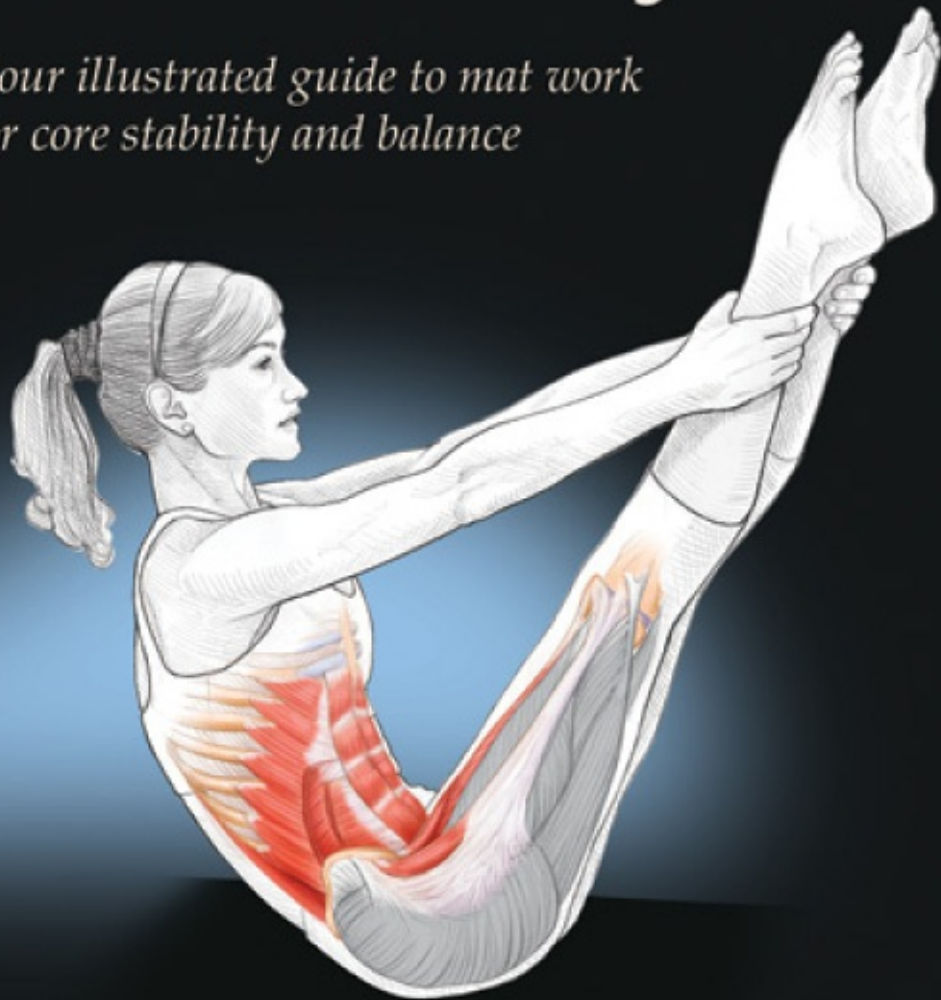


# PILATES

# Anatomy

*Your illustrated guide to mat work  
for core stability and balance*



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RAEL ISACOWITZ • KAREN CLIPPINGER

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# **PILATES ANATOMY**

**Rael Isacowitz  
Karen Clippinger**



**Human Kinetics**

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To Joseph and Clara Pilates and the many dedicated teachers who have kept their vision alive

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# Preface

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In recent years, a profound evolution of Pilates has occurred. The Pilates industry seemed to reach a tipping point (a point of critical mass) in the mid- to late 1990s, whereby it morphed from a little-known form of exercise with a devout but small following including dancers, singers, circus performers, and actors to a mainstream fitness regimen practiced in many households. It suddenly started appearing in Hollywood movies and television commercials, in cartoons and comedy shows, and on late-night television. It became synonymous with going to Starbucks and indulging in a low-fat triple-shot soy latte (no whipped cream please!).

How this happened, why this happened, and to what this phenomenon can be attributed remains somewhat of an enigma. However, few can dispute that the growth of active participants in the United States from approximately 1.7 million in 2000 to approximately 10.6 million in 2006 is a remarkable phenomenon. Worldwide participation also has exploded.

Of course, all growth comes with growing pains, and the Pilates industry is no exception. The accelerated education, which is often a part of rapid growth, has certainly taken hold in Pilates. Although we favor a more comprehensive approach, the accelerated approach has been one part of the expansion of Pilates that has led to a multitude of positive outcomes, such as Pilates' filtering into many new arenas including fitness clubs, training programs for athletes, and medical facilities.

Understanding Pilates requires some knowledge of its history. Joseph Pilates was born on December 9, 1883, near Düsseldorf, Germany. He died on October 9, 1967. Unfortunately he did not live to see the realization of his dreams. He adamantly believed that his approach to total well-being should be embraced by the masses and certainly by health care professionals. He hoped that *contrology*, as he called his system, would be taught in schools throughout the United States. He intended his method to be a mainstream form of conditioning for men, and initially it was practiced more by men, although it is largely women who have kept the flame alive all these years.

It is fortunate that several early students of Mr. Pilates and his wife, Clara, whom he met on his second trip to the United States in 1926 and who became his lifelong partner in his work, survived them and became exceptional teachers in their own right. These first-generation Pilates teachers taught directly by Joseph and Clara Pilates, have played a profound role in the evolution of the Pilates industry. Rael Isacowitz has had the distinct privilege of studying with several members of this unique group over the past 30 years. Ms. Kathleen Stanford Grant must be singled out as having a particularly powerful effect on this author's development and teaching style.

Joseph Pilates did not leave extensive written materials to guide future generations of Pilates professionals. The limited archival material—photographs, films, and texts—have been very valuable. However, mainly word of mouth and the universal language of movement have been used to pass much of his teachings down from first generation to second and on to following generations. Mr. Pilates did write two short books, and one of them, *Return to Life Through Contrology*, served as the primary reference for *Pilates Anatomy*. The decision to use the exercises as they appear in *Return to Life Through Contrology* as the basis for the primary descriptions of most exercises in *Pilates Anatomy* was an important one. Our goal is for *Pilates Anatomy* to transcend teaching styles and individual approaches to Pilates, or any particular school of Pilates. This book is written to be universal in its appeal, just as anatomy itself is universal. Using *Return to Life Through Contrology* brings the work as close to the source as one can get, with the intent that *Pilates Anatomy* can serve

a bridge for the many different approaches to Pilates that have emerged and can offer a meeting ground for all Pilates professionals and enthusiasts from every part of the Pilates spectrum and all corners of the globe.

Today Pilates can be found in every conceivable environment. Pilates is taught in private studios, academic institutions, fitness centers, and medical facilities. It is used with clients ranging from elite athletes to people with limited capacities due to disease or injury. Age groups ranging from kindergartners to folks in their 90s enjoy the benefits of Pilates. Is there another method that can accommodate such a wide variety of users? This is the magic of Pilates. It is so extremely adaptable. This is certainly one of the reasons for the boom in popularity.

