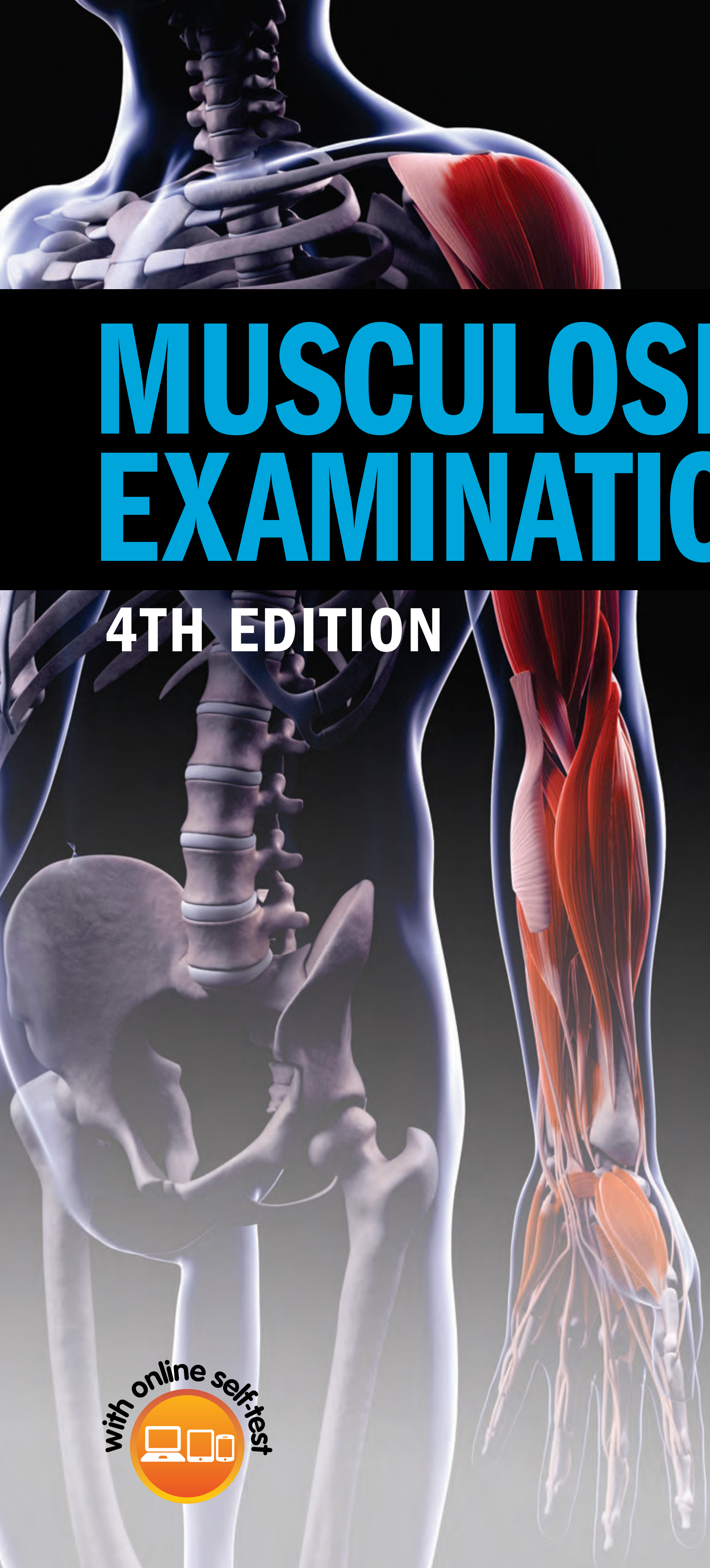
MUSCULOSKELETAL EXAMINATION

4TH EDITION



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Musculoskeletal Examination

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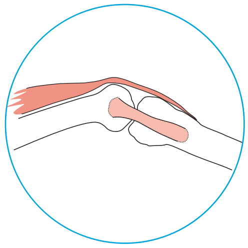
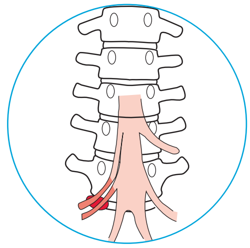
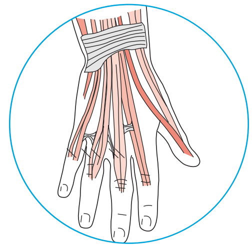

