LEARNING MADE EASY

Exercise Science

for dummies®

A Wiley Brand

Learn how exercise is medicine

Discover the science behind movement and exercise

Ace your exercise science courses

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Exercise Science

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Contents at a Glance

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Introduction

Life is movement. Starting from the smallest living cells to the most dynamic athletic skill, all aspects of the human body are in a constant state of movement. Exercise science is a field that studies the acute responses of the body to physical activity and exercise, as well as the chronic adaptations of the body to exercise as a student, within or beyond the classroom, you'll study how the body initiates and controls movement, starting with the brain and involving all the different body systems, including neuromuscular, cardiovascular, and metabolic.

About This Book

This book contains the primary principles of the field of exercise science, a vast field. Textbooks within even the subdisciplines contain so much information that you can get lost in the details. This book, on the other hand, covers the major concepts you need to know — the key aspects of exercise science across all the major systems of the body, the primary subdisciplines, and so on — in a much easier-to-read and easier-to-understand format than you'll find in other textbooks in the field.

Exercise Science For Dummies is an excellent introductory text to the entire field of exercise science. Here, we show you the forest rather than force you to focus too much on the trees. To make information easy to understand, we use the following conventions:

- Throughout the book, we introduce you to the jargon you'll hear as an exercise science student to help ease you into the complexity of the information. Understanding these basic concepts will help you confidently pursue deeper study in the field of exercise science, if you want.
- We've sprinkled sidebars and paragraphs accompanied by Technical Stuff icons throughout the book. You can skip these tidbits if you like, but if you're hungry for more information or deeper understanding, these discussions can help point the way.

Finally, within this book, you may note that some web addresses break across two lines of text. If you're reading this book in print and want to visit one of these web pages, simply key in the web address exactly as it's noted in the text, pretending

as though the line break doesn't exist. If you're reading this as an e-book, you've got it easy — just click the web address to be taken directly to the web page.

Foolish Assumptions

You may be an aspiring student of the exercise sciences. Maybe you're interested in a health profession, such as physical therapy, occupational therapy, physician assistant studies, athletic training, or public health. Maybe you want to work in the exercise science field as a cardiac rehab specialist, exercise physiologist, or strength and conditioning specialist. Maybe you want to work in corporate wellness or some environment that allows you to work one-on-one with clients trying to change their health and fitness using exercise as a tool. This book is for you!

Although we assume you don't have a substantial background in the exercise science field, we do assume that you have some knowledge of anatomy and basic physiology — things like the anatomy of muscle, the skeletal system, the heart and circulatory system, as well as the basic physiology of how these systems function within the body.

Here are a few other assumptions we've made about you:

- **If you're an avid exerciser,** you may be reading this book for your personal use, because you want to know more about how the body works. We assume you want the main points, the big picture, and useful information that will help you in your training.
- **If you're a budding exercise science student,** this book is an excellent way to get a broad view and some key information about exercise science and its many subdisciplines. Reading this text as part of an introductory course in the exercise sciences is a very good first step in your training.
- **If you're a coach or personal trainer,** you have a background in one or more aspects of exercise science, but you're trying to broaden the scope of your knowledge. Consider this book a refresher in material you may have learned already and an introduction to topics you may not have previously been exposed to.

Icons Used in This Book

You'll notice some images in the margins throughout this book. These icons clue you in to particular types of information:

TIP

This icon points you in the direction of understanding. Sometimes just a simple statement can make you think, "Aha! Now I get it!"

REMEMBER

This icon summarizes and reiterates important information that you need to know. Keep these tidbits filed away for later.

WARNING

An important aspect of studying movement is being able to recognize when an activity or situation increases the likelihood of an injury. We highlight these situations with this icon. When you see it, pay close attention so that you can avoid potentially dangerous situations.

TECHNICAL STUFF

This icon highlights information that we just had to share! We consider these points important enough to include but a bit technical or slightly beyond the scope of the text. You can read these for added information or skip them.

Beyond the Book

In addition to what you're reading right now, this product also comes with a free access-anywhere Cheat Sheet that explains how aerobic training strengthens the cardiovascular system, keys to building muscle, tips on avoiding injuries, and information on how to use exercise as medicine. To get this Cheat Sheet, simply go to `www.dummies.com` and enter **Exercise Science For Dummies Cheat Sheet** in the Search box.

Where to Go from Here

This book is designed so you can jump in anywhere. You don't need to begin at the beginning. Do you see a chapter that interests you? Start there! If you're not sure where to start, head to the table of contents or the index to find specific topics that may interest you.