*Pilates Anatomy* is the work of two authors with much in common but with different expertise to bring to this book. Over the past 30 years, Rael Isacowitz has done extensive study in Pilates, which has included work with the most highly respected early Pilates teachers. He developed an acclaimed Pilates center, and for the last 21 years has designed and directed an internationally renowned Pilates education organization. His knowledge and skill has earned him invitations to travel the world teaching and lecturing. Karen Clippinger has 30 years' experience in teaching anatomy at prominent centers and universities. Her keen ability to make anatomical concepts applicable is well known and has led to her lecturing internationally at many prestigious venues. In the last 17 years, her work has emphasized bringing Pilates to rehabilitation and academic settings, establishing her as a leader in the field. Both of them have rich backgrounds in exercise science and substantial experience as dancers and athletes. Combined they have more than 60 years' experience in study, performance, practice, and teaching, and philosophically they share much in common. Their paths crossed more than 17 years ago, and they have enjoyed a vibrant, often spirited, and always inspiring professional dialogue ever since.

Traveling extensively, presenting, and teaching in many parts of the world gave them a firsthand international perspective on how Pilates is being embraced in so many countries. From China to Russia, from Australia to South Africa, and from the United States to Europe, they have connected with people and contributed to the growth of the industry. There are few countries today in which Pilates is not present. They hope *Pilates Anatomy* will serve as a tool to connect Pilates professionals and enthusiasts alike as an international community speaking an international language.

The direction the expansion of Pilates has taken demands that Pilates professionals have sound knowledge of anatomy. Yet everyone should be able to benefit from the information in this book. The *Pilates Anatomy* approach is designed to be inclusive and not exclusive of any school of Pilates teaching, offering basic anatomical exercise descriptions that can be applied easily to different variations or modifications used by a given approach or for a specific participant. It should be useful for beginning students as well as for physical therapists and others with extensive knowledge of human anatomy. The complementary use of drawings showing targeted working muscles, lists of key muscles, and anatomical information within technique cues and exercise notes will allow the reader to use the information at different levels, in accordance with current knowledge and movement experience. The intention is to offer everyone a solid anatomically based foundation on which to practice Pilates with integrity. Most important, be safe and enjoy!

# Six Key Principles of Pilates

**P**ilates is not just exercise. Pilates is not just a random choice of particular movements.

Pilates is a system of physical and mental conditioning that can enhance your physical strength, flexibility, and coordination as well as reduce stress, improve mental focus, and foster an improved sense of well-being. Pilates can be for anyone and everyone.

Before exploring the anatomy of Pilates, it is important to note that many different approaches to this system have evolved. Some forms of Pilates focus primarily on the physical aspect of the system, while others emphasize the mind–body angle. In its original form, Pilates, as expressed emphatically by Joseph H. Pilates, was a system designed to be integrated into every facet of life. Film footage shows Joseph Pilates not only demonstrating exercises and physical activity but also advising on everyday activities such as how to sleep and wash. Although the majority of this book will be devoted to breaking down the muscular involvement in every movement and analyzing each exercise on that basis, it would be an injustice to the system (originally called *contrology*), its founder, and the industry not to address the principles of the method and the mind–body connection.

## Foundation Principles of Pilates

Although Joseph Pilates did not specifically notate tenets for his method, the following principles can be identified clearly throughout the pages of his texts and gleaned from original film footage and other archival material. Depending on the school of Pilates, the list of principles and the way they are presented may vary slightly; however, this list—breath, concentration, center, control, precision, and flow—includes those principles that form the basis of many approaches of Pilates and are generally accepted as the foundation of the system.

### Breath

Although all the foundation principles share equal importance, the importance of breath and its numerous implications can be observed far beyond the fundamental and crucial role of respiration. This inclusive view is the basis of some approaches to the study of Pilates, but certainly not all. In this context, breath can be described as the fuel of the powerhouse, which is the engine that drives Pilates. It may be viewed as being of the body, of the mind, and of the spirit, as Joseph Pilates regarded it. In this view breath can serve as a common thread that runs through all the foundation principles, in a sense sewing them together.

Breath is one of the keys to life itself—the respiratory muscles are the only *skeletal* muscles essential to life—and yet breath is so often taken for granted. An understanding of the anatomy underlying breath can facilitate optimal use of breath. Because of the complex anatomical processes involved in breathing, breath will be dealt with in greater depth later in this chapter.

### Concentration

Concentration can be defined as direction of attention to a single objective, in this case the mastery of a given Pilates exercise. A Pilates practitioner's intent is to perform the exercises as correctly as his or her current skill level will allow. This requires concentration. Begin by going through a mental

checklist of points to focus on for each exercise. This may take a few seconds or even a minute or two and should include awareness of the breath pattern as well as the muscles that are about to be worked. Concentrate on the alignment of the body and on maintaining correct alignment and stabilization throughout the execution of the exercise. Maintain mental concentration for the duration of the session.

## Center

The concept of center can have several levels of meaning. Primarily it relates to the body's center of gravity. The body's center of gravity is the single point about which every particle of its mass is equally distributed—the point at which the body could be suspended and where it would be totally balanced in all directions.

Each person is built differently and has an individual center of gravity. Where the center of gravity lies distinctly affects how an exercise feels and how difficult or easy it is to execute. Therefore it is a mistake to assume a person lacks strength if he cannot execute an exercise successfully. Lack of success may have more to do with how the person is built and the distribution of body weight. When standing upright with the arms down by the sides, the center of gravity of the average person is located just in front of the second sacral vertebra and at about 55 percent of the person's height. However, significant variances can be observed within, as well as between, genders.

Center also relates to the core and the muscles of the core. In Pilates this is referred to as the *powerhouse*, which will be discussed in greater depth in chapter 2. Center also may have a more esoteric connotation, referring to a feeling of balance within or the eternal spring of energy from which all movement emanates.

## Control

Control can be defined as the regulation of the execution of a given action. Refining control is inherent in mastering a skill. The first time someone executes an exercise, he or she has to use control, but as skill increases, this control will be more refined. You can see a distinct difference when viewing a movement performed by someone who has achieved a high level of control and someone who has not. Often a higher level of control is associated with fewer and smaller errors, exact alignment, greater coordination, greater balance, and greater ability to reproduce the exercise successfully over multiple attempts, using less effort and avoiding excessive muscle tension. Refining control requires a great deal of practice, which can aid in developing the necessary strength and flexibility of key muscles as well as allow for the development of more refined motor programs. This practice can also allow these motor programs to run with less conscious attention, so that attention can be paid to finer details and to making minute adjustments, only when needed.

## Precision

Precision is key when distinguishing Pilates from many other exercise systems. Precision can be described as the exact manner in which an action is executed. Often the exercise itself is not so different from other exercise regimens, but the way it is executed is different.

Knowledge of anatomy aids greatly in achieving precision. You will understand which muscles are working or should be working. You will align your body correctly and understand the goals of an exercise. The greater the precision, the more likely the goal will be achieved and the greater the benefit from doing the exercise. Precision is key to the Pilates approach to movement and to the infinite corrections that need to be implemented through the learning process.