Musculoskeletal Examination

Fourth Edition

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Contents

How to Use This Book

Musculoskeletal Examination is to be used as both a teaching text and a general reference on the techniques of physical examination. This volume represents the joint authoring efforts of a physiatrist, an orthopedic surgeon, and a physical therapist and presents the information in a clear and concise format, free of any professional biases that reflect one specialty's preferences. The importance of this will be seen as we take you through each anatomical region and delineate the basic examination. Included in each chapter are the abnormalities most frequently encountered or noted while performing an examination.

The book is organized into regional anatomical sections including the spine and pelvis, the upper extremity, and the lower extremity. The book opens with two chapters that define the structures of the musculoskeletal system and discuss the basic concepts and parts of the musculoskeletal exam. A final chapter describes the examination of gait.

Each main chapter is organized in an identical manner:

- overview of the anatomical region
- observation of the patient
- subjective examination
- gentle palpation
- trigger points (where applicable)
- active movement testing
- passive movement testing
- physiological movements
- mobility testing
- resistive testing
- neurological examination
- referred pain patterns
- special tests
- radiological views

In Chapter 2, Basic concepts of the physical examination, we provide you with a framework for performing the examination, beginning with observation and ending with palpation. However, in each regional anatomy chapter, palpation follows observation and subjective examination and precedes all other sections. This is deliberate. For reasons of length, we felt it important to discuss each anatomical region and its own special anatomical structures as soon as possible in each chapter. This avoids repetition, gives you the anatomy early in each chapter, and then allows you to visualize each structure as you read the subsequent sections on testing. Hopefully, this will reinforce the anatomy and help you apply anatomy to function and function to the findings of your examination.

Each chapter includes a generous number of original line drawings, many of which are two-color. These provide clear snapshots of how to perform each examination technique. Thirty-two X-rays and MRIs have been included to help you with radiological anatomy. Paradigms and tables provide additional information that will help you understand the how and why of each examination technique.

By using *Musculoskeletal Examination* as a guide and reference, the reader will be able to perform the complete basic examination and understand common abnormalities and their pathological significance. We hope that our readers will gain an appreciation for the intimate relationship between the structure and function of the components of the musculoskeletal system. This understanding should then enable any reader to make a correct diagnosis and a successful treatment plan for each patient.

Acknowledgments

The writing of *Musculoskeletal Examination* would not have been possible without the overwhelming support and understanding of my wife, Elizabeth, and my sons, Tyler and Preston. I also want to thank my parents, Malcolm and Zelda Gross, for their guidance and efforts on my behalf.

J.G.

Thank you to my wife and family for their understanding, patience, support, and love.

J.F.

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To my business partner and friend, Sandy, for being there whenever I needed her.

To my family for their support, and to my many patients, colleagues, and friends who have helped me grow.

E.R.

About the Companion Website

Don't forget to visit the companion website for this book:

www.wiley.com/go/musculoskeletalexam

There you will find:
Hundred interactive multiple-choice questions to test your learning.
Links to the examination videos mentioned in the book.

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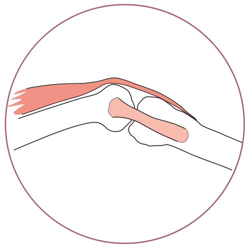

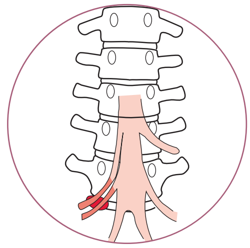

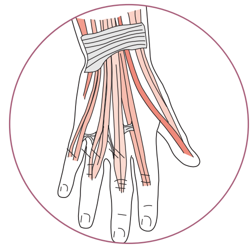

Introduction

The intention of this book is to provide the reader with a thorough knowledge of regional anatomy and the techniques of physical examination. A second and equally important intention is to describe a method for the interpretation and logical application of the knowledge obtained from a physical examination.

What Is a Physical Examination?

The physical examination is the inspection, palpation, measurement, and auscultation of the body and its parts. It is the step that follows the taking of a patient history and precedes the ordering of laboratory tests and radiological evaluation in the process of reaching a diagnosis.

