

INTRODUCTION TO KINESIOLOGY



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This text was compiled on 09/13/2026

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1: CHAPTERS

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1.1: The History of Kinesiology

Learning Objectives

- Be able to define kinesiology.
- Be able to explain the slow development of kinesiology over the last 1500 years.
- Understand the connection to Physical education and war.

Kinesiology is the study of human movement and comes from the Greek word kinesis meaning motion or movement. To move is a core part of the human experience, we play games as children like tag, we dance during culturally important events, and require movement for mental and physical health. The human body moves internally with a beating heart and expanding lungs to stay alive. When a person dies, stillness or a lack of movement is often cited as one of the first signs of something is wrong. The study and understanding of human movement has likely existed for as long as humans have walked this planet, but only in the last few hundred years has the scientific study of kinesiology started.

Critical Thinking

What is your current education and experience in kinesiology? What do you expect to get out of this class?

While the physical movement to participate in games and sports (more on sport in Chapter 11) are certainly tied to all human cultures of all time, the study of human movement and the idea of improvement and efficiency in those movements is newer with unclear roots. Throughout history human movement and warfare have been linked, the health and fitness of soldiers could determine the outcome of a battle.

“No man has the right to be an amateur in the matter of physical training. It is a shame for a man to grow old without seeing the beauty and strength of which his body is capable.”

-Socrates

[Aristotle](#) (384-322 B.C.) is usually considered the “father of kinesiology” by being the first known author to describe animal (humans included) movement of walking by converting rotary movement into forward movement. Aristotle was also the first to describe the actions of muscles.

For the next almost 1500 years kinesiology only made minor advancements until Leonardo da Vinci (1452-1519) started dissecting human bodies he dug up from graveyards. [Leonardo Da Vinci](#) described the mechanisms of the body when walking and standing up from a seated position. He also started to label muscles and nerves while identifying the action and insertion points of the tendons which connect muscles and bones.

In 1858 Henry Gray published a detailed and illustrated anatomy textbook “[Gray's Anatomy](#)”. Henry Gray dissected unclaimed bodies from hospitals and drew very detailed notes of human anatomy. “Gray's Anatomy” was a practical and cheap way for medical doctors to learn human anatomy without the need for a human cadaver. Today the new versions of the book are often called “The doctor's bible”.

As the knowledge of human anatomy developed and improved, the next step toward modern kinesiology was understanding movement. Remember kinesiology is the study of human movement. Sir Isaac Newton developed [three laws of motion](#) that are the foundation of understanding physical movement. Simply stated they are as follows:

1. The Law of Inertia. If a body is at rest or moving, it will remain at rest or moving until acted upon by an outside force.
2. Force is equal to mass x acceleration. This law describes the relationship between something's mass, acceleration, and force.
3. The Law of Action and Reaction. For every action, there is an equal and opposite reaction.

All of these laws are critical for understanding how humans move and interact with other objects.

Exactly when “modern” kinesiology started is an unclear and minorly debated topic but is usually cited as starting 1800's as

interest in [gymnastics in Sweden](#) and German developed and grew into an athletic rivalry. These gymnastics were not exactly what we would see in modern gymnastics but involved some rhythmic dance, bodyweight movements, wooden ring, and bar routines depending on the location. A strong rivalry developed between Sweden and Germany, expanding the gymnastics program to more people.

This “return” to fitness was a way people could become able-bodied civilians and become a war ready population if the need arose. Preparing the civilian population for war with physical education and sport is a common theme throughout history. The interest in gymnastics spread and German gymnastics were introduced to America in the 1820's.

Here is a look at a very early kinesiology/gymnastics [textbook](#):

Harvard University had organized exercise classes starting in 1826.

More schools with gymnasiums and pools were built, increasing opportunities to participate in sports and, leading to the development of intercollegiate athletics which will be discussed in more detail in Chapter 11.

The second wave of interest in physical activity included more weight lifting that blended gymnastics with [strongman activities](#) from the Viking and Scottish cultures like the Highland Games. The barbell is thought to be invited with the rise in curiosity into strength and muscle building. These athletes and events would be made famous as circus acts of men bending bars of steel or snapping chains apart. Commercial gyms, weightlifting, and bodybuilding can trace their origin to this premise.

During WWI 1 in 3 military recruits were deemed unfit for service and the US government passed legislation to improve and increase physical education classes for American children. Thus, America follows historical trends of developing a fit population through kinesiology to be able to better fight wars. By WWII the young American population was much more fit and able-bodied for war time activities. Today it is estimated that [less than 25%](#) of young Americans would be fit for war duty.

Kinesiology was and still is very linked to the study of human medicine. Modern medicine and kinesiology have a very similar base set of knowledge and only start to diverge as a person's education or experience advance. In modern education, aspiring kinesiologists and pre-med students will often have very similar class requirements for their undergraduate degrees.

Critical Thinking

Examine how each of the following scenarios includes each of Newton's 3 laws. How could factors like weight, size, or speed be altered to alter the outcome of the mental experiment? What facts could be altered to dramatically change the outcome of the movements? Share your thoughts with a classmate.

1. A golf ball is hit from a tee by a golf club.
2. A football player is running and gets tackled from the side by an opponent.
3. An athlete throws a ball to a teammate.
4. Someone riding a bike on a muddy road.
5. Someone during pull-ups in the gym.

1.2: Modern Kinesiology

Learning Objectives

1. Understand the difference between qualitative and quantitative research.
2. How do scientists and the general public interact differently with data?
3. Understand the power of social media for better or worse.

Kinesiology has developed into a wide-ranging scientific field, just check out the table of contents of this textbook. Today kinesiologists have powerful tools and a wealth of knowledge at their fingertips, but some modern trends like social media are a double-edged sword. In this chapter, we will explore the current issues and trends in kinesiology.

As discussed in the previous chapter, kinesiology has a long history of combining war, medicine, and sports. During the mid-1900s an unfortunate [stereotype](#) developed that kinesiology was only about grade school physical education classes. Kinesiology has always encompassed so much more than that, but grade school physical education is still a noble and necessary career.

Each chapter in this textbook will summarize the many branches of specification possible in kinesiology from Biomechanics (Chapter 8) to Psychology and Sociology of Sport (Chapter 14) and many more. Modern kinesiology is immense and continually growing. Kinesiology has a promising future and many opportunities for education and a career.

Kinesiology is a natural science backed by qualitative and quantitative research. Qualitative research generally has to do with gathering non-numerical data, including subjective feelings or opinions on a topic. Quantitative research gathers numerical data to test relationships between two variables like a person's height and 500m row time. All science and scientific research is the pursuit of understanding the truth of the world around us. Kinesiology research is scientific curiosity about the way the human body moves and performs in physical (usually athletic) ways.

Most scientific fields are currently facing problems with public credibility and the general population's understanding or believing any significant results. The lack of public credibility comes from several overlapping problems not unique to kinesiology but is something that any modern kinesiologist will have to deal with in their career.

In America, most scientific research follows a predictable pattern of following the [scientific method](#) of testing an idea and then publishing the results. While this method has its advantages, there are a few major issues with scientific research being published by subject-specific journals.

Highly educated individuals in a narrow subject matter write up complicated research methods and results to be reviewed by their peers, to be published, read and understood by their peers. Article publication requires specific formatting with concise language use to convey complex topics in as efficient a way as possible. Meaning that if a person does not have a high level of education in the field of research write-up, they are unlikely to be able to understand it.

Critical Thinking

Take a look at this research article [here](#) on balance training for preventing falls in older adults. How much of it do you understand? Could you read this over and explain to your grandmother with confidence what exercises she should start doing to improve her balance and decrease her risk of falling? Do you think your grandmother could read it and understand it?

The present problem is that most people are not taught how to read research articles (Chapter 15) and understand important information. Not to mention how to evaluate if the methods the scientists used, and the statistics performed are even valid choices to reach the conclusions of the publication. Hopefully, at the end of your kinesiology education, you can read that same article on older adults' balance and quickly understand it.

That article has terms, acronyms, and ideas it assumes the reader understands, quickly speeding through concepts that take years to understand and master. Unfortunately, that article is a very average representation of research studies and highlights how hard it is for someone without a college education to understand. A topic like balance and fall injuries impacts all people and

their families and significant findings should be made more approachable to the general public.

Most of the time the general public is not aware of new research publications unless it “goes viral ” or has some very controversial conclusions that go against commonly held beliefs.

Unfortunately, if the news journalist or reporter is not highly educated in the area of the research they are reporting on, leading to them taking a single line of the research article and using that for the entire story, not explaining any of the other details, or oversimplifying the results. Imagine this “Tonight on the 5 o'clock news we share with you a new scientific finding that eating salmon can double your risk of dying of a stroke!” But what the news did not share was that the people in the study were asked to eat salmon 3 times a day for 2 months (so very unlikely to be someone's normal diet), and it did double their risk of dying by a stroke from a risk of 1 in a 100,000 to 2 in a 100,00. Statistically, that did double their risk of death from my stroke, but a very small risk doubled, is still a very small risk.

That takes a lot of the strength out of the story and shows how problematic the media can be for misrepresenting scientific findings.

To make matters worse, many taxpayer-funded research findings are published behind a paywall, meaning anyone that wants to read and learn from the research needs to pay for access, fortunately this is slowly changing. Funding is also limited and can be hard to attain, forcing a scientist into a grant writer and finance manager. The ethics of receiving money for research also can be difficult to navigate. Coca Cola donates to scientific research in a wide variety of categories, but when science is funded by a private company can the results be trusted? Often research publications have an area to explain any possible conflicts of interests between the scientists, results, and funding or private interests. If a research article is published on the health effects of drinking soda, but the research is funded by Coca Cola, would you trust the results?

A great resource to save for your upcoming kinesiology education is PubMed, this website is a free-to-use search tool for research in the life sciences. There is also a way to search for only free-to-view articles. We will review how to read and evaluate a complete research article in Chapter 15.

Oftentimes scientific journals are not interested in publishing non-novel research. So very few published research articles are reproduced by other scientists, because their work is not likely to be published, as “this has already been done”. So results are not often verified. Meaning someone's findings could be a fluke. Even worse, many times when research is reproduced the same findings and conclusions are not made. This is known as the “Replication Crisis”. This is a massive hurdle that all the sciences are facing and will have to solve in the near future. The statistics and methodological issues of the Replication Crisis are out of the realm of the scope of this textbook, but you should learn much more about this in your education, especially statistics and kinesiology methodology classes.

Scientific journals usually won't publish null findings, meaning no difference in the treatment and control group was discovered. These results could still be important discoveries. Maybe there was no difference between barbell squats and leg presses on quad strength improvement over a 6-week training program. This shows null results but is actually important information if true. Publishing well-run research that leads to null results also makes it less likely someone else will repeat the study and find null results. How many people have had the same question, spent months on research only to find null results and just delete their data because it is very unlikely to be published.

Here is a great guide on what to look for when reviewing research articles for quality (or not so quality) scientific research.

Critical Thinking

How do you think scientific research, funding, publication, and readability could be improved?

Science is ever-changing with improvements in research tools and equipment. As you will learn throughout this textbook kinesiology is a convergence of many fields, and if there is a fundamental change in thinking or an impactful discovery made in those adjacent fields it can impact thought and understanding in kinesiology.

A kinesiologist uses a wide range of powerful equipment in research including but not limited to computers, lasers, cameras, gas exchange sensors, and force plates. As technology improves and more detailed data can be recorded, old “truths” may be overturned. Imagine how the understanding of the human foot strike on the ground has improved with cameras, then high definition, and slow motion. It is expected that scientific understanding will continue to improve and be refined as associated technology improves.