Precision can be associated with the activation of isolated muscles and at the same time with the integration of the required muscles to create movement. Precision can make the difference between accessing a muscle or not and between achieving the goal or not.

## Flow

Flow is an essential quality to strive for. Flow can be described as a smooth, uninterrupted continuum of movement. Romana Kryzanowska describes the Pilates method as “flowing motion outward from a strong center.” Flow requires a deep understanding of the movement and incorporates precise muscle activation and timing. As movement proficiency develops from extensive practice, each movement and each session should flow.

Some approaches also encourage a more esoteric use of flow. This meaning is exemplified in the statement by Mihály Csíkszentmihályi that “flow is the mental state of operation in which the person is fully immersed in what he or she is doing by a feeling of energized focus, full involvement, and success in the process of the activity.”

These six elements should be present when executing the exercises in this book and throughout daily activities. The common denominator of the six principles is that each one has a distinct physical and mental component. These very elements connect the body and the mind and permit the anatomic understanding to which this book is largely devoted to have a greater impact on your life.

The way in which each person integrates these principles into the practice of Pilates and life itself is individual. For example, one person may emphasize more of the physical aspects, using Pilates to enhance athletic performance, improve muscle tone, or aid with recovery from injury. Another person may place greater import on the mental aspects, using Pilates to reduce stress or aid with improving focus and concentration in his or her life. Yet the important issue is that the execution of each exercise and the practice of the system as a whole are not just a careless imitation of the illustrated exercise steps provided in this book, but rather a process focused on learning how the exercises are executed and applying these six principles in accordance with your current physical and mental acuity.

## A Closer Look at the Science of Breathing

Breath is the first principle mentioned in this chapter and one that, historically, has played a vital role in most mind–body systems. It is accepted by many Pilates professionals as having paramount importance in the practice of the method. Discussions and, at times, disagreements as to a particular breath pattern, or whether a set breath pattern is necessary at all, may arise. However, few people would dispute the importance of breath for exercise, and a better understanding of breathing can help you obtain greater benefits from the exercises in this book.

The major function of the respiratory system is to deliver oxygen to and remove carbon dioxide from the tissues of the body. Although every cell in the body must have oxygen to live, the body's need to rid itself of carbon dioxide, a by-product of cellular metabolism, is the most important stimulus for breathing in a healthy person. At least four processes are involved, collectively termed *respiration*. The first two processes, *external respiration*, involve movement of external air into the lungs (pulmonary ventilation) and from the lungs into the blood (pulmonary diffusion), and vice versa. This book will focus on these first two processes. The next two processes involve the transport of gases by the circulatory system to tissues such as muscles and the exchange of oxygen and carbon dioxide between the capillary blood and tissue cells.

## Anatomy of the Respiratory System

The lungs of an average-size person weigh about 2.2 pounds (1 kg). They are compact and fit within the thoracic cavity. However, because of the extensive network of tubes and millions of gas-filled air spaces (alveoli), if spread out the tissue would occupy a surface area about the size of a singles tennis court or a medium-size swimming pool. This unique structure provides the lungs with a massive surface area that is ideal for their vital function of gas exchange.

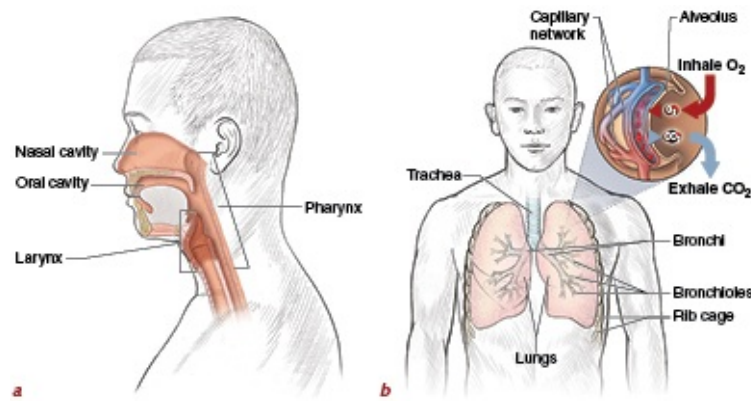


Figure 1.1 Respiratory system: (a) upper respiratory tract; (b) lower respiratory tract showing the alveolus and the region of gas exchange between the alveolus and capillary network.

Structurally, the respiratory system can be divided into two major parts—the upper and lower respiratory tracts. The upper respiratory tract (figure 1.1a) is a system of interconnecting cavities and tubes (nasal cavity, oral cavity, pharynx, and larynx) that provide a pathway for the air into the lower respiratory tract. This upper tract also serves to purify, warm, and humidify the air before it reaches the final portion of the lower tract. The lower respiratory tract (trachea, bronchi, bronchioles, and alveoli, figure 1.1b) terminates in structures that allow for the exchange of gases, including approximately 300 million alveoli and their associated extensive network of capillaries. The wall of an alveolus is thinner than a piece of tissue paper, easily allowing for oxygen to pass from the alveolus into the tiny pulmonary capillaries and for carbon dioxide to pass from the pulmonary capillaries into the alveolus by simple diffusion.

## Mechanics of Breathing

Pulmonary ventilation, commonly termed *breathing*, consists of two phases. The process of moving air into the lungs is called *inhalation* or *inspiration*, and the process of moving gases out of the lungs is called *exhalation* or *expiration*. In essence, pulmonary ventilation is a mechanical process that involves volume changes in the thoracic cavity that lead to pressure changes, which result in the flow of gases to equalize pressures. The changes in volume necessary for pressure changes are greatly aided by the structure of the thorax (sternum, ribs with associated cartilages, and vertebrae). The ribs articulate with the spine so that they can move upward and outward during inspiration and downward and inward during expiration.

### Inhalation

Inhalation (inspiration) is initiated by activation of the respiratory muscles, particularly the diaphragm. When the dome-shaped diaphragm contracts, it flattens out, allowing more height in the thoracic cavity (figure 1.2a). The external intercostals act to lift the rib cage and pull the sternum forward. The orientation of the ribs is such that the ribs of the midthorax and lower thorax increase volume more laterally, or sideways, while the ribs of the upper thoracic cavity increase thoracic volume more in a forward and backward direction (figure 1.2b). The increase in volume of the thoracic cavity produced by these respiratory muscles results in the pressure within the alveoli of the

lungs (intrapulmonary pressure) being lower than the outside atmospheric pressure. Thus, air enters the lungs until the intrapulmonary pressure is equal to the atmospheric pressure (the pressure exerted by the air outside the body).