What Is the Purpose of the Physical Examination?

The physical examination has two distinct purposes. The first is to localize a complaint, that is, to associate a complaint with a specific region and, if possible, a specific anatomical structure. The second purpose of a physical examination is to qualify a patient's complaints. Qualifying a complaint involves describing its character (i.e., dull, sharp, etc.), quantifying its severity (i.e., visual analog scale; grade I, II, III), and defining its relationship to movement and function.

How Is the Physical Examination Useful?

By relating a patient's complaints to an anatomical structure, the physical examination brings meaning to a patient's history and symptoms.

This, however, presupposes that the clinician possesses a thorough knowledge of anatomy. It also requires a methodology for the logical analysis and application of the information obtained from the patient's history and physical examination. This methodology is derived from a clinical philosophy based on specific concepts. These concepts are as follows:

1. If one knows the structure of a system and understands its intended function, it is possible to predict how that system is vulnerable to breakdown and failure (injury).
2. A biological system is no different from an inorganic system in that it is subject to the same laws of nature (physics, mechanics, engineering, etc.). However, the biological system, unlike the inorganic system, has the potential not only to respond but also to adapt to changes in its environment.

Such concepts lay the foundation for understanding the information obtained on physical examination. They also lead to a rationale for the treatment and rehabilitation of injuries. A correlation of this type of analysis is that it becomes possible to anticipate injuries. This in turn permits proactive planning for the prevention of injuries.

How Does the Musculoskeletal System Work?

The musculoskeletal system, like any biological system, is not static. It is in a constant state of dynamic equilibrium. This equilibrium is termed homeostasis.

As such, when subjected to an external force or stress, a biological system will respond in a very specific manner. Unlike the inorganic system (i.e., an

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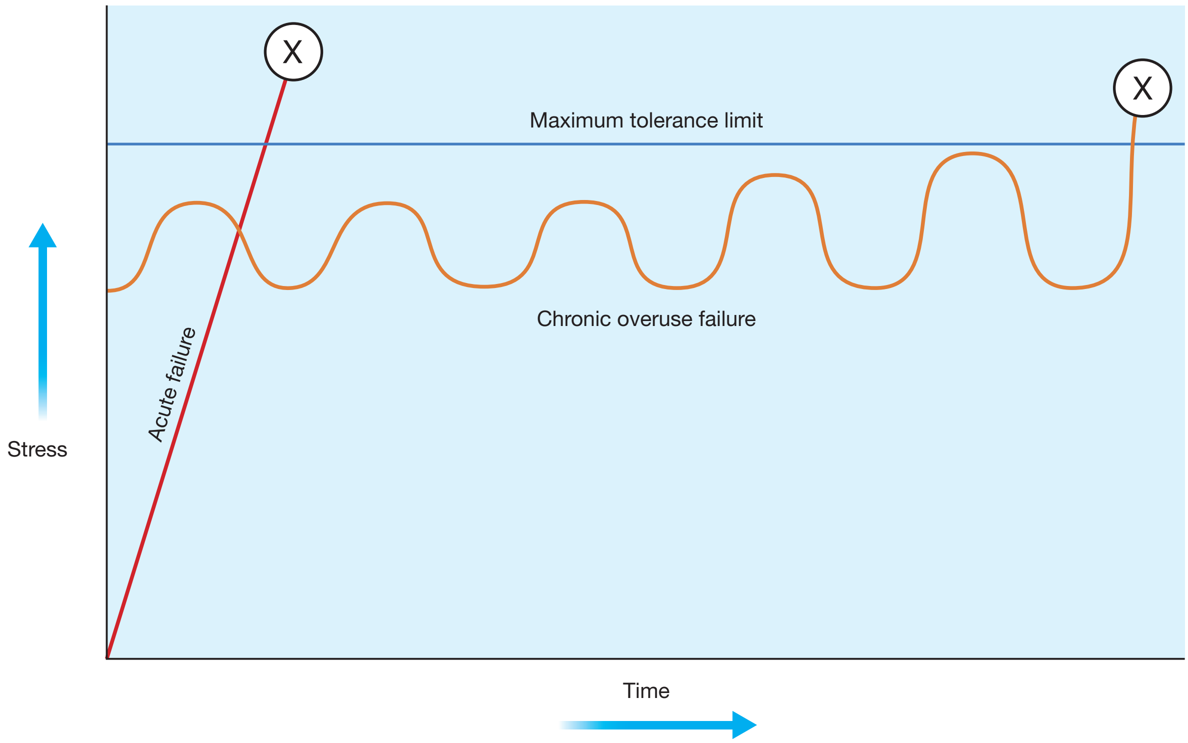