As nutrition (Chapter 4) has advanced, there has been a [classic debate](#) on if eggs, especially the yolk is healthy for humans to eat. The answer to this question changes based on the year and who you ask. This type of reversal on topics can lead to the general public feeling that they cannot trust science, because how can they trust you with complicated questions if you cannot even tell them if eggs are healthy to eat or not?

Social Media, the Good, Bad, and Ugly.

The good: social media is a powerful and cheap tool for spreading your knowledge, helping people, and advertising any business you might be a part of. Social media can build community and allow someone to solidify a reputation of knowledge and experience.

The bad: social media allows anyone to post just about anything without any [fact-checking](#) or credentials. So many people are forming opinions on what is good for them based on what an attractive shirtless guy is saying, and assuming he is speaking facts because “Look how fit he is!” Most people do not understand that there are very few simple answers in kinesiology. Even the most basic concepts of writing a training program require knowing their goals, how much time they can commit to training, what exercises they like to do, what equipment they have available to them, and their current fitness. People are unique, they have different injuries, goals, interests, and nutritional preferences making all aspects of kinesiology more complex than a one size fits all pill. Just because it works for an “attractive shirtless guy” on social media does not mean it will work for anyone else.

The ugly: Building off the bad, people can make a lot of money preying on others' lack of education and insecurities. Social media can be rampant with misinformation, fake reviews, bought likes and followers and scams to steal people's money.

You will be fighting against all of this in the world of modern kinesiology.

Critical Thinking

How can you help inform people of the value of scientific knowledge while also accepting there will also be room for change in ideas?

It is not all negative, kinesiologists have changed the world of health, fitness, and athletic performance in the last century through careful examination of human movement.

There are many new topics to tackle in the upcoming years as kinesiologists including national weight gain, social and racial inequality, continuing advancement for disabled athletes, and navigating how to fairly include trans athletes in sports competitions.

As Western culture continues to become more sedentary, the need for kinesiologists to help people stay active and healthy has never been greater.

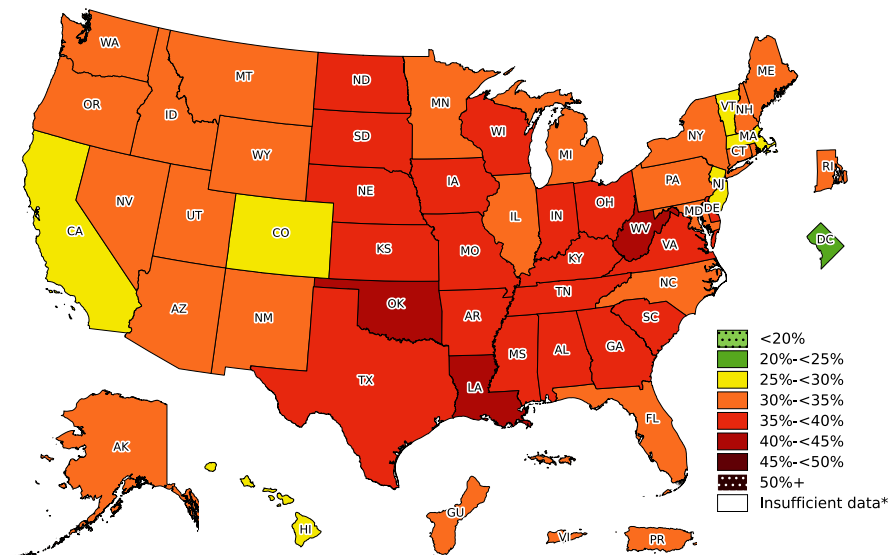


Figure 2: by CDC is in the Public Domain, CC0

Many jobs and careers have less physical labor or activity than in the past. There are more jobs completed entirely seated behind a computer, leading to very little physical activity for workers. Combined with the rise in fast food consumption (article [here](#)) has increased the prevalence of US obesity (Figure 2). 8 hour days at a computer are increasing rates of poor posture and low [back pain](#), creating a demand for physical therapists to fix the problem and biomechanics to solve with better chairs or desks.

Obesity [increases](#) all-cause mortality (death from any disease) especially cardiovascular disease and leads to an increased risk of developing Type 2 diabetes. The cultural trends of being sedentary and eating poorly have pushed cardiovascular disease to the #1 spot for the cause of death for Americans. The role of kinesiologists in counteracting this problem is critical for the future health of America.

Modern and future practitioners of kinesiology have to deal with socioeconomic and racial inequality in health and sport. Having access to fitness equipment and coaching can be expensive, and not available to all. Life expectancy in America varies based on [race](#), with some reasons directly related to kinesiology and wellness like access to healthy foods, medical appointments, and the opportunity to participate in an active lifestyle. Having the time and money to devote to working out and eating healthy can be a privilege that excludes the poor.

Sport and race have an entwined history of inequality. Historically the NFL has had very underrepresented Black quarterbacks, with about 70% of NFL players being Black but only about 25% of starting quarterbacks being Black. The racial divide goes further with many sports announcers commenting on a Black quarterback's success due to their athletic abilities while White quarterbacks are often praised for their intelligence.

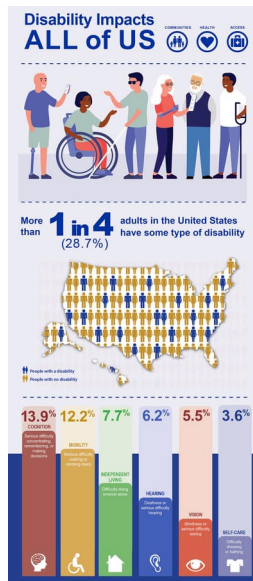


Figure 3: by CDC is in the Public Domain, CC0

With 26% of the adult American population having some type of disability it is important to be inventive on how to include all people in activities and sports. Creativity and new technology can go a long way to include people that once thought sports were out of reach for them. [Here](#) is a video showing how blind athletes can play baseball.

A relatively new issue in the kinesiology and sports community is how to fairly integrate transgender athletes into a competitive field. While this text is being written [different](#) sports and leagues have different inclusion/ban rules, and those will likely have changed by the time you are reading this.

Critical Thinking

How would you motivate more people to be healthy and active? How would you address the inequality of sport due to race, socioeconomic status, disability, or sexual identity?

Chapter 3 will continue the discussion of health and fitness and for the rest of the textbook, each chapter will look in detail at different branches of kinesiology. It is possible to earn degrees or certifications in each of these branches leading to a wide variety of modern kinesiology career options.

1.3: Health and Fitness

Learning Objectives

1. Define what health is.
2. Explain body composition.
3. Define aerobic vs anaerobic.

Many people think of “**health**” as someone’s physical fitness, and see someone as more healthy if they can run a fast mile or do a bunch of pushups in a row but that would be incorrect. Fitness or physical wellness is a measure of your body to work in an efficient manner to perform a physical activity. These activities can be part of daily living like standing up from a chair or carrying groceries up a flight of stairs, or they could be more sport related like running 100m or doing a barbell snatch. This idea of fitness is just a piece of a larger whole of health. Health is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” by the [World Health Organization](#).

Health or wellness is a [multifaceted](#) and all-encompassing term that can be thought of using nine categories, called the “[Nine Dimensions of Wellness](#)” which include: Cultural Wellness, Occupational Wellness, Emotional Wellness, Environmental Wellness, Financial Wellness, Intellectual Wellness, Social Wellness, Spiritual Wellness, and of course Physical Wellness.

Cultural Wellness: Cultural wellness refers to the way you interact with others who are different from you. This includes understanding and celebrating our differences. Culturally well people are aware of their own cultural background, as well as the diversity and richness present in other cultural backgrounds. Cultural wellness implies understanding, awareness and intrinsic respect for aspects of diversity. A culturally well person acknowledges and accepts the impact of these aspects of diversity on sexual orientation, religion, gender, racial and ethnic backgrounds, age groups, and disabilities.

Occupational Wellness refers to personal fulfillment and enrichment from one’s work and/or responsibilities. An occupationally well person enjoys the pursuit of a career which is fulfilling on a variety of levels. This person finds satisfaction and enrichment in work, while always in pursuit of opportunities to reach the next level of professional success.

Emotional Wellness: Coping effectively with life and expressing emotions in an appropriate manner are keys to emotional wellness. An emotionally well person successfully expresses and manages an entire range of feelings, including anger, doubt, hope, joy, desire, fear, and many others. People who are emotionally well maintain a high level of self-esteem. They have a positive body-image and the ability to regulate their feelings. They know where to seek support and help regarding their mental health, including but not limited to, seeking professional counseling services.

Environmental Wellness: Environmental wellness includes a desire to positively impact our planet Earth and our local community by striving to occupy pleasant, healthy, and safe environments that support well-being and positively impact the quality of our surroundings (including protecting and preserving nature). An environmentally well person appreciates the external cues and stimuli that an environment can provide. People who have achieved environmental wellness recognize the limits of controlling an environment and seek to understand the role an individual plays in the environment.

Financial Wellness: Financial wellness refers to achieving satisfaction with current and future financial situations by handling finances wisely. Those who are financially well are fully aware of their current financial state. They set long- and short-term goals regarding finances that will allow them to reach their personal financial targets.

Intellectual Wellness: Intellectual wellness includes being open-minded, recognizing creative abilities, and/or finding ways to expand knowledge and skills. Those who enjoy intellectual wellness engage in lifelong learning. They seek knowledge and activities that further develop their critical thinking and heighten global awareness. They engage in activities associated with the arts, philosophy, and reasoning. You are working your intellectual wellness currently by reading this book and learning new concepts.

Social Wellness: People who are focused on their social wellness are striving for positive relationships, developing a sense of connection, belonging, and a sustained support system. A socially well person builds healthy relationships based on interdependence, trust, and respect. Those who are socially well have a keen awareness of the feelings of others. They develop a network of friends and co-workers who share a common purpose, and who provide support and validation.

Spiritual Wellness: Spiritual wellness refers to having a sense of purpose and meaning in life, this may come from establishing peace, harmony, and balance in our lives. People who can be described as spiritually well have identified a core set of beliefs that guide their decision-making, and other faith-based endeavors. While firm in their spiritual beliefs, they understand others may have a distinctly different set of guiding principles. They recognize the relationship between spirituality and identity in all individuals.

Physical Wellness: Usually when someone thinks of health, they are actually imagining physical wellness. This is how healthy or fit your body is. This dimension of wellness could be measured by lack of diseases or body composition or a fitness test ([FitnessGram](#)) like many students throughout grade school.

All these traits combined and looked at can be used to determine someone's health or wellness. Each dimension is equally important, and individuals should spend time and effort improving and maintaining each of the nine dimensions of their wellness.

Critical Thinking

If your friend was an Olympic athlete but they had clinical depression, would you consider them healthy? What suggestions would you offer to help them improve their health? What about someone that earned tons of money at their job but dreaded work each day?

Check this [video](#) out about this topic.

As this is a kinesiology textbook the focus of the rest of this chapter will be in physical wellness, used interchangeably with the term fitness. As mentioned in Chapter 1 kinesiology and modern medicine overlap extensively including the basic physical nature of a person's health.

Physical fitness is important for the individual's health, but it is also critical for the livelihood of a tribe/group/culture. Being able to do physical work like hunting, farming, building houses has been essential for all but the very rich throughout history except for in current times. As discussed in Chapter 1, it is important for a culture to have physically fit individuals to go to war or defend from invaders. It is just as important for groups of humans to be able to hike mountains to find wild game, climb trees to gather fruit, or dig holes to create foundations for structures. A united group of people can work together to provide for the few that cannot provide for themselves like the sick, injured, children or elderly, but if too large a section of the population is unable to be physically productive the society will collapse, and many people will die. Even in prisons, [inmates](#) are peer pressured into staying physically fit by their fellow gang members so they can be counted on if a fight breaks out.