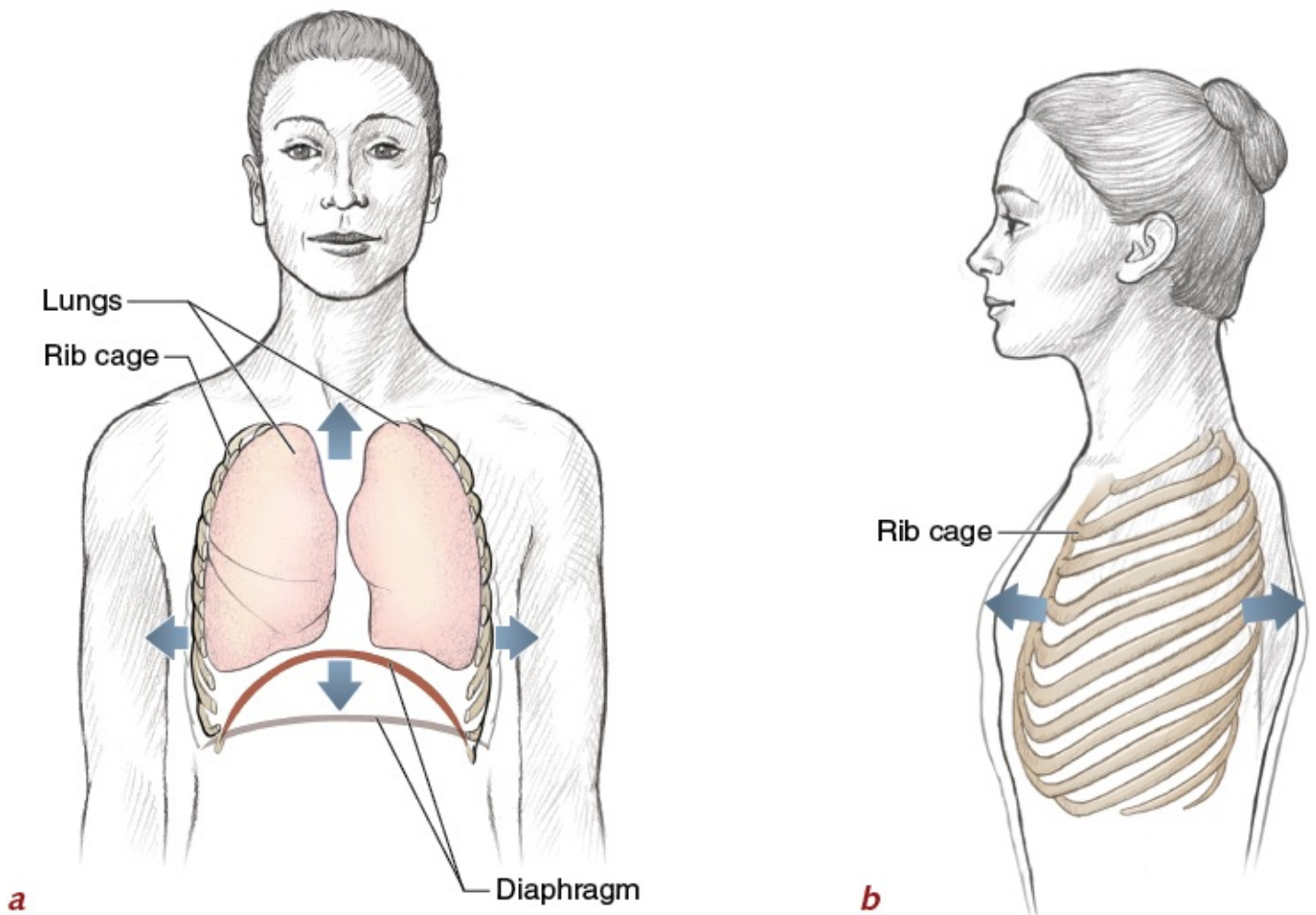


Figure 1.2 Changes in thoracic volume during inhalation: (a) front view displaying lateral expansion in the lower thorax due to orientation of ribs and contraction of the diaphragm; (b) side view displaying forward and backward expansion in the upper thorax due to orientation of ribs and sternum.

The expansion of the lungs is also aided by an additional mechanism relating to the surface tension between two important membranes. These two thin membranes are called *pleurae*. The *visceral pleura* covers the lungs, and the *parietal pleura* covers the inside of the chest wall and diaphragm. Between these two pleurae, the pleural space exists. It is airtight and contains a small amount of fluid. As the chest wall expands, the lungs are drawn outward, coupling the outer covering of the lungs with the inner lining of the thorax wall because of the increase of the negative pressure in the pleural space.

When pulmonary ventilation demands increase, such as during rigorous exercise or with some pulmonary diseases, the two previously described processes are aided by activation of many other accessory muscles. During inspiration, for example, additional muscles such as the scalene, sternocleidomastoid, pectoralis major, and pectoralis minor can be recruited to help further elevate the ribs. Muscles such as the erector spinae can help straighten the thoracic curve so that a greater increase in thoracic volume precipitates a greater volume of incoming air.

## Exhalation

Exhalation (expiration) with quiet breathing is primarily passive, relying on the elastic recoil of the lung tissue and changes associated with relaxation of the respiratory muscles. As the diaphragm relaxes, it moves upward into the thorax. The ribs lower as the intercostal muscles relax (figure 1.3).

The thoracic cavity volume decreases. This, in turn, increases the intrapulmonary pressure relative to the outside atmospheric pressure, resulting in air flowing from the lungs to outside the body.

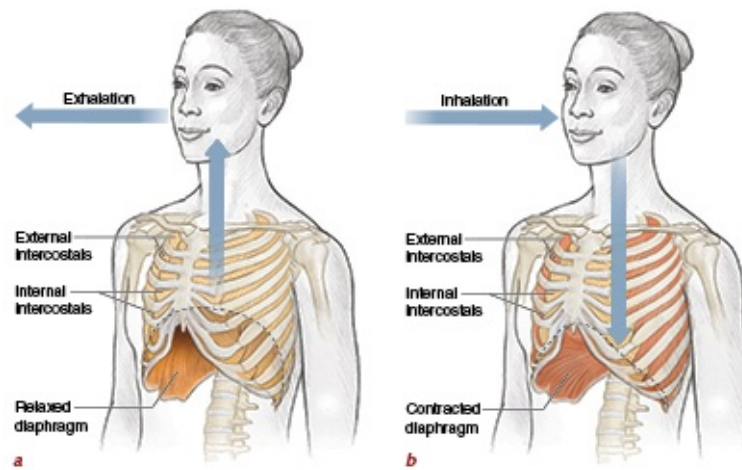


Figure 1.3 Action of the diaphragm, external intercostals, and internal intercostals: (a) after passive exhalation, showing the diaphragm in a dome shape and the external intercostals and internal intercostals relaxed; (b) during inhalation, displaying the diaphragm contracted (flattened), external intercostals contracted, and internal intercostals relaxed.

However, when exhalation is forced, such as when pulmonary ventilation requirements increase, active contraction of many muscles can be added to the passive mechanisms. For example, contraction of the abdominal muscles can press the diaphragm upward via intra-abdominal pressure as well as other muscles such as the internal intercostals, quadratus lumborum, and latissimus dorsi depressing the rib cage.