Figure 1.1 Biological systems, like inorganic systems, can fail under one of two modes: an acute single supramaximal stress or repetitive submaximal chronic loading.

airplane wing that is doomed to fail after a predictable number of cycles of load), the biological system will attempt to reestablish an equilibrium state in response to a change that has occurred in its environment. In doing so, the biological system will experience one of three possible scenarios: adaptation (successful establishment of a new equilibrium state without breakdown), temporary breakdown (injury), or ultimate breakdown (death). These scenarios can be expressed graphically. Any system can be stressed in one of the two modes: acute single supratolerance load or chronic repetitive submaximal tolerance load (Figure 1.1). In the first mode, the system that suffers acute failure is unable to resist the load applied. In the second mode, the system will function until some fatigue limit is reached, at which time failure will occur. In the biological system, either failure mode will initiate a protective-healing response, termed the inflammatory reaction. The inflammatory reaction is composed of cellular and humoral components, each of which initiates a complex series of neurological and cellular responses to the injury. An important consequence of the inflammatory reaction is the production of pain. The sole purpose of pain is to bring one's attention to the site of injury. Pain prevents further injury from occurring by causing protective guarding and limited use of the injured structure. The inflammatory response is also characterized by increased vascularity and swelling in the area of injury. These are the causes of the commonly observed physical signs (i.e., redness and warmth) associated with the site of injury.

However, the problem with pain is that although it brings protection to the area of injury (the conscious or unconscious removal of stress from the injured area), and permits healing to take place by removing dynamic stimuli from the biological system, this removal of stimuli (rest) promotes deterioration of a system's tolerance limit to a lower threshold. In this way, when the injury has resolved, the entire system, although "healed," may actually be more vulnerable to reinjury when "normal" stresses are applied to the recently repaired structures. This initiates the "vicious cycle of injury" (Figure 1.2).

Contrary to this scenario is one in which the biological system successfully adapts to its new environment before failure occurs. This situation represents conditioning of a biological system. The result is

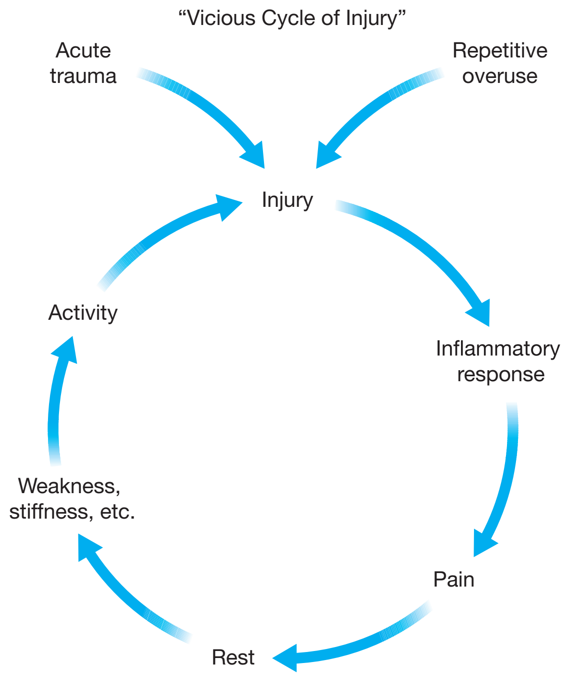

Figure 1.2 The "vicious cycle of injury" results from the reinjury of a vulnerable, recently traumatized system. This increased vulnerability occurs due to a diminishing of a system's tolerance limit as a result of adaptation to a lower level of demand during the period of rest necessitated by pain.

hypertrophy, enhanced function, and a consequent increase in the system's tolerance limit. The concept acting here is that the biological system's tolerance limit will adapt to increased demands if the demands are applied at a frequency, intensity, and duration within the system's ability to adapt (Figure 1.3).