A relatively new trend in the fitness world is cheap and accurate wearable fitness trackers. Devices like Fitbit, Apple Watch, and [WHOOP](#) allow people to track their daily steps, activity, and estimated calories used. These devices have helped many people become more active by giving them small daily goals to hit or building habits by hitting these goals day after day. While these devices have come down in price and improved in accuracy it is important to understand that they are still not perfect, but give close estimations. The habit building and social aspect of these wearable fitness trackers is much more important in motivating people to become more active, even if they are not perfectly [accurate](#).

Clearly, this reliance on using one's body to be fit and productive has changed drastically in the last few decades with the development of computers and robotics. One farmer operating a GPS-guided tractor can likely [produce more food](#) than 100 farmers working from horses. Many people now work their entire career and earn a lucrative income sitting in front of a computer.

The individual and cultural importance placed on personal physical fitness has dramatically decreased in the last few decades, but people and society are seeing the detriment from this decline in activity.

Worldwide obesity [rates](#) have tripled since 1975 and almost 50% of adults in the US are overweight or obese.

Currently, obesity-related health care costs the US healthcare system [173 billion](#) dollars a year. Only 2 in 5 young adults are physically ready for military basic training.

All these health-concerning stats are why it is so important for people to study and work in the health and fitness area. Jobs as a group fitness instructor or personal trainer can make a literal life or death difference to those they work with.

Body Composition

This is simply the ratio of fat mass vs fat-free mass of a human body. Fat mass is all of the adipose tissue in the body and fat-free mass is everything else including bone, muscle, water, and organs. Some body composition sampling methods may be powerful enough to separate fat vs muscle vs bone. The key to understanding is knowing how much excess body fat mass a person may have, increasing their risk for certain diseases and all-cause mortality.

Remember some fat is vitally important to health. For women dropping below, about 13% body fat can cause menstrual cycle problems and other hormonal imbalances. Men can safely drop to 3-5% but there are no health benefits of being that lean.

Ideal body fat % for optimal health range from 15-25% for women and 6-17% for men.

Skeletal Muscle Mass is exactly what it sounds like, the total mass or weight of the amount of muscle tissue someone has on their body. It is a common saying that “muscle weighs more than fat” which is slightly incorrect, but 1lb of fat is the same weight as 1lb of muscle. Muscle is **more dense** so that 1lb has less volume. This is important to know because often when someone starts working out, they may not lose much weight (they might actually gain weight depending on what exercises they are doing) because their body composition is changing. They are losing fat and gaining muscle, so the weight on the scale remains the same but their body composition is becoming healthier. Oftentimes people will start to feel that their clothes fit them differently or they look different in the mirror even with no weight loss. Weight is not a health issue; excess body fat is. This is important information for people that want to “tone up”, as they often incorrectly think they will lose weight because they are physically smaller.

Cardiovascular Health: The cardiovascular system is made up of the heart, lungs, arteries, veins, and capillaries in your body. This system delivers nutrients and oxygen to your muscles and removes metabolic waste during exercise (and all parts of the body all the time) so the more efficient this system is the more capacity a person will have to physically move.

The following are some key terms needed to understand and evaluate cardiovascular health.

Resting Heart Rate is the beats per minute (BPM) someone’s heart takes while at rest. Ideally, this should be measured immediately after waking up for the morning but before standing up. This is not always practical so individuals should rest for 3-5 minutes while seated before finding their resting heart rate from counting their pulse over 60 seconds. Any prior caffeine, nicotine, or exercise that day could skew the results. In general, the lower someone’s resting heart rate is the better their cardiovascular health. It is common for someone’s resting heart rate to decrease as they become more fit.

Blood Pressure: The **heart works** as a pump to circulate blood around the body. Each beat of the heart consists of two parts, contraction (systole) and relaxation (diastole). A blood pressure measurement consists of two numbers, a pressure reading (denoted as in millimeters of mercury, mmHg) one for each. Systole is reported on top of diastole. Normal or healthy blood pressure is under 120 systole and under 80 diastoles. A reading of 120/80 would be spoken aloud as “One hundred and twenty over eighty”. Resting blood pressure consistently **higher** these numbers can cause health problems including arterial damage and decreased blood flow leading to more severe cardiovascular disease issues like heart attack or stroke.

Another easy fitness test using very little equipment is to evaluate how fast an individual’s heart rate can return to baseline after completing a brief but challenging activity such as a sprint or climbing a set of stairs. The quicker their heart rate drops back to baseline the more fit they are.

Heart rate variability (**HRV**) is the amount of time between heart beats. Some wearable fitness trackers can measure this but not all of them. The amount of variation is miniscule and tracked in milliseconds. The more variability in time between heartbeats, the better, in other words this can be understood as the person is in good health and recovered and ready to train. A variability of 100+ milliseconds is considered healthy/recovered. The less variability or difference in time between heartbeats (so the time between beats is all very close to the same) the less recovered a person is likely to be. HRV will decrease with age as well.

Many of the measures and evaluations can be quickly and easily taken when working with clients and these tests can be used to set goals and track progress.

You are not qualified to diagnose any disease, illness, or injury. Do not overstep your bounds, which could lead to legal repercussions. You can educate people and inform them of what their measurements and evaluations are indicative of but you cannot take someone’s blood pressure, find a high reading and diagnose them with **hypertension**.

A goal of being healthy certainly is to live a long high-quality life. Life expectancy data is gathered and published each year in the United States by the Centers of Disease Control (CDC) [here](#) and on average Americans can expect to live into their mid

to late 70's. These trend lines are often subdivided by gender, race, income level, or education. There is a commonly believed misconception that hundreds of years ago our ancestors' life expectancy was much less, that living to 40 was uncommon. This is a statistical misinterpretation because childhood mortality was more frequent that it lowered the entire population's life expectancy, but if you could survive childhood living to your 50s or 60s or even 70s was not uncommon.

Critical Thinking

Imagine what you would like your senior years and retirement to look like? Do any of your travels or dream activities involve movement like hiking, playing with grandchildren, or rebuilding a classic muscle car? How can the actions of your today affect the health and wellness of your life far into the future?

What has changed in the last 100 years is what kills us. For most of history humans have mostly died of [infectious diseases](#) like influenza, pneumonia, tuberculosis, or even dehydration from diarrhea. The discovery of antibiotics and the development of modern medicine has greatly reduced the deaths from infectious diseases in developed countries of the world. Now the leading [causes](#) of death in America are called [Chronic Diseases](#) and they mostly come from lifestyle factors. Heart disease and cancer are the top two causes of death in America, and both have major risk factors from lack of physical activity and poor nutrition.

Exercise reduces the risk of developing almost every chronic disease, develops strong muscles, dense bones, improves posture and joint range of motion and has been shown to improve mental health. All of this extends life expectancy and increases quality of life.

Physical activity is defined as any bodily movement using skeletal muscles. Which would include moving your eyes as you read this line but usually physical activity is discussed as non-structured activity such as playing frisbee in the park with a friend or walking a dog . Non-Exercise Activity Time ([NEAT](#)) is low intensity activity like walking from the parking lot to your classroom or doing yard work.

Exercise is planned, structured, and possibly repetitive physical activity usually with a goal. Exercise includes strength training, spin class, hiking, yoga, and much more.

When building an exercise program or plan the two most important aspects are that the person following the program enjoys the activities and the design aligns with their personal goals. This is covered in much more detail in Chapter 10.

Anaerobic vs aerobic

[Anaerobic](#) refers to the energy pathway used by the body for short term powerful bursts of movement. This includes sprints, heavy lifting, or high intensity interval training. These events can last for a maximum of about 120 seconds before rest is needed or the intensity decreases. Anaerobic training can improve strength and muscular power. At the basic level this can be thought of as "strength training".

Reading in depth more on anaerobic training it is often discussed as energy production "without oxygen". This means that the chemical reaction in the body converting glucose to usable energy in our muscles is done without oxygen molecules. This anaerobic reaction is quick but less efficient than aerobic energy production. This does not mean that if you are breathing during a workout it makes it not anaerobic.

[Aerobic](#) movements are powered by a slower, more efficient energy pathway that requires oxygen. This includes walking, biking, swimming, or any movement at a set intensity you can maintain for at least 10 minutes but with training, humans can perform aerobic exercise for many hours, like completing a marathon or [Ironman triathlon](#). Aerobic training can improve cardiovascular fitness and build endurance. At a basic level this can be thought of as "cardio".

The [CDC](#) recommends "Move More and Sit Less" but adults should be getting at least 150 minutes of moderate-intensity aerobic activity per week, or 75 minutes of vigorous activity, or a mix of both. Combined with two or more strength training sessions per week. There are greater health benefits for exceeding these recommendations.

Making physical activity part of each day can help individuals move more and sit less. Starting to be active does not mean a person needs a fully detailed workout plan using lots of different exercise equipment, a person can start by adding in a 10-minute brisk walk around their neighborhood each day. Gradually increasing the level of activity over time will increase the health benefits. Increasing activity can be done by increasing duration, number of days they are done, or intensity of the activity (from walk to

run). These increases should be taken slowly and done over a period of weeks to months to reduce the chance of injury. Much more detail on exercise and programming is covered in Chapter 10.

As a kinesiologist you may work with people that are not interested or motivated to be physically active often, especially at a vigorous rate, but here are some tips on how to motivate people with ways to make the workout a little more palatable.

- Make the activities social, get a group together to walk everyone's dogs around the neighborhood. This also adds in some social accountability.
- Find workouts that only use bodyweight or minimal equipment. A single [kettlebell](#) or [jump rope](#) can be used for endless workouts.
- Find free YouTube [videos](#) of workouts that can be done at home.
- Join a gym or hire a personal trainer.

Physical Recovery:

Sleep is very important for mental and physical health. Muscle recovery and “gains” are made while sleeping. During strenuous exercise muscle tissue is damaged with [microscopic tears](#), during sleep the body rebuilds those tears and that leads to size and strength development in humans. Every adult should be aiming to get 7.5 to 8.5 hours of sleep per night.

Proper nutrition will be discussed at length in the next chapter, but eating the proper calories and macro nutrients for a healthy body composition and recovery of the day's activity is very important for physical recovery from exercise. Chapter 4 will also cover supplements, which many people incorrectly think are very important.

If this field of study is of interest to you, you may consider a degree in Public Health and looking at career opportunities in local or national organizations like [The World Health Organization](#) or the [Center for Disease Control](#).

1.4: Nutrition

Learning Objectives

1. Describe the 3 (or 4) macronutrients.
2. Understand what each macronutrient's role in the body is.
3. Understand Basal Metabolic Rate.

Steak and potatoes? Salmon and kale? Popcorn and soda? Our bodies run on what we ingest, and these choices make a massive difference in our health. As a kinesiologist in any field, questions about diet and nutrition are common because there is so much misinformation, fear, and fad diets circulating through social media that many people do not know what to believe.

Nutrition is the study of everything we eat and drink. Food and drink fuel the body for temperature regulation, physical activity, repair of tissues, and even thinking. The brain uses about [20% of ingested calories](#). People's choices about what they consume make massive differences in their health and their body's ability to grow and repair from exercise. In terms of all-cause mortality (everything that kills us) from cancer to heart disease to getting hit by a bus, most diseases have risk factors that we cannot change like our genetics, gender, or ethnicity but there are also lifestyle factors that we can change like nutrition and exercise. Broadly speaking, eating better, healthier food will reduce risk factors for many diseases. This is why it is so important to learn and understand the basics, because healthy eating is basic and it's important for all of us, since we all eat. Proper nutrition is also critical for building and fueling an athletic body, and the food intake will vary based on the athletic goals.