## Breathing During the Practice of Pilates

The belief that breathing exercises, or voluntarily controlled breathing patterns, may provide health benefits or enhance physical performance has been shared by many cultures for centuries. The proposed benefits range from enhanced relaxation and decreased stress to lowered blood pressure, improved focus, activation of specific muscles, better circulation and respiration, and even lower risk for cardiovascular disease. Although some scientific research exists regarding the potential positive effects of various controlled breathing techniques, additional research is needed to better understand these benefits and create optimal training techniques. However, one cannot ignore the number of disciplines, both Eastern and Western, that use breath in a profound way—yoga, tai chi, aikido, karate, capoeira, dance, swimming, weightlifting, and so on. Some systems of training have endeavored to harness different effects of breath to enhance performance or foster health of the body, mind, and spirit.

Pilates uses breathing in various ways in an attempt to foster these greater benefits. Three key ways that breathing is shaped, or controlled, in Pilates is through lateral breathing, set breath patterns, and active breathing.

### Lateral Breathing

*Lateral, or intercostal, breathing* emphasizes the lateral expansion of the rib cage while maintaining consistent inward pull of the deep abdominal muscles during both inhalation and exhalation (figure 1.4). This is in contrast to the type of breathing that emphasizes the lowering of the diaphragm during inhalation (often called *diaphragmatic breathing*), with the abdominal muscles relaxed so they are allowed to push outward.



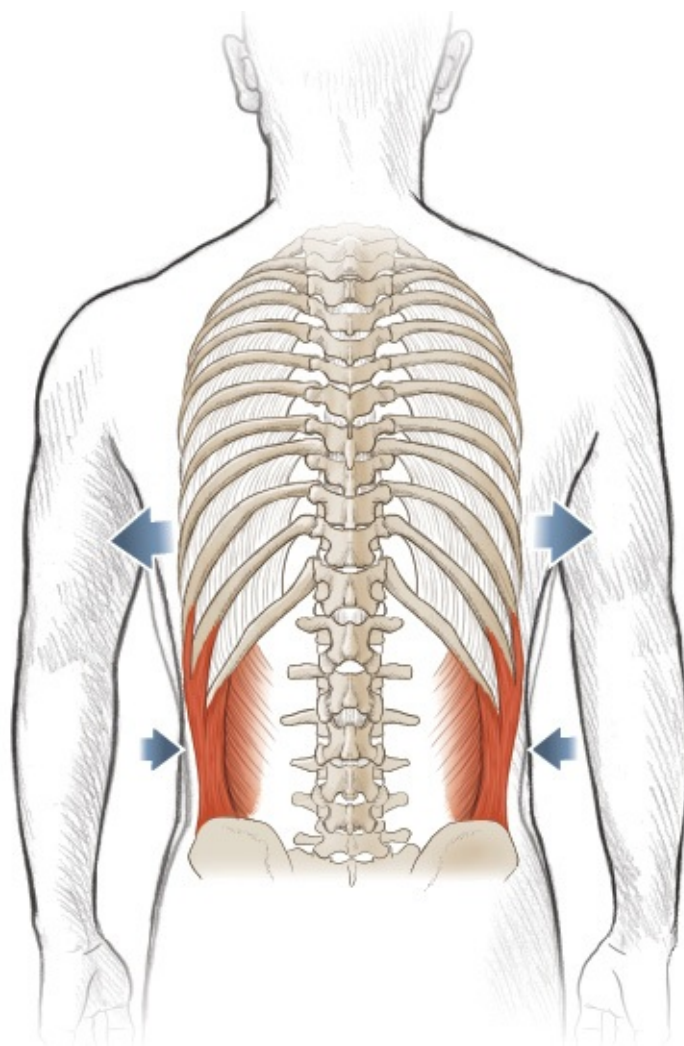


Figure 1.4 Expansion of the rib cage during inhalation when using lateral breathing, with a corsetlike action around the middle trunk for support.

A reason for using lateral breathing is to help maintain abdominal contraction while performing Pilates exercises during which keeping a stable core is important for successful performance and for protection of the body. This by no means implies that diaphragmatic breathing is negative or that the diaphragm does not still play a vital role in breathing, only that lateral breathing is the preferred mode during the practice of Pilates.

## Set Breath Patterns

The Pilates exercises in this book have a set breath pattern. An inhalation occurs during some phase of the movement, and an exhalation occurs during another phase. One reason for these patterns is to keep you from holding your breath, particularly when a lot of effort is required in an exercise. Holding the breath can be associated with excessive muscle tension and an undesired and potentially dangerous increase in blood pressure (the Valsalva maneuver). Exhaling during the phase that requires greater exertion can prevent holding the breath.

A given breath pattern may also influence the muscles being recruited. For example, an exhalation can foster activation of the deep abdominal muscle called the transversus abdominis, discussed in chapter 2.

Lastly, the breath pattern can help establish the dynamic, or rhythm, of a given Pilates exercise. Every exercise in Pilates has a particular quality. Some exercises or phases of a given exercise are performed more slowly and smoothly. Others are performed more rapidly and forcefully. The varying dynamics assist in giving a Pilates session variety as well as simulating daily activities more closely.

## Active Breathing

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A special case in which breathing may dramatically influence the dynamic of an exercise is active breathing. In signature exercises such as Hundred, the breath is pushed out not only more forcefully during exhalation but also with a percussive emphasis as the practitioner actively contracts the abdominals and particularly the internal intercostals in stages. On the inhale, the breath is drawn in with a percussive emphasis in stages, highlighting the external intercostals. Hundred, for example, requires five beats during inhalation and five beats during exhalation. Each beat represents further contraction of these muscles.

Use of active breathing should be individual. People who work with excessive tension are encouraged to use a more relaxed and softer mode of breathing. For some, active breathing may help activate target muscles and inject a higher energy into a Pilates session.

Ron Fletcher, an early student of Joseph and Clara Pilates and one of the foremost teachers of Pilates, developed an approach to breathing called Percussive Breathing. He explains: “The breath shapes the movement and defines its dynamic.” *Percussive* should not be mistaken for *forceful*; rather, it offers a sound and rhythm to the breath that fluctuates with each exercise. Think of it as inflating a balloon and then releasing as much air as possible through a small opening in a constant, steady stream. This concept is reminiscent of Joseph Pilates’ breathometer, a spinning wheel that turned as one blew at it. The goal was to keep the wheel turning at a consistent velocity. “There needs to be attention to both the inhale and exhale,” Fletcher notes, recalling Joseph Pilates saying in his thick German accent, “You must out the air before you can in the air.” Fletcher adds, “Inspiration is inspiration for the movement.”

## Application of Foundation Principles to Mat Work

Mat work forms the foundation of Pilates, not only in terms of the exercises but also in terms of the practice and integration of the principles into the work and into your life. The foundation principles should be present throughout your practice of Pilates in order to produce maximum results. Follow these steps while learning and mastering the exercises.

First focus on learning the basic movement pattern based on the breath pattern described in each exercise. Closely note the positions of the body shown in the illustrations, and read the descriptions.