Therefore, during the physical examination, asymmetry must be noted and analyzed as representing either adaptation or deconditioning of a given system. Any of these fundamental principles under which the musculoskeletal system functions makes it possible to organize the information obtained from a physical examination and history into general categories or pathological conditions (traumatic, inflammatory, metabolic, etc.), and the subsets of these conditions (tendinitis, ligamentous injuries, arthritis, infection, etc.). From such an approach, generalizations called paradigms can be formulated. These paradigms provide a holistic view of a patient's signs and symptoms. In this way, diagnoses are arrived at based on an analysis of the entire constellation of signs and symptoms with which a given patient presents. This method, relying on a multitude of factors and their interrelationships rather than on a single piece of information, such as the symptom of clicking or swelling, ensures a greater degree of accuracy in formulating a diagnosis.

What Are Paradigms?

Paradigms are snapshots of classic presentations of various disease categories. They are, as 19th-century clinicians would say, "augenblick," a blink-of-the-eye impression of a patient (Table 1.1). From such an impression, a comparison is made with an idealized patient, to evaluate for congruities or dissimilarities. Here is an example of a paradigm for osteoarthritis: a male patient who is a laborer, who is at least 50 years old, whose complaints are asymmetrical pain involving larger joints, and whose symptoms are in proportion to his activity. Another example might be that of rheumatoid arthritis. This paradigm would describe a female patient who is 20–40 years old, complaining of symmetrical morning stiffness involving the smaller joints of the hands, with swelling, possibly fever, and stiffness reducing with activity.

Paradigms may also be created for specific tissues (i.e., joints, tendons, muscles, etc.). The paradigm for a joint condition such as osteoarthritis would be well localized pain, swelling, stiffness on sedentary posturing, and pain increasing in proportion to use, whereas a paradigm for a mild tendon inflammation (tendinitis) may be painful stiffness after sedentary posturing that becomes alleviated with activity and gentle use. A paradigm for ligament injury would include a history of a specific traumatic event, together with the resultant loss of joint stability demonstrated on active and passive tensile loading of a joint.

The reader is encouraged to create his or her own paradigms for various conditions—paradigms that include the entire portrait of an injury or disease process with which a given patient or tissue may be compared. In this process, it will become obvious that it is not sufficient to limit one's expertise to the localization of complaints to an anatomical region. It is also necessary to be able to discriminate between the involvement of specific structures that may lie in close proximity within that region (i.e., bursae and tendons overlying a joint).

It can be concluded therefore that an accurate physical examination is as critical to the process of diagnosis as is a complete and accurate history of a patient's complaints. An accurate physical examination demands a thorough knowledge and familiarity with anatomy and function.