Food is often discussed in terms of its calories, and calories are units of energy. 1 kcal (1000 calories) is the amount of [energy required](#) to increase the temperature of 1kg (2.2lbs) of water from 0 Celsius to 1 Celsius. The Food and Drug Administration ([FDA](#)) set the average adult daily requirement for calories at 2000, and this number is commonly used as a starting point for most individuals, although true needs can vary greatly based on body composition, age, gender, and activity level.

Basal metabolic rate (BMR) is how many calories your body uses at rest. BMR is used in combination with your activity level to calculate how many calories are needed to maintain current body composition at current activity levels. The largest use of calories is to keep the human body warm and alive. Calculate an estimate of how many calories you need [here](#). Protein and carbohydrates have 4 calories per gram and fat has 9 calories per gram. (Alcohol has 7 calories per gram).

There are many diets advertised to consumers but usually the best intake of food for health and fitness is consuming the correct number of calories through fresh minimally processed foods of a wide variety.

Some of the more common diets are discussed below:

1. The [DASH](#) diet: focuses on reducing sodium intake to reduce high blood pressure, and promotes the consumption of whole grains, fruits, vegetables, low-fat dairy products, lean meats, and heart-healthy fish.
2. The gluten-free diet: recommended for people with celiac disease and gluten intolerance, this diet excludes foods containing gluten such as wheat, barley, and rye. It emphasizes fresh fruits, vegetables, and other foods without gluten.
3. Low-carb diets/[Keto](#): focus on limiting carbohydrates, including grains, fruit, and starchy vegetables, to promote weight loss. This diet emphasizes whole, unprocessed foods and a de-emphasis of refined carbohydrates.
4. The macrobiotic diet: a health and wellness regimen based on Eastern philosophy, it combines certain tenets of Zen Buddhism with a vegetarian diet and supports a balance of yin and yang's oppositional forces. The diet emphasizes whole grains, raw and cooked vegetables, small amounts of fish and seafood, and prohibits certain foods such as chocolate, tropical fruits, and animal products.
5. The [Mediterranean diet](#): emphasizes small portions of nutritionally-sound food from plant sources, including vegetables, fruits, whole grains, beans, nuts, seeds, and emphasizes the use of healthy fats like olive oil. This diet also limits the consumption of red meat and processed foods.
6. [Fad Diets](#): Unfortunately, there are a lot of people giving unhealthy advice to uneducated people that believe it. Most diets do not work because they are not sustainable for long periods of time. The goal of any solid nutrition advice is that a person should be happy to continue following those guidelines for the rest of their life. Setbacks are normal.

[Anorexia](#), also known as anorexia nervosa, is a psychiatric illness that involves excessive preoccupation with one's weight and food intake. This condition leads to severe malnourishment and eventually organ failure. Although relatively rare, affecting only

0.9% of females and 0.3% of males in their lifetime according to the National Institute of Mental Health (NIMH), it exemplifies how an imbalanced diet can severely impact one's health.

In contrast, **bulimia** involves consuming large amounts of food followed by purging through methods such as vomiting, taking laxatives or diuretics. Unlike anorexia, individuals with bulimia typically maintain a normal weight, making the disorder harder to identify and diagnose. The signs of bulimia resemble those of anorexia, including fear of gaining weight, extreme dieting, and excessive exercise routines.

Having a basic understanding of eating disorders and other psychological illnesses is important in all fields of kinesiology because someone you work with may be using exercise and diet to an unhealthy obsession.

Nutrients are divided into two categories: Macro and Micronutrients.

Macronutrients

These are the three nutrients that we need daily and in large portions: protein, carbohydrates, and fat. Water is sometimes listed as a fourth macronutrient (and will be in this book). Protein, carbohydrates, and fat provide the energy needed for life and the building blocks to grow and repair a body.

Protein:

Function: **Protein** generally is used for muscle and bone growth and repair. Protein can be used for energy in starvation situations.

Proteins are made up of **amino acids**. There are **20 amino acids**, 9 of them are “essential” meaning the human body cannot create them, so they must be ingested and derived from food sources. The other 11 amino acids are “nonessential” meaning the human body can repurpose other amino acids to create them if needed. Understandably confusing due to their naming, nonessential amino acids are still essential to human health. Protein can come from eating animal products like fish and eggs, but it is also possible to meet all of your protein requirements with a vegetarian/vegan diet.

Many people are not ingesting enough protein, current **recommendations** indicate that a range of at least 1.2 to 1.6 grams of protein per kilogram of bodyweight is the ideal target for health outcomes in adults to eat per day, and spreading this across the day by eating protein in each meal. Consuming enough protein is essential for building and maintaining muscle mass. This is especially important for athletes because strength training causes micro tears in muscles, and gains in strength and size are made as the muscle tissue is repaired. Without adequate protein this process cannot happen.

Ideal protein sources would come from lean meat including chicken and fish, other animal products including eggs and Greek yogurt, and complete protein plant source including quinoa, hempseed and soybeans. Many plants offer incomplete proteins but can be combined to include all the amino acids. Some of these **combinations** are nuts/seeds and whole grains, beans and rice, peas and pasta.

Carbohydrates

Mostly function as our bodies short term energy source. **Carbohydrates** are digested and turned into glucose and transported around the body as fuel. Much of this fuel is used to keep us warm, much more than exercise daily. For athletes carbohydrates are critical fuel for training and competition. Refueling the body during and after is imperative for them to be ready to work the following day. Carbs are also important because they spare protein and fat for other uses when energy is needed. If there are no carbs available for energy production the body will turn to breaking down muscle tissue for an energy source.

Many people think of carbs as evil things that cause weight gain, and that carbs only come from bread, pasta, or beer. Both of those statements are false. True, too many carbs can cause weight gain, but that is true of all food types and our bodies store extra consumed calories as adipose tissue around the body for use in the future. Most plant-based food are carbohydrates as well. Kale is a carb. Apples are carbs. Most food contains at least some amount of carbohydrate including animal products like milk.

Carbohydrates are often divided into three groups: Simple sugars, complex carbohydrates, and fiber.

Simple Carbs, sometimes called simple sugars, including glucose, maltose, fructose, and lactose.

Simple Sugar	Example Food source (there are many unlisted examples)
Glucose	Raisins and Honey
Maltose	Wheat and Barley
Fructose	Fruit and Fruit Juice
Lactose	Milk and Cheese

These carbohydrates are quick to be digested. With quick digestion comes quick energy, and our bodies love simple carbohydrates. While simple sugars are a part of daily life and the human body readily uses them for a supply of quick energy, over consumption of simple carbohydrates leads to weight gain and Type 2 Diabetes.

There is an artificial simple carbohydrate called [High Fructose Corn Syrup](#), which is created by converting some of the glucose into fructose in corn syrup. High fructose corn syrup is a common additive in processed foods and sweets. There is some debate on if high fructose corn syrup is unhealthy, increasing the risk of heart disease, metabolic syndrome, and fatty liver disease. Research results are mixed, but it is probably best to limit processed food intake in general.

Complex Carbohydrates: These food groups are still primarily needed for energy but take longer to breakdown during digestion. They are named, as their molecular composition is more complex with long chains of sugar molecules. These foods usually provoke less of a blood sugar spike and can keep someone feeling full for longer. Some examples of complex carbohydrates are whole grains, beans, lentils, and vegetables like broccoli. These energy sources are generally believed to be the healthier option.

Fiber: We as humans can not break down and digest everything we eat, some of the non-digestible “roughage” in carbohydrates is known as fiber. Consuming adequate amounts of high fiber foods including green leafy vegetables and complex carbohydrates is important for gastrointestinal health. Fiber inherently has 0 calories so it can be used to regulate body weight and it keeps people regular with bowel movements.

Fat/Lipids

Fats (aka lipids or adipose tissue) are the most vilified of the macros because fat is seen as bad and unhealthy. The truth is that fat is critical to life. Humans need fat tissue to pad their internal organs, help with thermoregulation, and hormone production. Much more information on healthy body fat levels was covered in Chapter 2.

Nutritional levels fat helps with the feeling of satiety or feeling full after eating. It is also used as long-term energy storage on the body.

Saturated and unsaturated fats differ in their chemical structure and have different effects on health. Most oils contain higher amounts of unsaturated fats, which can help reduce the risk of heart disease and stroke. Monounsaturated fats can also help regulate blood cholesterol levels and promote normal cell development and healthy skin.

Monounsaturated fats are mainly found in plant oils, such as extra virgin olive oil, avocado, nuts (such as almonds, cashews, pecans, peanuts, and walnuts), sesame oil, high oleic safflower oil, sunflower oil, and canola oil.

Polyunsaturated fats are mainly found in plant-based foods, oils, and fish, such as nuts (like walnuts, hazelnuts, pecans, almonds, and peanuts), soybean oil, corn oil, safflower oil, flaxseed oil, canola oil, and fatty fish (such as trout, herring, and salmon). On the other hand, saturated fat is found in animal products, dairy products, palm and coconut oils, and cocoa butter. It is recommended to limit the consumption of saturated fat to less than 10 percent of your overall dietary fat intake. High levels of saturated fat in the diet are associated with increased cholesterol levels, which can lead to an increased risk of heart disease and other health issues. It is important to avoid or at least limit the consumption of saturated fat.

Omega-3 fatty acids, a type of polyunsaturated fats also called alpha-linolenic acid, are crucial for cell growth and overall health. These fatty acids have additional benefits for heart health, with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) being the two most common types found in fatty fish like salmon, sardines, and herring. Other sources of omega-3s include flaxseeds, walnuts, soybean oil, and chia seeds. It's recommended that an individual's diet should include 0.6 – 1.2% of total calories from omega-3 fatty acids each day. Studies show that consuming at least two servings of EPA and DHA per week can help reduce the risk of cardiovascular disease.

Cholesterol, an essential component of the cell membrane, is primarily synthesized by the body for various functions, such as Vitamin D synthesis, bile salts, and reproductive hormones. Although minimal cholesterol intake occurs through certain foods

like animal sources, cheese, or egg yolks, unhealthy eating habits, lack of physical activity, and smoking can increase cholesterol build-up, leading to various coronary artery disease complications. High levels of cholesterol contribute to the build-up of plaque, which can further result in artery blockages.

The liver produces lipoproteins, including low-density lipoprotein (LDL) and high-density lipoprotein (HDL), that assist in transporting fat and cholesterol throughout the bloodstream. While LDL, also known as "bad" cholesterol, contributes to arterial plaque build-up, HDL, also known as "good" cholesterol, aids in removing cholesterol and returning it to the liver.

Water

The unofficial fourth macronutrient, water, is vital to all life on earth. Our bodies are [about 60%](#) water, and most of the chemical reactions keeping you alive are done in an aqueous environment. Water also helps eliminate waste products through urine and bowel movements. It even helps keep our joints lubricated for movement.

As a kinesiology one of the most important functions of water for us to focus on is the thermoregulation sweating provides humans during activity and exercise. As we move and exercise our core body temperature rises and we naturally [sweat](#) to help remove excess heat. The loss of water through sweat can lead to dehydration, muscle cramping and heat exhaustion. [Water and electrolytes](#) need to be replaced during and after exercise to fully recover. Electrolytes are minerals in your body that are important for muscular contraction. Dehydration and lack of electrolytes can lead to muscle cramping during long or strenuous exercise.

The amount of water a person needs to drink each day depends on body size and activity level but between 0.5-1.0 ounces of water per pound body weight, increasing that amount with physical activity.