Use keen concentration when practicing the movement to help achieve the sense of center and control associated with making a movement second nature through the development of an easily recalled, accurate, and reliable motor program. Focus on the cues (and feel free to add more of your own) to aid in achieving the precision inherent in Pilates. Practice the movement pattern until you become familiar with the many nuances of the movement. Each movement demands intricate timing and activation of the correct muscles in a particular recruitment pattern.

As you master the timing and apply all the principles, the quality of flow will be born in the movement. At this point you may pay attention to the transitions from one movement to the next. This helps create a general flow in your workout as a whole.

Combining the foundation principles of Pilates with a deeper understanding of the workings of the body through the anatomical information in the upcoming pages is a powerful combination and one that will certainly bring with it a multitude of benefits. A key to success lies in practice. With consistent practice and reinforcement of the movements, you will undoubtedly enjoy the wonderful world of Pilates.

# Spine, Core, and Body Alignment

Body alignment can be described as the relative positioning of body segments, such as placement of the head relative to the shoulders. *Static alignment* is this relative positioning when the body is stationary. The relative positioning that occurs during movement is *dynamic alignment*. Both static and dynamic alignment are important in Pilates. Pilates should improve awareness of body alignment as well as your ability to achieve the desired body alignment associated with a given movement in any position.

## The Skeleton

To understand and improve alignment, we need to look deep inside the body at the structural building blocks—the 206 bones of the human skeleton—that help determine alignment. The skeleton has two major divisions: the axial skeleton and the appendicular skeleton. As seen in figure 2.1 on page 10, the *axial skeleton* (in yellow) is made up of the skull, vertebral column (spine), ribs, and sternum (breastbone). As its name suggests, when standing, the axial skeleton forms the central upright axis of the body to which the limbs are attached.

The *appendicular* skeleton consists of the bones that make up the limbs, or appendages. The appendicular skeleton has two subdivisions: the paired upper extremities and the paired lower extremities. Each of the two *upper extremities* (shown in green in figure 2.1) contains one clavicle (collarbone); one scapula (shoulder blade); one humerus (upper arm bone); one radius and one ulna (the forearm bones); and eight carpals, five metacarpals, and 14 phalanges (the bones of the hand). Each of the two *lower extremities* (shown in blue in figure 2.1) contains one os coxae (hip bone); one femur (thigh bone); one tibia (shinbone) and one fibula (the smaller bone in the lower leg); and seven tarsals, five metatarsals, and 14 phalanges (the bones of the foot). In the adult, one hip bone, technically termed the *os coxae* or *coxal bone*, is made up of three fused bones: the ilium, ischium, and pubis.