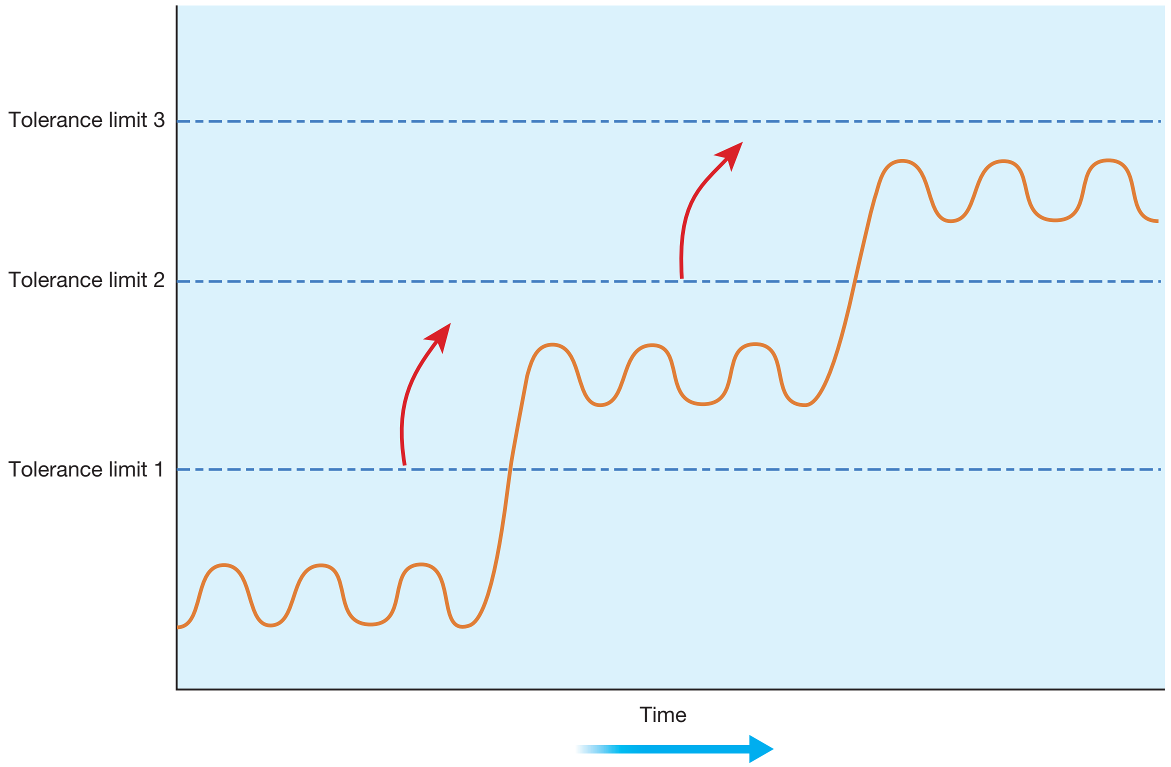

Figure 1.3 Conditioning is the adaptation of a biological system to the controlled application of increasing stress at a frequency, intensity, and duration within the system's tolerance limit, with a resultant increase in the system's tolerance limit.

What Are the Components of the Musculoskeletal System?

The musculoskeletal system is composed of bone, cartilage, ligaments, muscle, tendons, synovium, bursae, and fascia. This system is derived embryologically from the mesenchyme and is composed of soft and hard connective tissues. These tissues have evolved to serve two basic functions: structural integrity and stable mobility. The tissues are composite materials made up of cells lying within the extracellular matrix they produce.

Collagen, a long linear protein (Figure 1.4a), is the most abundant of the extracellular materials found in connective tissues. The foundation of collagen is a repetitive sequence of amino acids that form polypeptide chains. Three such chains are then braided together to form a triple helical strand called tropocollagen. These strands join to make microfibrils; long linear structures specifically designed to resist tensile loading. The microfibrils are bonded together through chemical cross-linking to form collagen fibers. The degree of cross-linking determines the physical properties of a specific collagen fiber. The more cross-linking that exists, the stiffer the fiber will be. The degree of collagen cross-linking is in part genetically and in part metabolically determined. This explains why some people are much more flexible than others. Vitamin C is critical for the formation of cross-links. As such, scurvy, a clinical expression of vitamin deficiency, is characterized by "weak tissues." Hypermobility of joints (i.e., ability to extend the thumbs to the forearms, ability to hyperextend

Table 1.1 Paradigms for Osteoarthritis and Rheumatoid Arthritis

Paradigm for Osteoarthritis	Paradigm for Rheumatoid Arthritis
Male	Female
Laborer	20–40 years old
50 + years old	Symmetrical small joint involvement
Large joint involvement	Associated swelling, fever, rash, morning stiffness
Asymmetrical involvement	Abating with use
Pain in proportion to activity	