The key thing to remember is that this book is designed so that you can jump in anywhere, get the info you need, and jump back out. Jumping, as you'll soon discover, is a great way to approach both this book and the study of movement.

1 Getting Started with Exercise Science

IN THIS PART . . .

Get up to speed on the disciplines you'll be exposed to as a student of exercise science with insights into various careers within the field.

Understand how exercise and movement can reduce the impact of chronic disease and is considered a form of medicine.

IN THIS CHAPTER

- Identifying the fields within exercise science
- Grasping the concept of a systems approach to the control of the body
- Studying the many aspects of exercise
- Evaluating whether a career in exercise science is a good fit for you

Chapter 1

Introducing Exercise Science

The human body was made to move. Your health depends on it, your survival is supported through it, and your ability to engage and interact with the world requires it. *Exercise science* is the science behind exercise, how the body adapts to exercise, and using exercise as therapy to improve the body's condition.

Because the human body is complex, the study of exercise and exercise itself is complex as well. In this chapter, we offer a quick overview of the science, the field, and the options available to you as a student — official or not — of exercise science.

Getting Familiar with Key Areas of Study

Exercise science grew out of the areas of physiology, medicine, and physical education. It has only been around as a field since the 1970s, and it's connected to many disciplines that examine the human body at rest, during motion, and as it adapts and changes because of exercise and physical activity.

Forming the foundation of exercise science

Before you can understand how the body moves and adapts to exercise, you must understand the human body at rest. These basics — knowing important biological processes, explaining the function of the body's structural components and its systems, knowing the chemical reactions that occur in the body, being familiar with principles governing matter in motion, and so on — give you a working knowledge of the human body and how it works.

Here's a quick rundown of the subjects you need to know *before* you get into exercise science, arranged in a way to give you a glimpse of how the body works:

- **Biology:** Learning about living organisms and what makes them tick sets you on the right path. Biology helps you understand the structure and function of cells, their growth and development, and how they come together to form complex life-forms.
- **Anatomy:** When you understand how organisms function at the level of the cell, you can then begin to understand how humans (and animals) are constructed. Understanding anatomy gives you the blueprint of a species. Anatomical study ranges from the structure of the very small (cells and tissues) to the very large (the hip-bone-connected-to-the-thigh-bone kind of info).

  
  TIP

  If you want to learn how to train someone to increase muscle growth or bone strength, you really need to know how the muscles and bones are constructed.
- **Physiology:** With a firm understanding of cellular processes (biology) and how the body is put together (anatomy), you can start to examine how cells, tissues, and organs work together in a living body. *Physiology* examines the functions of the living tissues of the body. Whereas anatomy teaches you how the heart is constructed, physiology shows you how the heart works in relation to the lungs and the muscles and reveals its purpose throughout the body. By studying human physiology, you begin to see that the different structures of the body are designed for specific functions that, altogether, keep the entire body functioning while at rest
- **Chemistry:** Humans are made of matter and require energy to live. Because the body is constructed of atoms, and energy is exchanged through the interaction of various atoms, molecules, and enzymes, you need a basic understanding of chemistry. This knowledge helps you understand what goes on in the body during exercise. After you know the basics of chemistry, you can then focus more closely on the chemistry of the human body.
- **Biochemistry:** Biochemistry gives you a more in-depth understanding about how the body makes energy from the food eaten and how it uses that energy to keep the cells alive.

- **Physics:** Bodies are always in motion, even when they seem to be sitting still. Therefore, understanding matter in motion — the realm of *physics* — is essential to the study of exercise science. Physics helps you understand the relationship between energy and force, levers (like joints!), center of gravity, and acceleration.
- **Psychology:** You can't fully understand exercise and movement unless you also understand the brain and human behavior! Not only do you need to know the anatomy and basic physiology of the functioning areas of the brain, but you also must understand that people learn new things, how people handle stress, and how people prepare themselves mentally for peak performance. Psychology also delves into how emotions influence the body and behaviors.

Getting serious: Focusing on the fields specific to exercise science

Sometimes, the hardest part of starting a career in exercise science is deciding which field to focus on! Your interest may gravitate toward the microscopic: the actions of cells and organ systems and how they function during exercise. Or, maybe you prefer to focus on the way the body performs during exercise and generates forces, or how the body heals through physical training. Maybe you want to blend exercise and nutrition as a means of preventing disease There is a field for all interests within the study of exercise science. We cover some of the primary fields in the following sections.