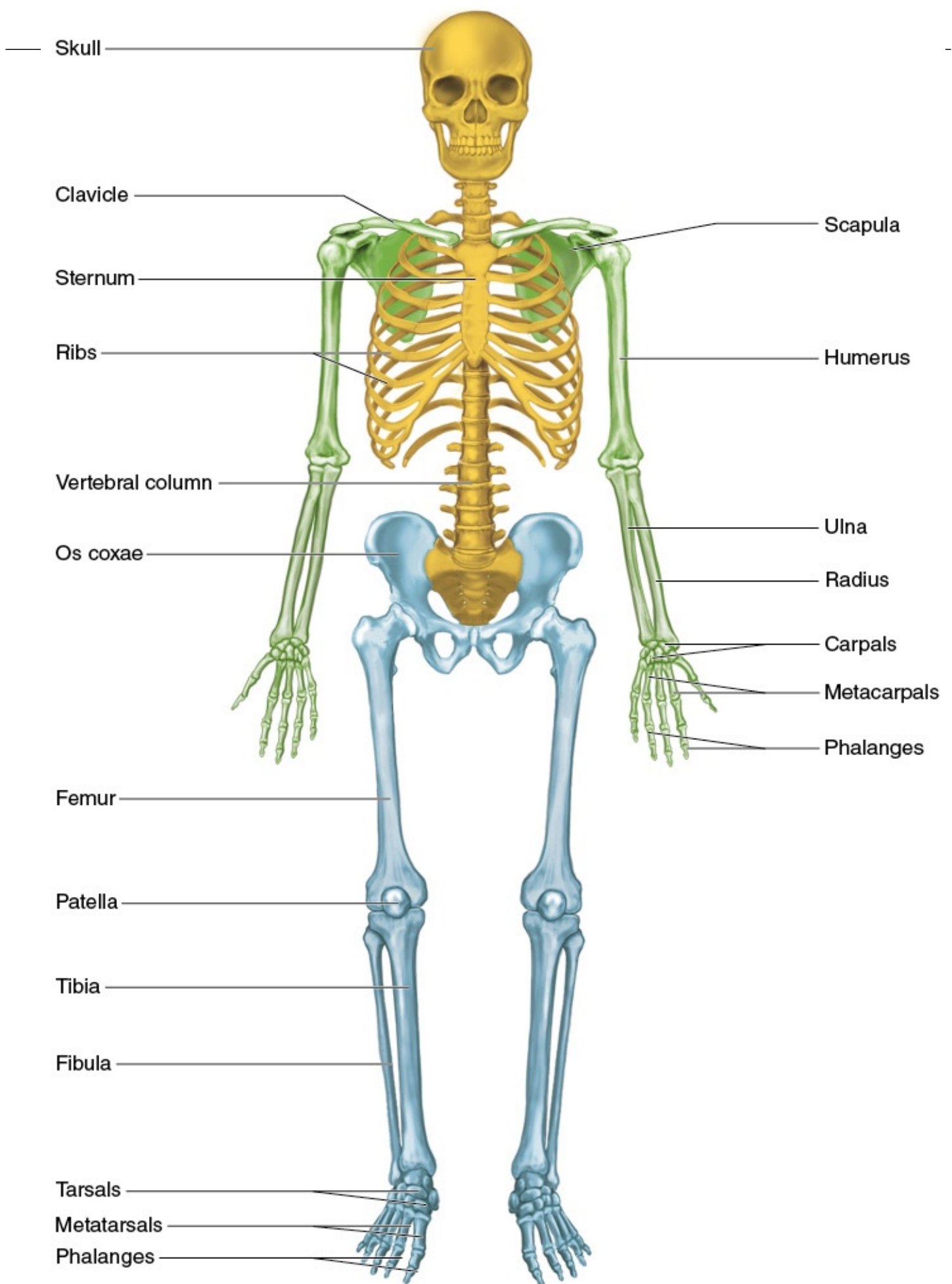


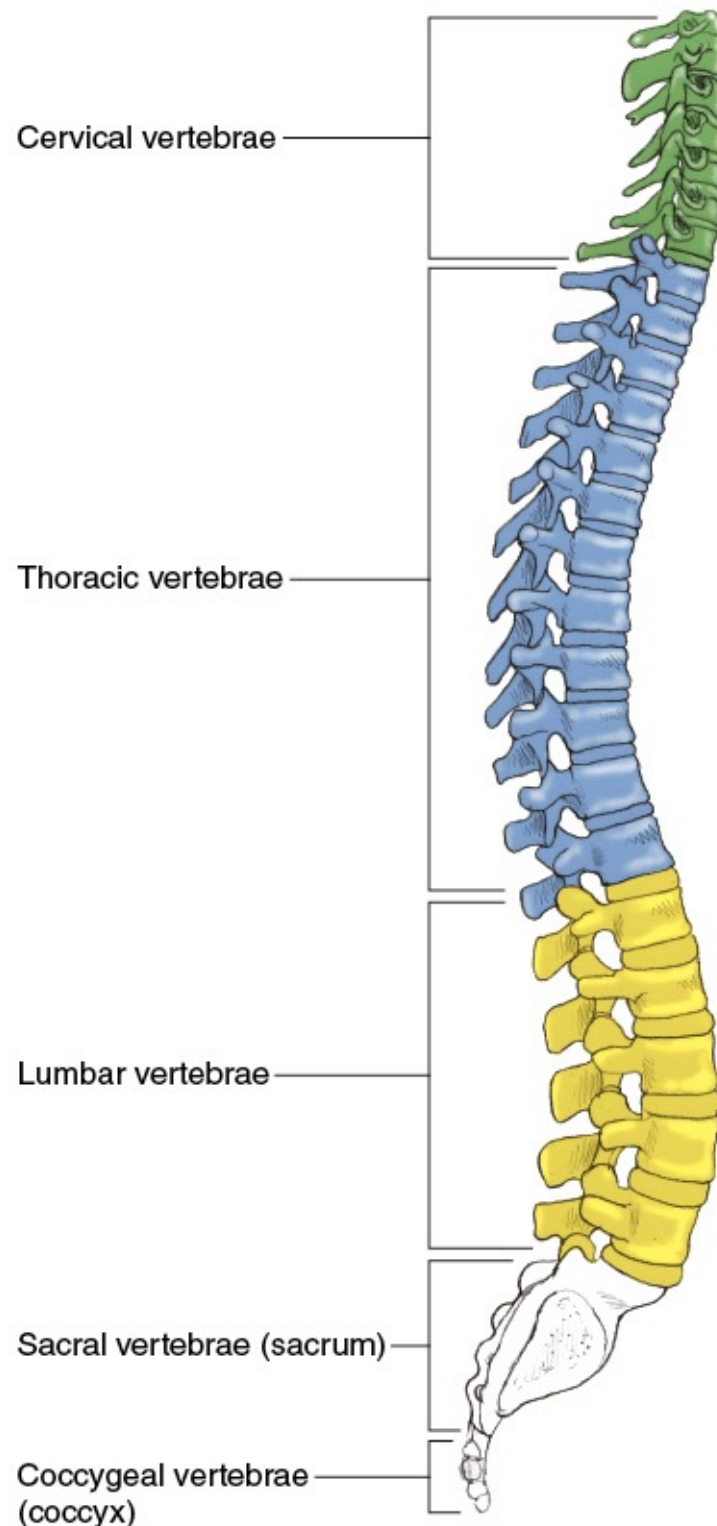
Figure 2.1 Bones of the skeleton (front view). The axial skeleton is in yellow. The two subdivisions of the appendicular skeleton are shown; the upper extremities are in green, and the lower extremities are in blue.

# The Essential Spine

The spine provides the primary movements of the axial skeleton. And the movement, stability, and alignment of the spine are an essential focus in Pilates.

## Elemental Vertebrae

The spine, or vertebral column, is made up of 33 bones called *vertebrae* that are stacked one upon the next to form a long columnlike structure. As shown in figure 2.2 on page 11, the vertebrae get larger in size from top to bottom as they progress from the neck to the pelvis. The vertebrae are arranged in five regions. The first three regions are depicted in color in figure 2.2 for emphasis, as these three regions contain the 24 vertebrae that are responsible for the primary movements of the spine.



- **Cervical (green).** The top seven vertebrae that span from below the head to the base of the neck are the *cervical vertebrae*. The smallest and lightest vertebrae, they are essential for movements of the head and neck.
- **Thoracic (blue).** The next 12 vertebrae are the *thoracic vertebrae*. They span from just below the neck to the last rib and gradually increase in size from top to bottom. They are unique in that they articulate with the ribs. The thoracic vertebrae are key for movements of the thorax, including the upper back.
- **Lumbar (yellow).** The next five vertebrae are the *lumbar vertebrae*. They span from just below the last rib to the pelvic girdle. These vertebrae are stronger and more massive than those above and are essential for their weight-bearing function. The lumbar vertebrae are important for movements of the lower back.
- **Sacrum.** The next five vertebrae are called the *sacral vertebrae*. Rather than act independently, they are fused in adults to form the triangular-shaped *sacrum*. Each side of the sacrum joins with one hip bone, providing important stability for the pelvis. Because these vertebrae are fused, the primary movements of the sacrum occur relative to the last lumbar vertebrae. This joint between the last lumbar vertebra and the sacrum is called the *lumbosacral joint*. Movements at this joint have a profound influence on alignment of the lower back and pelvis.
- **Coccyx.** The last four (or sometimes three or five) vertebrae are called the *coccygeal vertebrae*. They are fused to form a small triangle that is considered the vestigial tailbone. Hence, these vertebrae are often collectively referred to as the tailbone, although their technical name is the *coccyx*.

As can be seen in figure 2.2, the spine is not a straight rod. Instead, each of these regions has a distinct curve when viewed from the side. The cervical and lumbar regions are curved such that they are concave to the back, while the remaining regions are curved such that they are concave to the front. Ideally, these curvatures are each of a normal magnitude and are balanced relative to one another. These curves play an important role in both enhancing movements of the spine and shock absorption.

## Joints Between Vertebrae

The lumbar, thoracic, and all but the top two cervical vertebrae are joined to the vertebrae above and below by a series of joints that greatly influence the ranges of motion that are possible between consecutive vertebrae. As shown in figure 2.3, the front rounded portion of each vertebra (the vertebral body) is joined to adjacent vertebrae by an *intervertebral disc*, forming a cartilaginous joint. This intervertebral disc has a strong outer ring of fibrous tissue called the *annulus fibrosus* (shown in gray) and an inner gelatinous central mass, the *nucleus pulposus* (shown in purple). The nucleus pulposus has a high water content, and the discs can be likened to little water cushions between the vertebrae that are vital for shock absorption and protection of the spine.