Critical Thinking

What does your daily food intake look like? How could it be improved? Compare this to [Tour de France Cyclists](#). What is similar? What is the difference? Why?

Micronutrients

Micronutrients may get less of a spotlight in diet and nutrition, or lumped all together in one category, but they are also critical for optimal health and recovery. As the name suggests micronutrients are needed in much smaller amounts compared to macro nutrients. Micronutrients can be broken down into vitamins (including antioxidants) and minerals.

Vitamins can be subclassified into water soluble or fat-soluble vitamins. There are nine water soluble vitamins which are not stored in the body and eleven [fat soluble vitamins](#) which are stored in the body.

[Minerals](#) are inorganic substances like calcium and iron that humans use for a wide variety of crucial functions to life. Minerals are needed in small amounts, and only available from food intake.

Most healthy adults can ingest adequate amounts of micronutrients from eating a wide variety of fresh foods in a range of different colors.

Reading and understanding food labels is very important for knowing what calories, macros, and micro nutrients are in the food. Here is an interactive [link](#) to learn more.

The Nutrition Labeling and Education Act has made it mandatory for food items sold in the United States to feature a Nutrition Facts panel. This panel provides accurate information about the nutrients present in the food. It includes details such as the number of servings per container, calories per serving, and important micronutrients such as Vitamin D, Calcium, Iron, and potassium. This labeling is crucial as it helps individuals to compare different products and make informed choices about their food consumption. The Nutrition Facts panel contains information on both macronutrients and micronutrients, making it an essential tool for evaluating a food item's nutritional value. By analyzing the serving size and the nutrient content, one can make better decisions about what to consume. For example, a seemingly healthy snack like a bag of mixed nuts may contain multiple servings, and it is important to check the label for the total calorie, fat, protein, carbohydrate, vitamin, and sodium content.

The [percent DV](#) (daily value) listed on the label helps individuals determine if a food item is a good or poor source of nutrients. It reflects the nutrient's percentage in the food concerning its recommended daily intake. Therefore, it is essential to understand how to read the label to make informed decisions about one's diet.

The order of [ingredients](#) in a product's list is based on weight, with the heaviest ingredient being listed first. In the United States, manufacturers are required by law to indicate any potential allergens in the ingredient list, either in parentheses or after the list. Foods that have a lot of unfamiliar ingredients are often highly processed and contain preservatives and additives. These are added to extend the food's shelf life and improve its texture, color, or other properties. Highly processed foods tend to have fewer nutrients, so it's recommended to choose foods with recognizable ingredients whenever possible.

Dietary supplements are readily available in the United States, and are defined as products intended to supplement the diet and contain one or more dietary ingredients, such as vitamins, minerals, herbs, amino acids, or other substances. The Dietary Supplement Health and Education Act ([DSHEA](#)) of 1994 regulates the marketing and sale of supplements, but under different regulations than those governing conventional foods and drugs. Supplements come in various forms, including tablets, capsules, powders, and liquids. The [FDA](#) is only responsible for ensuring the safety of supplements that contain new ingredients, not their effectiveness, which is the responsibility of the manufacturer to test. It is important to be aware of the potential risks and benefits of using supplements, and to consult with a healthcare provider before taking any new supplements.

If a person is eating a healthy, well varied diet, they likely do not need to take supplements.

As a kinesiologist of any field, you will be asked many questions about nutrition. Many people are misinformed about what healthy eating is like or have never been taught. Altering their eating habits is one of the easiest and most effective ways people can improve their health. Here are a few topics that often come up in conversations.

[Nutrient timing](#) refers to the specific timing and distribution of macronutrients (carbohydrates, protein, and fat) in relation to exercise. Proper nutrient timing after working out might be beneficial for optimal recovery and muscle growth, but not as important as many people stress if overall proper nutrition is consistent.

Carbohydrates are the primary fuel source for [high-intensity exercise](#), and consuming carbohydrates after working out can help replenish glycogen stores that were depleted during exercise. Protein is also important for muscle repair and growth. Consuming protein after working out can help promote muscle protein synthesis and aid in muscle recovery.

Some experts recommend consuming carbohydrates and protein within 30 minutes to an hour after exercise to maximize recovery and muscle growth. However, the specific timing and distribution of macronutrients may vary depending on individual goals and needs. It is also important to consider overall daily nutrient intake and to choose nutrient-dense, whole foods to support overall health and wellness.

Fasted Cardio is cardiovascular exercise that is performed on an empty stomach, typically in the morning before eating. The theory behind fasted cardio is that by exercising in a fasted state, the body will use stored fat as the primary source of energy, which can lead to greater fat loss.

However, the evidence on the effectiveness of fasted cardio for fat loss is [mixed](#).

Macro percentages: there are many thoughts about how much protein, carbohydrates and fat people should be eaten each day to reach their goals. These are discussed as macronutrient percentages, or "[macros](#)". There is no one size fits all solution to this problem. Each person's starting body composition and activity level is different, with different goals, different genetics, and different foods they like. Individual experimentation is really the only way to find what works for each person.

A good place to start is to hit protein goals of at least [1.2 to 1.6 grams of protein](#) per kilogram of bodyweight. Then eat enough carbohydrates that a person feels energized for their day-to-day activities and workout program, and finish with a bit of fat for satiety and flavor.

[Dietary Guidelines for Americans](#) 2020-2025 suggest the following ranges for macronutrient intake based on a person's calorie needs:

- Carbohydrates: 45-65% of daily calories
- Protein: 10-35% of daily calories
- Fat: 20-35% of daily calories

The best nutrition guide is to eat a wide variety of minimally processed fresh foods in a wide range of colors.

If you are interested in furthering your nutritional education leading to a career as a registered dietitian, you should start by looking for a Nutritional Science/Dietitian bachelor's program.

Without being a registered dietitian, you cannot prescribe a precise diet. Do not overstep your role.

In Chapter 5 we will explore human anatomy.

1.5: Human Anatomy

Learning Objectives

1. Describe what planes specific motions happen in.
2. Differentiate between a tendon and a ligament.
3. Explain the movement of blood through the body.

Anatomy is the study of the biological tissues of the human body. This chapter will cover the basics of human anatomy focusing on the skeletal and muscular systems. As with all the chapters in this textbook, the information presented will be a basic overview of the topics in preparation for future classes and professional conversations.

Even in entirely healthy normally developed people, some [slight variation in anatomy](#) is normal. An easy way to check this is to examine the blood vessels in your forearm and the top of your hand compared to someone else. Severe anatomical abnormalities will not be covered in this chapter but could lead to serious health conditions or movement restrictions.

Many colleges will combine human anatomy and physiology together, but in this chapter, we will focus on understanding and naming the physical structures of the human body, and Chapter 6 will detail exercise physiology separately.

Remember from Chapter 1 that the scientific study of the physical structures of the human body largely started with dissecting the recently deceased. Many of the original anatomical drawings have a morbid or religious feel. These original drawings built the foundation of anatomical knowledge that much of this entire textbook is based on.

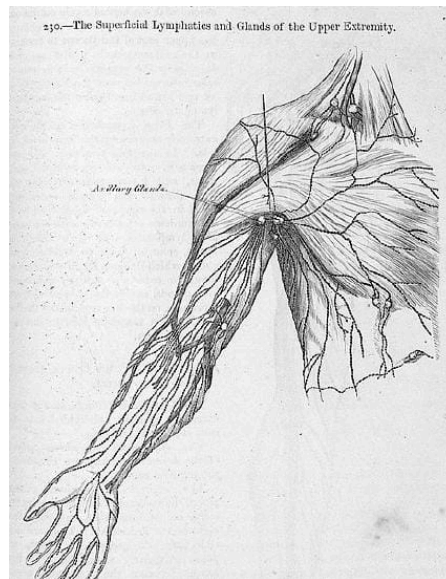


Figure 1: A black and white detailed drawing of muscle tissue and blood vessels in the upper chest and arm. "[File:H. Gray, Anatomy Descriptive and Surgical. Wellcome L0028363.jpg](#)" is licensed under CC BY 4.0.

Kinesiology and the medical field are closely related and being able to accurately and precisely describe the human body, physical orientation, and movements is critical to professional communication and treatment of patients. As kinesiologists, it is important to be able to have the anatomical knowledge to communicate with other professionals, but also be able to clearly explain the information to someone not educated in the field.

Most people will not understand "You have a grade 2 syndesmosis injury with tissue disruption in the tibiofibular joint" but if they will understand "You have a pretty serious high ankle sprain."

In this chapter, you will learn many of the scientifically correct names and movement patterns of human biological tissue. Still, it is important to practice correctly explaining concepts in simple terms.

Anatomical Position and Terminology:

The standard anatomical position is of the body standing upright with feet at shoulder width, toes pointed forward, arms out to the side of the body, and palms of the hand facing forward, as shown in the figure below. This starting position might seem simple, but it is important to remember so that discussion of movements, injuries, or deformities can be properly communicated.

Many of the body parts are labeled with their scientific names as well as more common names.

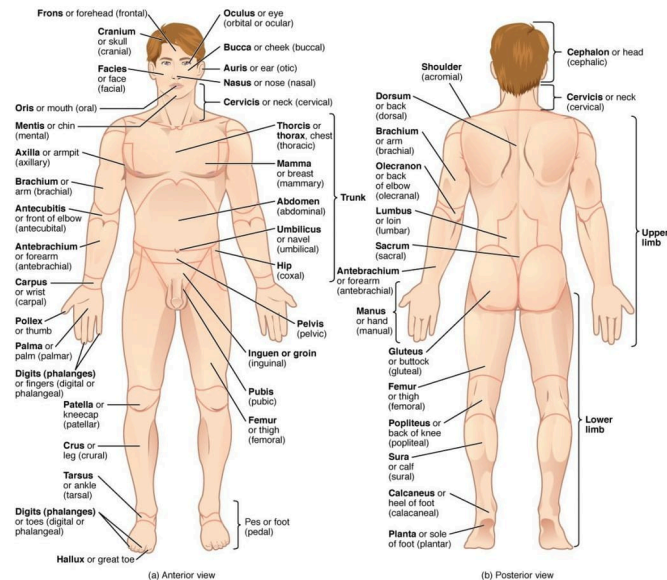


Figure 2: A human male shown front and back in anatomical position with many labeled body parts. "Regions of the Human Body" by Leanne Dooley is licensed under [CC BY-SA-4.0](https://creativecommons.org/licenses/by-sa/4.0/)

Describing directionality between two relative locations is also standardized:

- Anterior (or ventral) Describes the front or direction toward the front of the body. The toes are anterior to the foot.
- Posterior (or dorsal) Describes the back or direction toward the back of the body. The popliteus is posterior to the patella.
- Superior (or cranial) describes a position above or higher than another part of the body proper. The orbits are superior to the oris.
- Inferior (or caudal) describes a position below or lower than another part of the body proper; near or toward the tail (in humans, the coccyx, or lowest part of the spinal column). The pelvis is inferior to the abdomen.

Lateral describes the side or direction toward the side of the body. The thumb (pollex) is lateral to the digits.

Medial describes the middle or direction toward the middle of the body. The hallux is the medial toe.

Proximal describes a position in a limb that is nearer to the point of attachment or the trunk of the body. The brachium is proximal to the antebrachium.

Distal describes a position in a limb that is farther from the point of attachment or the trunk of the body. The crus are distal to the femur.

Superficial describes a position closer to the surface of the body. The skin is superficial to the bones.

Deep describes a position farther from the surface of the body. The brain is deep to the skull.

