The chapter begins by discussing how our understanding about back pain perception has changed over the years and discusses why traditional views (suggesting that tissue damage must be present) may not be realistic. This chapter outlines the various sequences of events that we believe occur within the human during the back pain experience and, where available, thresholds for tissue damage and pain initiation are described. The chapter describes how muscle tensions within the low back can activate the various pain pathways. This chapter also establishes that understanding how work and nonwork factors influence muscle tensions is the key to understanding pain pathway initiation.

Chapter 6 provides an overview of occupational biomechanics. Biomechanical analyses are often used to assess workplaces in order to assess risk of low back pain. However, biomechanical assessments have evolved rapidly over the past few decades. This chapter reviews the progression of commonly used biomechanical assessments and concepts and will discuss state-of-the-art techniques that have the ability to precisely evaluate tissue stress associated with various work-related exposures.

The results of biomechanical assessments performed on potential physical work factors will be reviewed in Chapter 7. This chapter will show how physical work factors affect both spine forces and muscle tension.

Psychosocial and organizational influences on the biomechanics of spine loading and muscle recruitment patterns are discussed in Chapter 8. Several recent studies have shown that these cognitive environment factors affect spine loading and muscle activities in much the same way as physical load exposure.

Chapter 9 reports on the biomechanical behavior of the spine that is associated with individual factors such as gender and personality. Since the systems approach must consider biomechanical effects of the unique characteristics the worker brings to the job, this chapter evaluates the extent to which tissue loads are influenced by these unique individual characteristics.

The next chapter, Chapter 10, reviews the quantitative biomechanical literature that has been able to investigate the interaction between the workplace factors, psychosocial/organizational factors, and individual factors. This chapter emphasizes that the low back pain is the result of a system of interactions that must be considered if back pain is to be controlled in the workplace.

Interventions intended to control low back pain are discussed in Chapters 11 and 12. We have no ability to control individual factors at work, so the focus in these two chapters is on what we can control from a work perspective. Chapter 11 discusses ways that one can control and intervene in the physical risk factors associated with work, whereas Chapter 12 discusses the options for controlling the psychosocial and organizational environment at work.

Chapter 13 will show case studies of how physical and psychosocial/organizational aspects the workplace have been manipulated to minimize the occurrence of low back pain and lead to optimal working health.

A major challenge to the working environment involves assimilating workers back into the workplace once low back pain has occurred. Chapter 14 will review some of the biomechanically relevant literature associated with the previously described pain pathways and secondary (recurring) low back pain. Finally, Chapter 15 consolidates the information from the previous chapters into system logic to stimulate the reader to consider whatever new (yet unexplored) factors might also influence this systems approach to understanding low back pain.

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