Biomechanics

Exercise and movement involve forces, levers, balance, and acceleration. Starting with a foundation in mathematics and physics, *biomechanics* studies the mechanics of exercise and physical movement. Exercise can be as simple as lifting a weight or as complex as walking (gait) or doing a high jump. Biomechanics uses technologies that can measure forces (through *force platforms*) and the activation of muscles (through *electromyography*), and it often uses video to analyze all the aspects of body exercise. (Part 3 delves deeply into the biomechanics of exercise.)

Exercise physiology

Exercise physiology is all about the body in motion. As a field, exercise physiology is often associated with a job in a clinical setting (like cardiac rehabilitation) or sports medicine (working with athletes). Understanding how the systems of the body (for example, muscular or cardiovascular) behave during exercise and how they adapt because of exercise training is a major part of exercise physiology. (For detailed information on exercise physiology, head to Part 2).


TIP

Exercise is used as a tool to change the body, as well as to better understand how the body functions. For this reason, exercise physiology is a key component of the many careers and fields that use exercise as a way to improve the body. (You can discover a number of these fields in Chapter 18.)

Fitness and wellness

Cardiovascular disease and cancer are the leading killers of men and women in America. Research has shown a strong link between these conditions and physical inactivity and poor nutrition. Chapter 2 introduces today's view of exercise as a key therapy for health and well-being.

Exercise is Medicine (`www.exerciseismedicine.org`) is an initiative across the medical and exercise science disciplines. It takes advantage of modern medicine while using exercise to build the foundation of fitness that can lead to many years of health. Fitness and wellness professionals, along with doctors, use exercise and physical activity as part of a comprehensive approach to reduce the incidence of cancer, heart disease, and many other common health challenges. Exercise, body fat reduction, and dietary improvements go a long way toward putting people on a path to health. (Chapter 17 delves into the link between physical inactivity and health problems related to obesity.)

Graduate-level health professions

Having a strong background in exercise science means that you have the knowledge of how exercise can change the systems of the body. You also gain hands-on skills in assessment of the body — things like measuring fitness, body composition, and blood pressure and performing a bunch of cool tests for both athletes and those with chronic diseases. These skill sets are what graduate programs in athletic training, physical therapy, occupational therapy, physician assistant, public health, and more advanced exercise physiology studies are looking for. Exercise science is an excellent degree for a range of bachelor's degree-level careers, as well as a way to be competitively prepared for graduate degree programs in the health professions.

Rehabilitation therapy

Injuries can happen for a variety of reasons: perhaps from a exercise that isn't performed correctly (you lift something wrong, for example), an accident (you fall on an arm), or some underlying health issue (a problem exists with your heart or lungs, for example).

Understanding how the body heals and the interaction between exercise and the healing process is an area of study that spans a number of career fields. These fields often combine medical knowledge with exercise physiology, biomechanics,

and even sports psychology. Studies for this field may focus on cardiac rehabilitation, physical therapy, respiratory therapy, occupational therapy, physician assistant studies, athletic training and therapeutic recreation. (Parts 2 and 3 help contribute knowledge to rehabilitation of the body.)

Sports and exercise psychology

After the body has been trained for an activity, the mind becomes the most important aspect of performance. Mood, behavior, and confidence all influence performance, for better or for worse. This area of study seeks to answer questions like, "How do athletes control the stress of a competition and still do their best?" and "How can an athlete be 'in the zone' one day and then perform terribly the next?"

What about people trying to get beyond failed new year's resolutions and make changes to their lifestyle that result in long lasting, consistent health behaviors? Changing a lifestyle that resulted in obesity and heart disease into one that can maintain nutrition and exercise behaviors can be rewarding for an exercise psychologist. Sports and exercise psychology studies human behavior and the mind and applies that knowledge to determine how best to train athletes to get the most out of their performance. If this is an area you find interesting, check out *Sports Psychology For Dummies* by Leif Smith and Todd Kays (John Wiley & Sons, Inc.)

Strength and conditioning

Athletes' bodies can perform at their best only if they've been properly conditioned for the activity. Because exercise requires conditioning the muscular and cardiovascular systems, as well as training the body to hold off fatigue, studying strength and conditioning gives you a deep understanding of how exercise changes the body. You also learn how to apply training principles that are specifically designed to improve performance in a sport. Careers in strength and conditioning range from working with populations trying to condition for fitness to high-level athletes seeking peak performance through strength and conditioning. Parts 2 and 3 cover aspects of conditioning related not only to the muscles (like Chapter 3) but also to the other systems of the body that are essential for peak performance. Part 4 provides more specific guidance on creating a conditioning program.