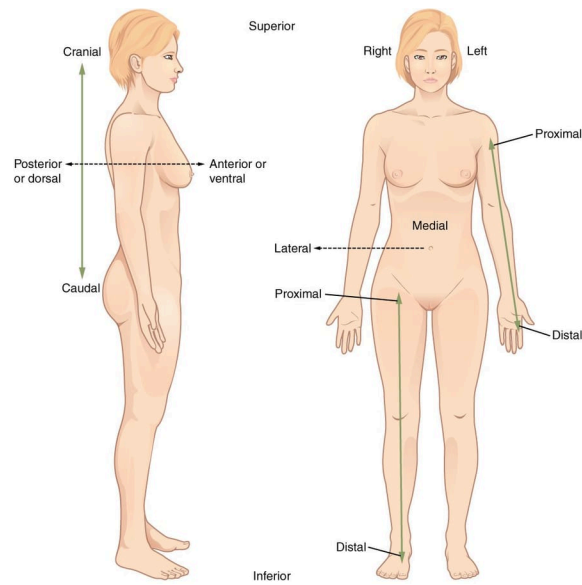


Figure 3: Directional terms applied to the human body. "Directional Terms" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

Critical Thinking

Why would it be important for a surgeon and their team to communicate using these terms when operating?

Body Planes

The [body and its movements](#) can also be discussed in terms of planes, or two-dimensional surfaces passing through the body.

The sagittal plane is the plane that divides the body vertically into the right and left sides. If this vertical plane runs directly down the middle of the body, it is called the midsagittal or median plane. If it divides the body into unequal right and left sides, it is called a parasagittal plane or less commonly a longitudinal section.

The frontal plane is the plane that divides the body into an anterior (front) portion and a posterior (rear) portion. The frontal plane is often referred to as a coronal plane. ("Corona" is Latin for "crown.")

The transverse plane is the plane that divides the body or organ horizontally into upper and lower portions.

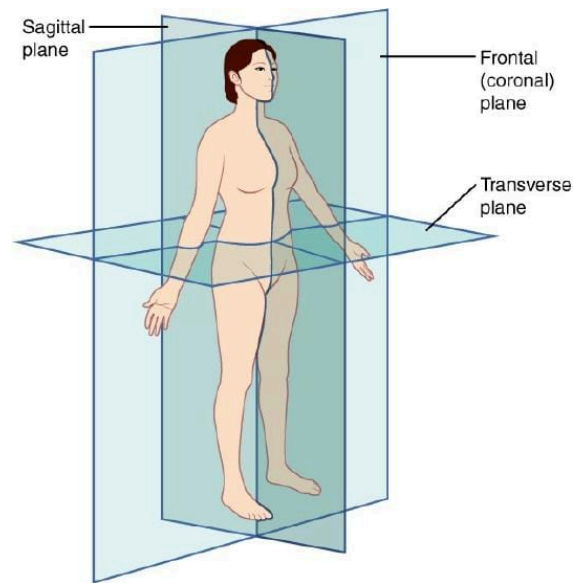


Figure 4: The human body bisected into the planes of movement "Planes of the Body" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

In kinesiology, these body planes are used to discuss how a person is moving or rotating during activity and exercise. Imagine a person doing a regular forward lunge, they would be said to be moving through the sagittal plane, because they are moving their body front to back. Sagittal plane movements also include forward running or bench press. In contrast, a lateral lunge would be moving through the frontal plane because a person is moving left to right. Finally, the transverse plane includes twisting or rotating movements, like putting on a seatbelt.

Of course, many athletic movements performed in sports will combine motion from two or all three of the body planes.

The human body is organized into four broad categories of tissue types: Epithelial, Connective, Muscle, and Nervous.

Epithelial tissue, also referred to as epithelium, refers to the sheets of cells that cover exterior surfaces of the body, line internal cavities and passageways, and form certain glands.

Connective tissue, as its name implies, binds the cells and organs of the body together and functions in the protection, support, and integration of all parts of the body.

Muscle tissue is excitable, responding to stimulation and contracting to provide movement, and occurs in three major types: skeletal (voluntary) muscle, smooth muscle, and cardiac muscle in the heart.

Nervous tissue is also excitable, allowing the propagation of electrochemical signals in the form of nerve impulses that communicate between different regions of the body.

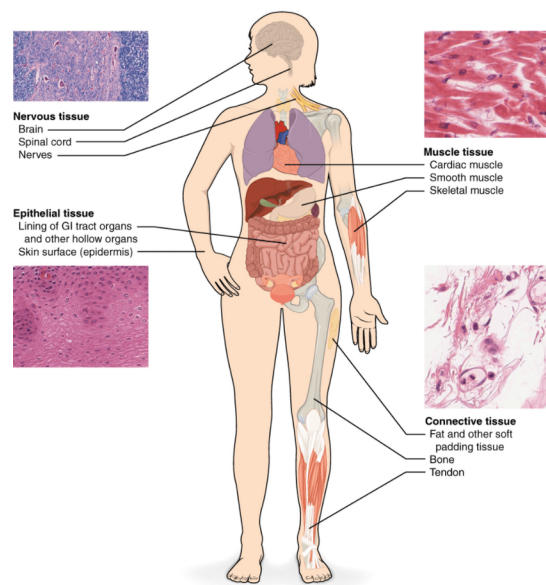


Figure 5: An anatomical look inside the human body showing where various tissue types can be found. "Four Types of Tissues" by Leanne Dooley is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

Skeletal Muscle

The primary function of **skeletal muscles** is to contract and produce movement. However, they also play a crucial role in maintaining posture by resisting gravity and making small, constant adjustments to keep the body upright and balanced. In addition, skeletal muscles prevent excessive movement of bones and joints, ensuring skeletal stability and preventing damage or deformation. By pulling on associated bones, muscles keep joints stable and prevent misalignment or dislocation. Skeletal muscles are also responsible for controlling the movement of substances through various internal tracts, such as the digestive system, urinary system, and reproductive system. This allows functions such as swallowing, urination, and defecation to be under voluntary control. Lastly, skeletal muscles protect internal organs, especially abdominal and pelvic organs, by acting as an external barrier against external trauma and supporting the weight of the organs.

Skeletal muscles play a critical role in maintaining homeostasis in the body by **generating heat**. The body expends more calories to maintain warmth than any other activity, including exercise. As muscles contract, they require energy, and when adenosine triphosphate (**ATP**) is broken down, heat is produced. During exercise, sustained muscle movement causes body temperature to rise, and in extremely cold conditions, shivering triggers random skeletal muscle contractions that generate heat. This heat production is a noticeable effect of muscle contraction and is essential for the body to maintain a constant internal temperature.

Skeletal muscles are intricate organs comprising various interdependent tissues, such as skeletal muscle fibers, blood vessels, nerve fibers, and connective tissue. These tissues collaborate to generate the intended movement.

The anatomy of a skeletal muscle consists of three layers of connective tissue that envelop and compartmentalize the muscle fibers. The outermost layer, called the **epimysium**, comprises dense and irregular connective tissue that imparts structural stability to the muscle. This layer enables the muscle to contract forcefully while maintaining its form and structural coherence. Furthermore, epimysium separates the muscle from adjacent tissues and organs, facilitating its autonomous movement.

Skeletal muscles comprise fascicles, which are individual bundles of muscle fibers held together by a middle layer of connective tissue known as the perimysium. This arrangement is especially prevalent in limb muscles and enables the nervous system to activate specific movements of the muscle by triggering a subset of muscle fibers within a given fascicle.

Each muscle fiber within a fascicle is enveloped by a thin layer of connective tissue called the **endomysium**, which consists of collagen and reticular fibers. The endomysium contains the extracellular fluid and nutrients necessary to support the muscle fiber, and these nutrients are provided to the muscle tissue through the blood supply.

Skeletal muscles work in tandem with **tendons** to pull on and move bones. The collagen fibers in the three tissue layers, or myofascia, of the muscle interlock with the collagen fibers of the tendon. At the opposite end of the tendon, it blends with the periosteum, which is a thin layer of connective tissue covering the bone's surface. The tension generated by the muscle fiber contraction is

transmitted via the myofibrils to the tendon, then to the periosteum, which pulls the bone, leading to the skeleton's movement.

Each skeletal muscle is richly supplied with blood vessels, delivering the necessary nourishment, oxygen, and waste removal to sustain the muscle's operation. Additionally, every muscle fiber in a skeletal muscle is triggered to contract by a motor neuron's axon. Unlike cardiac and smooth muscle, the sole way to stimulate a skeletal muscle contraction is through signals from the nervous system.

Skeletal Muscle Fibers

Because skeletal muscle cells are long and cylindrical, they are commonly referred to as muscle fibers. Skeletal muscle fibers can be quite large for human cells, with diameters up to 100 μm and lengths up to 30 cm (11.8 in) in the upper leg muscle tissues. During early development, embryonic myoblasts, each with its own nucleus, fuse with up to hundreds of other myoblasts to form the multinucleated skeletal muscle fibers. Multiple nuclei mean multiple copies of genes, permitting the production of the large amounts of proteins and enzymes needed for muscle contraction.

Some other terminology associated with muscle fibers is rooted in the Greek "sarco", which means "flesh." The plasma membrane of muscle fibers is called the **sarcolemma**, the cytoplasm is referred to as sarcoplasm, and the specialized smooth endoplasmic reticulum, which stores, releases, and retrieves calcium ions (Ca^{++}) is called the **sarcoplasmic reticulum** (SR) (Figure 3). As will soon be described, the functional unit of a skeletal muscle fiber is the sarcomere, a highly organized arrangement of the contractile myofilaments' actin (thin filament) and myosin (thick filament), along with other support proteins.

Here is a great [video](#) on actin and myosin.

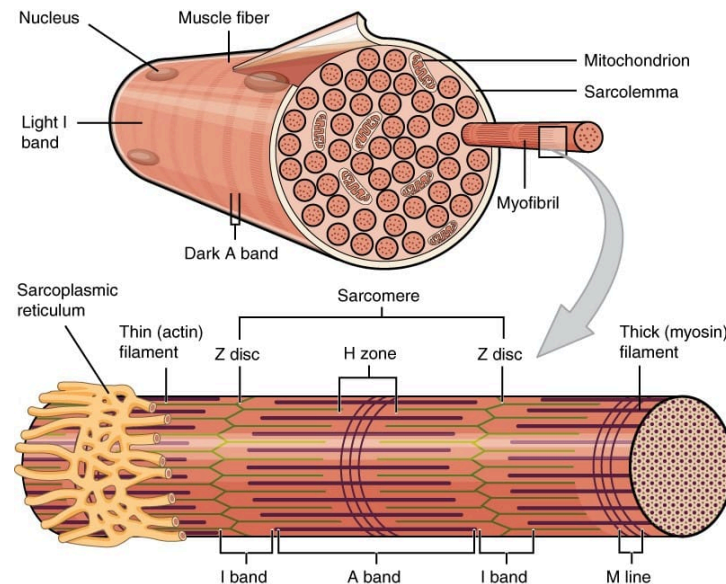


Figure 3. An artistic rendering of a skeletal muscle fiber at microscopic view with many anatomical points listed. "Muscle Fibre" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

A skeletal muscle fiber is surrounded by a plasma membrane called the sarcolemma, which contains sarcoplasm, the cytoplasm of muscle cells. A muscle fiber is composed of many fibrils, which give the cell its striated appearance.

The Sarcomere: The striated appearance of skeletal muscle fibers is due to the arrangement of the myofilaments of actin and myosin in sequential order from one end of the muscle fiber to the other. Each packet of these microfilaments and their regulatory proteins, troponin and tropomyosin (along with other proteins) is called a **sarcomere**.