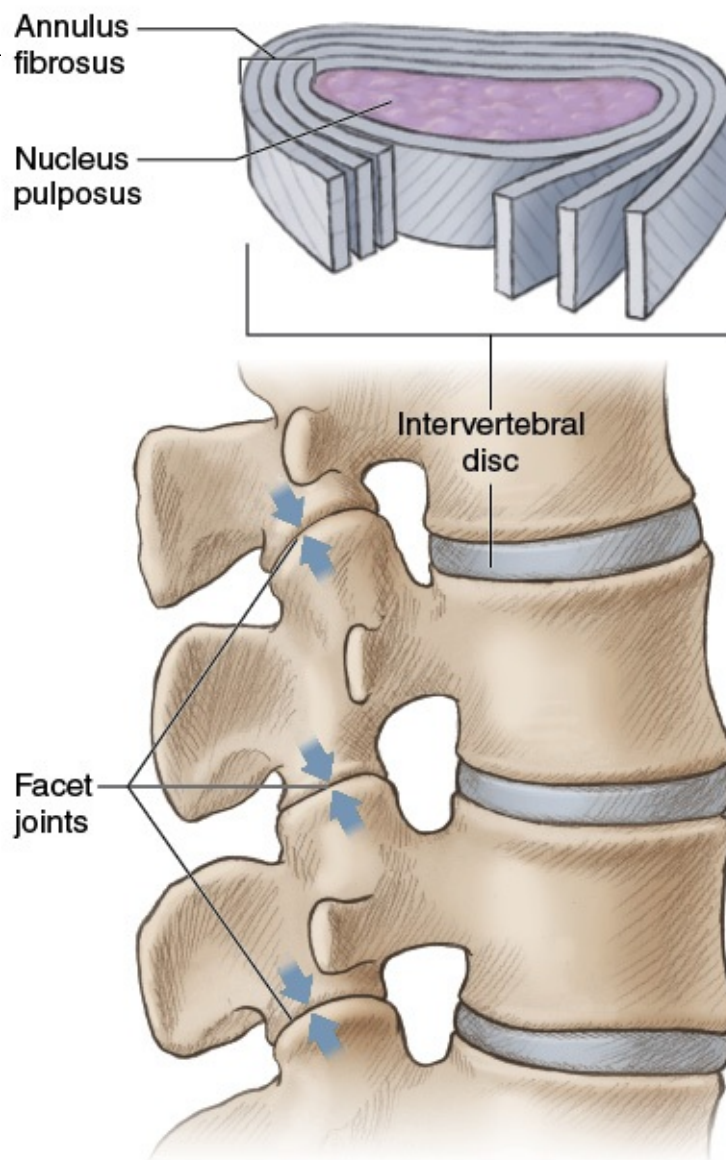


Figure 2.3 Joints of the spine. Facet joints and intervertebral discs, with a detail of an intervertebral disc.

The back portions of these vertebrae are also connected by little paired joints called *facet joints* that allow small gliding movements. The shape and facing of the projections of the vertebrae (the articular processes) that come together to form these facet joints influence the movement allowed in this region of the spine. For example, the facing of the facet joints enhances rotation in the thoracic region but limits rotation in the lumbar region.

The motion of the vertebral column is also influenced by the presence of many strong bands of fibrous tissue that span between the vertebrae. These ligaments help control how far a vertebra can move in a given direction, provide important stability for the spine, and help prevent forward or backward bulging of the intervertebral discs.

Many factors such as strength imbalances, flexibility imbalances, postural habits, and injuries result in most people having areas in the spine in which movement is restricted, movement is excessive, or movement is asymmetrical. One of the goals of Pilates is to help fully utilize the potential range in each segment of the spine in a symmetrical manner.

## Movements of the Spine

The large movements of the spine utilized in Pilates are illustrated in figure 2.4. Spinal *flexion* refers to a forward bending of the spine such as what occurs when rolling the spine down to touch the toes or when curling the upper trunk forward and up into a sit-up; *extension* describes a straightening of the

spine from a flexed position or movement backward beyond straight (figure 2.4a). The backward movement beyond straight can also be termed spinal *hyperextension*. Bending the spine sideways to the right is called *right lateral flexion*, while bending it back up toward a straight position or to the opposite side is termed *left lateral flexion* (figure 2.4b). Rotating the head or upper trunk so that the face or chest faces to the right is called *right rotation*, while rotating the head or upper trunk back to center or toward the other side is termed *left rotation* (figure 2.4c).

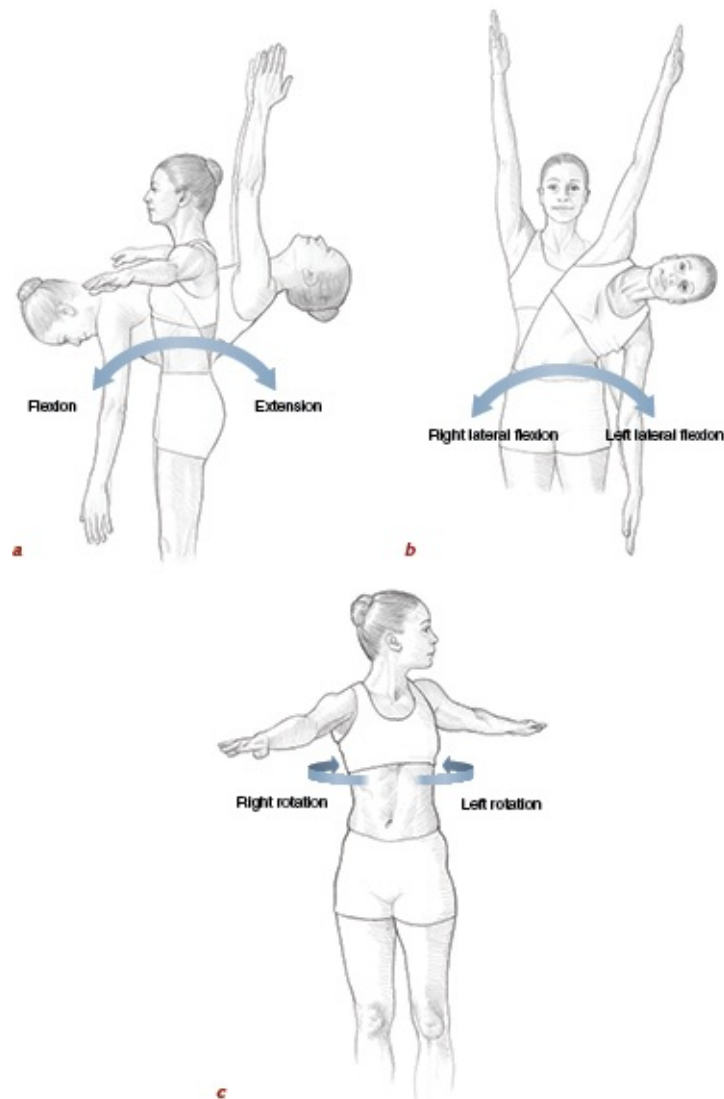


Figure 2.4 Movements of the spine: (a) flexion and extension; (b) right lateral flexion and left lateral flexion; (c) right rotation and left rotation.

## Primary Muscles of the Spine

Many muscles of the spine produce movement or affect stability. Two of the most vital muscle groups are the abdominals and spinal extensors. The iliopsoas and quadratus lumborum also are key in certain circumstances.

### Abdominals

The abdominals have long been appreciated for their potential to help create a flatter abdomen, enhance movement technique, improve certain postural problems, and reduce the risk for certain types of back injuries. There are four paired abdominal muscles: rectus abdominis, external oblique, internal oblique, and transversus abdominis. All of the abdominals attach into a tendinous band that runs vertically down the center of the abdomen (linea alba), but the location and direction of their muscle fibers are quite different. As seen in figure 2.5a, the rectus abdominis runs straight up and down in the



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