Understanding the Many Systems That Make Up the Human Body

Single-cell organisms have it so easy! Everything they need is contained in one cell. All their biological processes (eating, generating energy, moving, "thinking," and reproducing) have to be carried out within their single cell, and their range of

interactions with the environment is quite limited. Human bodies, on the other hand, are able to adapt and interact with each other and the environment. To function at such a high level, the human body is *much* more complicated. Structurally, it has multiple levels (cells, tissues, organs, and organ systems) that build on each other and that must all function in a coordinated way to maintain the health of the organism — you.

As a student of exercise science, you're introduced to the following systems. Exercise science helps you understand how these systems interact and change as a result of exercise and physical activity.

The brain and nervous system

The brain and the neurons that make up the brain function together as a central processing center where all the information about your body and your environment can be interpreted. The other systems of your body communicate with each other through the nervous system, enabling you to see, hear, move, and interact with your surroundings. This system constantly adjusts and adapts to exercise and your environment. To find out about the nervous system, head to Chapter 7. Chapter 6 explores how your body adapts to different environments.

The circulatory system

Humans need continual sustenance to survive, and the circulatory system is the primary highway over which nutrients like *glucose* (the sugar your body uses for energy), fatty acids, oxygen, and hormones travel. The arteries transfer nutrient-rich blood to your tissues, and thin capillaries create easy access to the tissues. Your veins help guide the nutrient-depleted blood back to the heart and lungs for a refresher. The circulatory system changes its flow during times of stress or exercise. Chapter 5 covers the key functions of the circulatory system related to oxygen and nutrient transfer.

The cardiorespiratory system

To keep a constant flow of oxygen and nutrients coming to your tissue and to keep waste moving out, the body needs a pump and a fueling station. Fortunately, it has both: the heart and the lungs. The heart keeps blood moving, and the lungs serve as the station where oxygen-depleted blood fills up again. Every time a *ventricle* (a chamber in the heart) contracts, its dual chambers either push blood to the lungs to pick up more oxygen (right ventricle) or push oxygen-rich blood to the entire body (left ventricle). Exercise can help train this pump to do more work, push more blood, and get you in shape.

The skeletal system

The human body is about 70 percent water, and most of the tissue in it is made up of some pretty soft stuff. Without a frame to mount the soft, squishy bits on, we'd all be big blobs of humanity! The skeletal system provides a rigid framework that allows you to move about and see the world. Strong bones, constructed with plenty of calcium, mean a strong frame. Functioning joints enable you to move with little effort. When this system begins to weaken (and lose calcium), mobility really drops. You can read about the skeletal system and joints in Chapter 9. In Chapter 10, you can learn about the high-tech methods we have for measuring motion.

The muscular system

Exercise wouldn't be possible without something to produce force. In the body, those "force producers" are your muscles. Muscles provide the horsepower you need to move your body and interact with your world. They're also very adaptable. If you make them do a lot of work, they grow stronger. If you let them sit around and do nothing, they shrink! Strong muscles play a role in good health and quality of life. Head to Chapters 3 and 11 to find out about exercise in general and the muscular system in particular; turn to Chapter 10 to delve into motion analysis.

Energy, metabolism, and nutrition

Humans are hybrid vehicles in a sense that we may only run on a chemical called *adenosine triphosphate* (ATP), but we have systems in our body that can take carbohydrate, fat, and protein and turn them into ATP. The faster we can make the systems run, the more "fit" we are! Chapter 4 explains how we keep the metabolic engine running.

The systems don't run if we can't continually provide our bodies with key nutrients (carbohydrate, fat, and protein), as well as other important nutrients (water, vitamins, and minerals). In Chapter 15, you see how diet can help performance and find some guidelines to get you moving in the right direction.

The endocrine system

Although the brain can control many of the functions of the body through the nervous system, other controls require chemical stimuli. Glucose, for example, can't get into the cells unless the pancreas secretes insulin to help create a pathway into the cells. The endocrine system involves a number of organs and glands that secrete chemicals that bind to receptors both inside and outside cells to essentially open and close cell doors, either letting in or blocking out these

chemicals. Sometimes, the release of hormones can cause a fast response (insulin helping to drop blood glucose levels, for example); other times, the release of hormones may cause changes that occur slowly over time (thyroid hormones can slowly make changes in your resting metabolic rate, for example).