The sarcomere is the functional unit of the muscle fiber. The sarcomere itself is bundled within the myofibril that runs the entire length of the muscle fiber and attaches to the sarcolemma at its end. As myofibrils contract, the entire muscle cell contracts. Because myofibrils are only approximately 1.2 μm in diameter, hundreds to thousands (each with thousands of sarcomeres) can be found inside one muscle fiber.

Each sarcomere is around 2 μm in length with a cylinder-like arrangement and is bordered by structures called Z-discs (also called Z-lines, because pictures are two-dimensional), to which the actin myofilaments are anchored (Figure 4). Because the actin and

its troponin-tropomyosin complex (projecting from the Z-discs toward the center of the sarcomere) form strands that are thinner than the myosin, it is called the thin filament of the sarcomere. Likewise, because the myosin strands and their multiple heads (projecting from the center of the sarcomere, toward but not all the way to, the Z-discs) have more mass and are thicker, they are called the thick filament of the sarcomere.

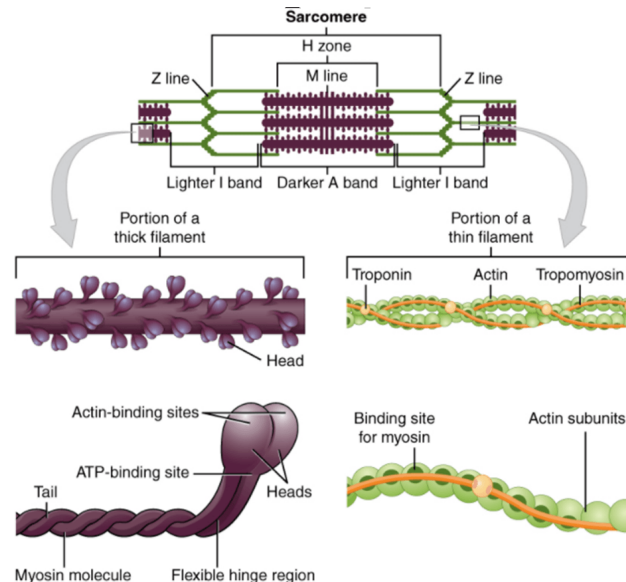


Figure 4. An artistic rendering of a sarcomere with actin and myosin binding sites. "The Sarcomere" by Leanne Dooley is licensed under CC BY-SA 4.0

The sarcomere, the region from one Z-line to the next Z-line, is the functional unit of a skeletal muscle fiber.

Types of Body Movement

The most common type of joint in the human body is a synovial joint which allows the body a tremendous range of movements. There are two other types of joints in the human body, cartilaginous and fibrous, but they are limited in movement. Each movement at a synovial joint results from the contraction or relaxation of the muscles that are attached to the bones on either side of the articulation. The type of movement that can be produced at a synovial joint is determined by four factors:

- Orientation of the muscle. Each muscle is attached at an origin and an insertion. The origin of the muscle is its attachment to the bone that will remain relatively stable when that muscle contracts. It is the bone to which the muscle is anchored. The other end of the muscle will be its insertion, which is its attachment to the bone which will move when that muscle contracts. The orientation of the muscle – which bone it is anchored to and which bone it inserts in, will determine the movement.
- Action of other muscles that may insert and/or originate on the same bone(s) that when any particular muscle contracts, the bone will be moved in a particular direction, different from the direction any single muscle may produce. It is not uncommon to see the same muscle being involved in two or more different movements.
- Type of joint between the bones. There are several different types of joints between bones. Only the synovial joint allows for any significant movement. Each specific joint is limited in the movement it can provide because of the shape of the ends of the bones in the joint, and because of the tension in the [ligaments](#) holding the bones together.
- Muscle tension. This is a limitation that works in a similar manner to tension in the ligaments. An example of the role of muscle tension is demonstrated when touching one's toes with the knees straight. The movement is restricted by the tension of the hamstring muscles.

While the ball-and-socket joint gives the greatest range of movement at an individual joint, in other regions of the body, several joints may work together to produce a particular movement. Overall, each type of synovial joint is necessary to provide the body with its great flexibility and mobility. There are many types of movement that can occur at synovial joints. Movement types are generally paired, with one being the opposite of the other. Body movements are always described in relation to the anatomical position of the body: upright stance, with upper limbs to the side of body and palms facing forward.

Type of Joint	Movement	Examples

Pivot	Uniaxial joint; allows rotational movement	Atlantoaxial joint (C1-C2 vertebrae articulation); proximal radioulnar joint
Hinge	Uniaxial joint; allows flexion/extension movements	Knee; elbow; ankle; interphalangeal joints of fingers and toes
Condyloid	Biaxial joint; allows flexion/extension, abduction/adduction, and circumduction movements	Metacarpophalangeal (knuckle) joints of fingers; radiocarpal joint of wrist; metatarsophalangeal joints of toes
Saddle	Biaxial joint; allows flexion/extension, abduction/adduction, and circumduction movements	First carpometacarpal joint (carpometacarpal joint of the thumb); sternoclavicular joint
Plane	Multiaxial joint; allows inversion/eversion of the foot, flexion/extension and lateral flexion of the vertebral column	intertarsal joints of foot; superior-inferior articular process articulations between vertebrae
Ball-and-socket	Multiaxial joint; allows flexion/extension, abduction/adduction, circumduction, and medial/lateral rotation movements	Shoulder joint, hip joint

For the following discussions, please take your time and physically act the movements out.

Flexion and extension are movements that take place within the sagittal plane and involve anterior or posterior movements of the body or limbs. For the vertebral column, flexion (anterior flexion) is an anterior (forward) bending of the neck or body, while extension involves a posterior-directed motion, such as straightening from a flexed position or bending backward. Lateral flexion is the bending of the neck or body toward the right or left side. These movements of the vertebral column involve both the **symphysis** joint formed by each intervertebral disc, as well as the plane type of synovial joint formed between the inferior articular processes of one vertebra and the superior articular processes of the next lower vertebra.

In the limbs, flexion decreases the angle between the bones (bending of the joint), while extension increases the angle and straightens the joint. For the upper limb, all anterior-going motions are flexion, and all posterior-going motions are extension. These include anterior-posterior movements of the arm at the shoulder, the forearm at the elbow, the hand at the wrist, and the fingers at the metacarpophalangeal and interphalangeal joints. For the thumb, extension moves the thumb away from the palm of the hand, within the same plane as the palm, while flexion brings the thumb back against the index finger or into the palm. These motions take place at the first carpometacarpal joint. In the lower limb, bringing the thigh forward and upward is flexion at the hip joint, while any posterior-going motion of the thigh is extension. Note that extension of the thigh beyond the anatomical (standing) position is greatly limited by the ligaments that support the hip joint. Knee flexion is the bending of the knee to bring the foot toward the posterior thigh, and extension is the straightening of the knee. Flexion and extension movements are seen at the hinge, condyloid, saddle, and ball-and-socket joints of the limbs (Figure 5a-d below).

Hyperextension is the abnormal or excessive extension of a joint beyond its normal range of motion, thus resulting in injury. Similarly, hyperflexion is excessive flexion at a joint. Hyperextension injuries are common at hinge joints such as the knee or elbow. In cases of “whiplash” in which the head is suddenly moved backward and then forward, a patient may experience both hyperextension and hyperflexion of the cervical region.

Abduction and Adduction: Abduction and adduction motions occur within the coronal plane and involve medial-lateral motions of the limbs, fingers, toes, or thumb. Abduction moves the limb laterally away from the midline of the body, while adduction is the opposing movement that brings the limb toward the body or across the midline. For example, abduction is raising the arm at the shoulder joint, moving it laterally away from the body, while adduction brings the arm down to the side of the body. Similarly, abduction and adduction at the wrist moves the hand away from or toward the midline of the body. Spreading the fingers or toes apart is also abduction, while bringing the fingers or toes together is adduction. For the thumb, abduction is the anterior movement that brings the thumb to a 90° perpendicular position, pointing straight out from the palm. Adduction moves the thumb back to the anatomical position, next to the index finger. Abduction and adduction movements are seen at condyloid, saddle, and ball-and-socket joints (Figure 5e).

Circumduction is the movement of a body region in a circular manner, in which one end of the body region being moved stays relatively stationary while the other end describes a circle. It involves the sequential combination of flexion, adduction, extension, and abduction at a joint. This type of motion is found at biaxial condyloid and saddle joints, and at multiaxial ball-and-sockets joints (Figure 5e).

Rotation can occur within the vertebral column, at a pivot joint, or at a ball-and-socket joint. Rotation of the neck or body is the

twisting movement produced by the summation of the small rotational movements available between adjacent vertebrae. At a pivot joint, one bone rotates in relation to another bone. This is a uniaxial joint, and thus rotation is the only motion allowed at a pivot joint. For example, at the atlantoaxial joint, the first cervical (C1) vertebra (atlas) rotates around the dens, the upward projection from the second cervical (C2) vertebra (axis). This allows the head to rotate from side to side as when shaking the head “no.” The proximal radioulnar joint is a pivot joint formed by the head of the radius and its articulation with the ulna. This joint allows for the radius to rotate along its length during pronation and supination movements of the forearm.

Rotation can also occur at the ball-and-socket joints of the shoulder and hip. Here, the humerus and femur rotate around their long axis, which moves the anterior surface of the arm or thigh either toward or away from the midline of the body. Movement that brings the anterior surface of the limb toward the midline of the body is called medial (internal) rotation. Conversely, rotation of the limb so that the anterior surface moves away from the midline is lateral (external) rotation (Figure 5f). Be sure to distinguish medial and lateral rotation, which can only occur at the multiaxial shoulder and hip joints, from circumduction, which can occur at either biaxial or multiaxial joints.

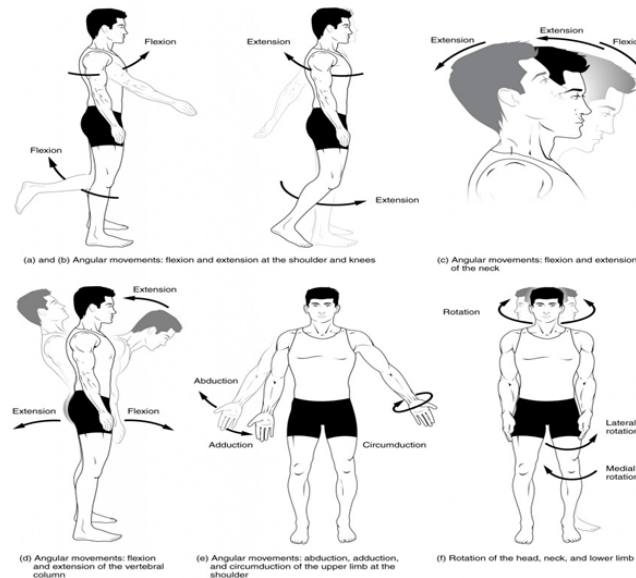


Figure 5. Multiple drawings of physical human movements and their names. "Joint Movement" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

Synovial joints give the body many ways in which to move. (a)–(b) Flexion and extension motions are in the sagittal (anterior–posterior) plane of motion. These movements take place at the shoulder, hip, elbow, knee, wrist, metacarpophalangeal, metatarsophalangeal, and interphalangeal joints. (c)–(d) Anterior bending of the head or vertebral column is flexion, while any posterior-going movement is extension. (e) Abduction and adduction are motions of the limbs, hand, fingers, or toes in the coronal (medial–lateral) plane of movement. Moving the limb or hand laterally away from the body, or spreading the fingers or toes, is an abduction. Adduction brings the limb or hand toward or across the midline of the body or brings the fingers or toes together. Circumduction is the movement of the limb, hand, or fingers in a circular pattern, using the sequential combination of flexion, adduction, extension, and abduction motions. Adduction/abduction and circumduction take place at the shoulder, hip, wrist, metacarpophalangeal, and metatarsophalangeal joints. (f) Turning of the head side to side or twisting of the body is rotation. Medial and lateral rotation of the upper limb at the shoulder or lower limb at the hip involves turning the anterior surface of the limb toward the midline of the body (medial or internal rotation) or away from the midline (lateral or external rotation).