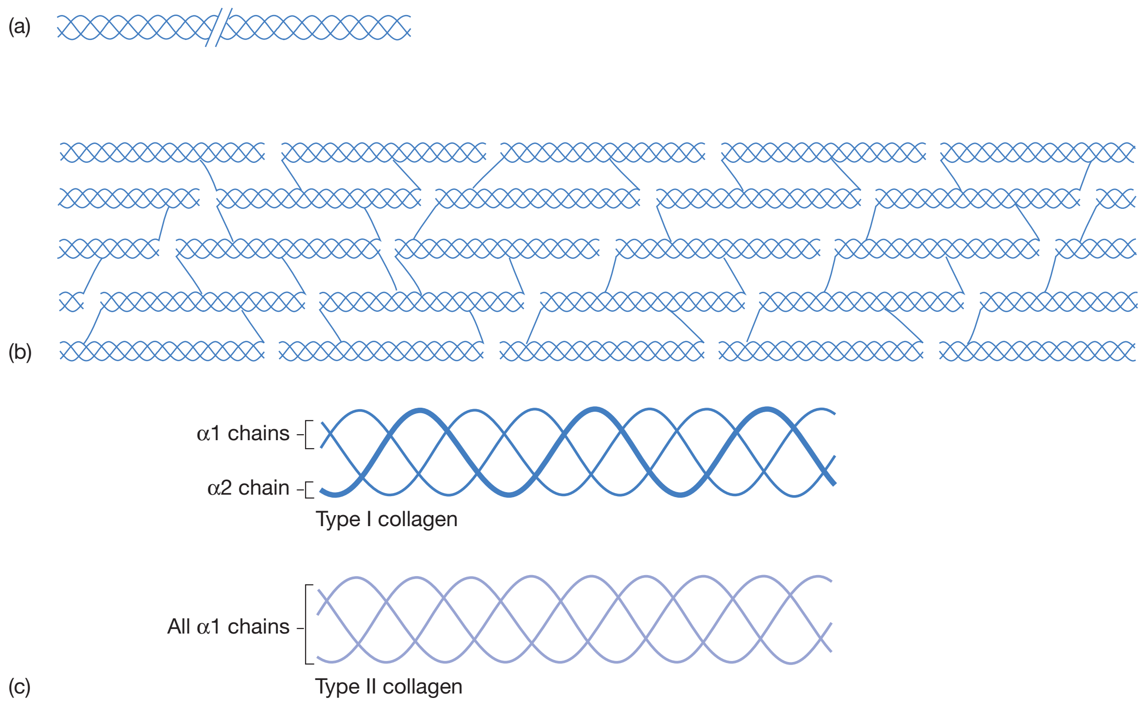

Figure 1.4 (a) Collagen is a linear protein made of α chains that wind into a triple-helix. (b) Collagen fibrils are formed by the cross-linking of collagen monomer proteins. (c) The different types of collagen are determined by the number of $\alpha1$ and $\alpha2$ collagen monomers that join to form a triple-helix collagen molecule. For example, two $\alpha1$ chains and one $\alpha2$ chain that join to form a triple-helix make type I collagen, which is found in bone, tendon, ligament, fascia, skin, arteries, and the uterus. Type II collagen, which is found in articular cartilage, contains three $\alpha1$ chains. There are at least 12 different collagen types.

at the knees and elbows, excessive subtalar pronation with flat, splayed feet) is a clinical manifestation of genetically determined collagen cross-linking (Figure 1.4b).

Different types of collagen exist for different categories of tissues. These types are defined by the specific composition of the polypeptide chains that form the strands of the collagen molecules. Type I collagen is found in connective tissue such as bone, tendons, and ligaments. Type II is found uniquely in articular hyaline cartilage. Other collagen types exist as well (Figure 1.4c).

If collagen represents the fiber in the composite structure of connective tissue, ground substance represents the "filler" between the fibers. The main components of ground substance are aggregates of polyglycan macromolecules. An example of such a macromolecule is the proteoglycan hyaluronic acid, found in articular cartilage. Hyaluronic acid is a molecule of more than 1 million daltons. It is composed of a long central core from which are projected many protein side chains containing negatively charged sulfate radicals. It can best be visualized as a bristle brush from which many smaller bristle brushes are projected (Figure 1.5). These strongly negative sulfate radicals make the hyaluronic acid molecule highly hydrophilic (water attracting). This ability to attract and hold water allows the connective tissue ground substance to function as an excellent hydrostatic bearing surface that resists compression load.

Immobilization reduces the diffusion and migration of nutrients throughout the connective tissues. This in turn compromises cellular activity and upsets the normal homeostatic balance of collagen and ground substance turnover. The result is an atrophy of collagen fibers and a diminution of ground substance (Cantu and Grodin, 2011), with subsequent deterioration of the connective-tissue macrofunction (i.e., chondromalacia patellae).

Bone

Bone provides the structure of the body. It is the hardest of all connective tissues. One-third of bone is composed of collagen fibers and two-thirds mineral salts, primarily calcium hydroxyapatite. Bone is formed in response to stress. Although genetically