TIP

Check out *Anatomy & Physiology For Dummies*, 3rd Edition, by Erin Odya and Maggie Norris, or *Biology For Dummies*, 3rd Edition, by René Fester Kratz (both published by John Wiley & Sons, Inc.), for complete discussions on the endocrine system and the role of hormones.

Examining Exercise from Many Angles

Chances are, when you hear the term *exercise*, you have your own idea of what it means and how people use it in their lives. But you can think about exercise and the connections between it and the world in more ways than you probably imagine. In the following sections, we outline the many ways exercise can be examined.

Studying the science of human performance

When you throw a ball, clear a hurdle, or balance on a beam, you probably focus on the result (were you successful?) or the "feel" of the exercise (the power of your release, for example, or the steadiness of your stance). *Biomechanists* study these aspects of exercise, using the tools of physics and math.

Exercise physiologists examine the energy systems and fuels used during exercise, and how exercise can be used to enhance human performance during athletics and rigorous work situations. focus on these aspects of performance and training.

Both of these careers are focused on answering questions like the following:

- **How is exercise or any movement impacted by changes in the center of gravity?** Does changing the position of the arms and legs, for example, impact how someone jumps over a high-jump bar or executes a gymnastic move?
- **What forces and velocities exist in vertical, horizontal, and rotational dimensions?** By knowing the forces, you may change how a spin and rotation are completed in a high-dive maneuver.

- **How is balance maintained and lost?** Do older people fall because their muscles are too weak to handle a change in direction, or is it due to a delay in the muscle's ability to generate the required force?
- **How can changes in speed, load, and training volumes affect performance**? In athletics, even a 1 percent improvement can mean taking first place in an event. Exercise scientists look for that improvement by training energy systems, muscles, and the nervous system.
- **What kind of training is best to condition the athlete, help them train specifically for their activity, and keep them from getting worn out?** For example, can someone run faster simply by changing their running technique? What about tapering activity before a big event to get the most out of a performance? How can they prevent overtraining and a loss in performance?
- **How can the principles of exercise be used to prevent injury?** Are there ways to land from a jump that can reduce forces on the knee and prevent someone from tearing a ligament? How soon can rehabilitation of muscle and ligaments begin? The goal is to get the athlete back in action quickly and safely.

TIP

Check out *Biomechanics For Dummies*, by Steve McCaw (published by John Wiley & Sons, Inc.) for more on this subject.

Focusing on the health-enhancement aspects of exercise

The human body is meant to move. A body at rest begins to *atrophy* (wither away) and lose muscle mass, bone density, and even heart size. Exercise can be a tool to help the body's systems function at a more optimal level. In fact, regular exercise can produce the following beneficial results:

- Reduced blood pressure and a stronger heart
- Increased bone density
- Improved blood cholesterol levels
- A stronger immune system
- Reduced incidence of cancer and heart disease
- Reduced stress, anxiety, and depression

If exercise is medicine, how do you "prescribe" exercise? Obviously, there are wide-ranging differences among people, including goals, present physical

condition, initial fitness level, and underlying health condition. But there are guidelines and principles to set people on the right path. Part 4 is all about improving fitness and performance. Depending on individual goals (weight management, better eating, strength, aerobic fitness), the exercise program can be adjusted to suit needs.

Using exercise as a tool for rehabilitation

Although exercise can serve to prevent a number of chronic health conditions, it's also a key factor during the recovery from a range of health issues that people deal with every day:

- Cardiac rehabilitation uses exercise to condition patients after heart surgery or heart attack.
- Cancer patients use exercise to build strength and boost the immune system.
- Exercises can help provide blood glucose control for people with diabetes.
- Physical therapy is used for a range of bone, joint, and muscle injuries; arthritis; and stroke recovery.
- Exercise therapy is used as treatment alongside medical treatments for autism, neuromuscular diseases, and stress management.

In many cases, exercise reverses the years of decline due to a lack of movement and the resulting health conditions that come with physical neglect.

Determining Whether Exercise Science Is the Field for You

Because exercise is an inherent part of life, exercise science is an inherently important field! Exercise science techniques and areas of study are used by medical professionals, athletic departments, sports organizations, corporations, and fitness and wellness industries to enhance performance, improve health, overcome mobility challenges, and more — all by changing the way people move.