Supination and pronation are movements of the forearm. In the anatomical position, the upper limb is held next to the body with the palm facing forward. This is the supinated position of the forearm. In this position, the radius and ulna are parallel to each other. When the palm of the hand faces backward, the forearm is in the pronated position, and the radius and ulna form an X-shape.

Supination and pronation are the movements of the forearm that go between these two positions. Pronation is the motion that moves the forearm from the supinated (anatomical) position to the pronated (palm backward) position. This motion is produced by rotation of the radius at the proximal radioulnar joint, accompanied by movement of the radius at the distal radioulnar joint. The proximal radioulnar joint is a pivot joint that allows for rotation of the head of the radius. Because of the slight curvature of the shaft of the radius, this rotation causes the distal end of the radius to cross over the distal ulna at the distal radioulnar joint. This crossing over brings the radius and ulna into an X-shape position. Supination is the opposite motion, in which rotation of

the radius returns the bones to their parallel positions and moves the palm to the anterior facing (supinated) position. It helps to remember that supination is the motion you use when scooping up soup with a spoon (Figure 6g).

Dorsiflexion and plantar flexion are movements at the ankle joint, which is a hinge joint. Lifting the front of the foot, so that the top of the foot moves toward the anterior leg is dorsiflexion, while lifting the heel of the foot from the ground or pointing the toes downward is plantar flexion. These are the only movements available at the ankle joint (Figure 6h).

Inversion and eversion are complex movements that involve the multiple plane joints among the tarsal bones of the posterior foot (intertarsal joints) and thus are not motions that take place at the ankle joint. Inversion is the turning of the foot to angle the bottom of the foot toward the midline, while eversion turns the bottom of the foot away from the midline. The foot has a greater range of inversion than eversion motion. These are important motions that help to stabilize the foot when walking or running on an uneven surface and aid in the quick side-to-side changes in direction used during active sports such as basketball, racquetball, or soccer (Figure 6i).

Protraction and retraction are anterior-posterior movements of the scapula or mandible. Protraction of the scapula occurs when the shoulder is moved forward, as when pushing against something or throwing a ball. Retraction is the opposite motion, with the scapula being pulled posteriorly and medially, toward the vertebral column. For the mandible, protraction occurs when the lower jaw is pushed forward, to stick out the chin, while retraction pulls the lower jaw backward. (Figure 6j.)

Depression and elevation are downward and upward movements of the scapula or mandible. The upward movement of the scapula and shoulder is elevation, while a downward movement is depression. These movements are used to shrug your shoulders. Similarly, elevation of the mandible is the upward movement of the lower jaw used to close the mouth or bite on something, and depression is the downward movement that produces opening of the mouth (Figure 6k).

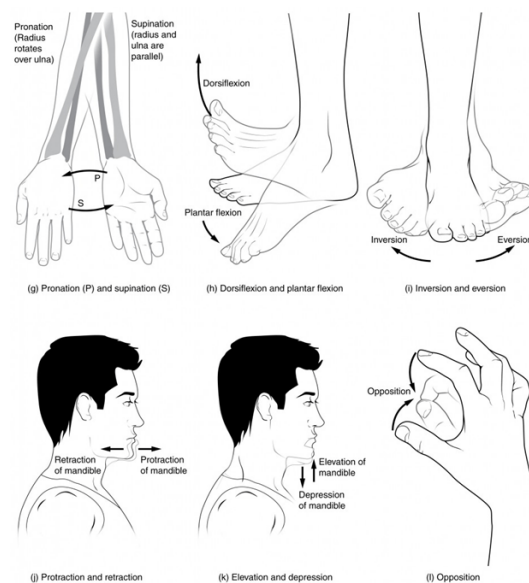


Figure 6. Multiple drawings of physical human movements and their names. "Joint Movement" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

(g) Supination of the forearm turns the hand to the palm forward position in which the radius and ulna are parallel, while forearm pronation turns the hand to the palm backward position in which the radius crosses over the ulna to form an "X." (h) Dorsiflexion of the foot at the ankle joint moves the top of the foot toward the leg, while plantar flexion lifts the heel and points the toes. (i) Eversion of the foot moves the bottom (sole) of the foot away from the midline of the body, while foot inversion faces the sole toward the midline. (j) Protraction of the mandible pushes the chin forward, and retraction pulls the chin back. (k) Depression of the mandible opens the mouth, while elevation closes it. (l) Opposition of the thumb brings the tip of the thumb into contact with the tip of the fingers of the same hand and reposition brings the thumb back next to the index finger.

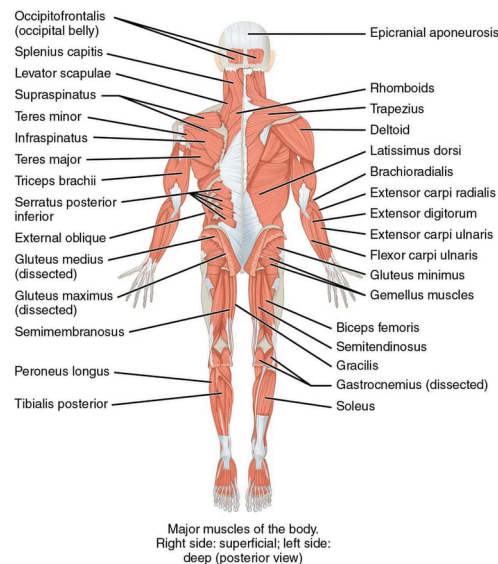
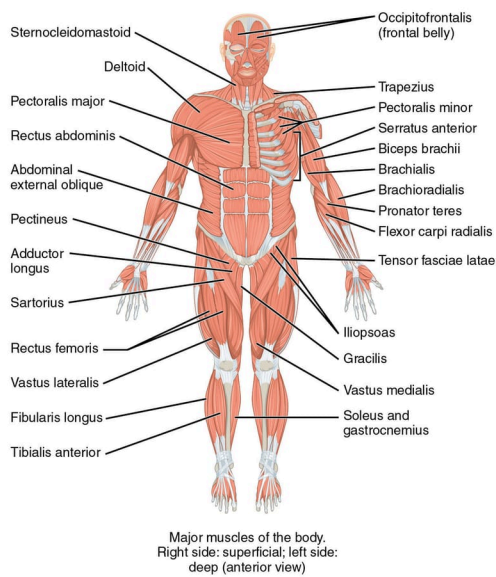


Figure 7. Anatomical overview of most major human muscles. "Human Muscles" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

On the anterior and posterior views of the muscular system above, superficial muscles (those at the surface) are shown on the right side of the body while deep muscles (those underneath the superficial muscles) are shown on the left half of the body. For the legs, superficial muscles are shown in the anterior view while the posterior view shows both superficial and deep muscles.

The Heart!

The pump that keeps oxygen flowing to all parts of the body while also removing metabolic by-products and circulates different hormones and other nutrients. Over a lifetime, the heart can beat nearly 3 billion times, while never taking a break. This ability to not fatigue is one of the main differences between cardiac muscle tissue and skeletal muscle tissue.

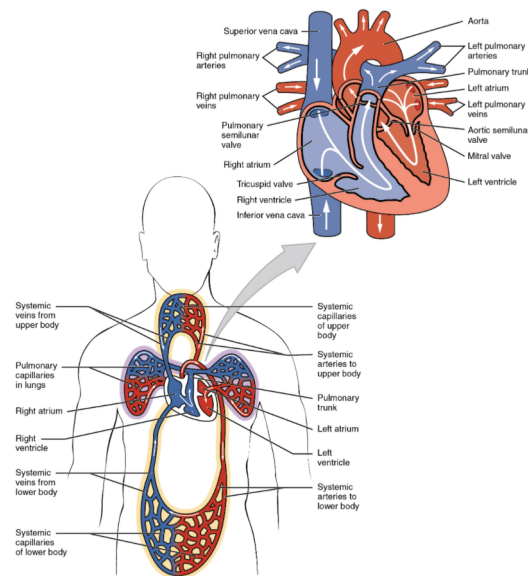


Figure 8: A drawing of the heart and its anatomical structures named with a crude example of the systemic and pulmonary circuits. "Heart and Position" by Leanne Dooley is licensed under [CC BY-SA 4.0](#)

The heart has four chambers (two atria and two ventricles) and pumps blood throughout the body by contracting and squeezing those chambers to force the blood to move forward by utilizing one-way valves. The right atrium receives deoxygenated blood from the body the left atrium receives oxygen-rich blood from the lungs. The atria contract to pump the blood into their corresponding ventricles which then contract to pump the oxygenated blood out to the body and the deoxygenated blood to the lungs. These two intermixing circulations are the systemic and pulmonary systems. The pulmonary system is the circulation of blood from the heart to the lungs and back. This system is smaller; therefore the right side of the heart is less muscled. The systemic system is the circulation from the heart to the body and back to the heart, so the left side of the heart is much larger to create the required force to push the blood through the body.

Blood pressure measurements using a **sphygmomanometer** (blood pressure cuff) is a common kinesiology lab test. How the heart physically beats and circulates blood through a double chambered pump makes it possible to hear the classic “lub dub” heart beat sound and measure the internal pressure of the arteries. A blood pressure cuff works by collapsing an artery completely blocking all of the blood flow. As the pressure of the cuff is reduced, the heart will be creating enough force to push the blood through the now partially open artery. Listening with a blood pressure cuff will allow determination of systolic and diastolic pressures, which are reported in **mmHg**.

Systolic blood pressure is the first number (or number on top) reported in a blood pressure reading, this pressure reading is from when the heart is fully contracted and pushing the blood through the arterial system.

Diastolic pressure readings show the pressure in the arteries between heart beats when the heart is relaxed. An average blood pressure reading for a healthy adult is 120/80mmHg.

The heart needs the lungs for respiration, removing carbon dioxide from the blood and providing new oxygen. The respiratory system is made up of the nose, **pharynx**, larynx, trachea, **bronchi**, and the lungs. As the lungs expand air travels down the respiratory system to the alveoli in the lungs. The alveoli are very small thin membrane sacs in the lungs that allow for gas exchange from the outside air to the blood.

The **lungs are much less adaptable** compared to the heart for exercise and fitness improvements. It is possible to make some small improvements but cardiovascular fitness adaptations are primarily made in the heart.

The muscles, joints, heart, and lungs all work together to allow humans to move and exercise. Focused training over a period of time will bring fitness adaptations and improvements to these systems which will be discussed in more detail in Chapter 10.

The information in this chapter is relevant to all fields of kinesiology and it is recommended to review the common terminology describing body placement and movement often.

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1.6: Exercise Physiology

Learning Objectives

1. What is lactic acid and what does it do?
2. How do muscles contract?
3. What are the different types of muscle and how are they different?

Exercise Physiology is the study of the effect exercise has on the body. This includes all types of sport from rock climbing, to lifting weights, to swimming in a triathlon and how the body changes or adapts to these activities acutely and chronically.

The most obvious physical changes from exercise might be visually apparent with muscular development or the change in body composition. One might also correctly guess that exercise physiologists (those who study exercise physiology) are interested in physical fitness, but the wide area of study also includes metabolism, nervous system changes, exercise in diseased populations, environmental changes, and much more.

History of Exercise Physiology

While discussed multiple times previously in this text, humans have moved and been active for as long as humans have been around. A link between repetitive training and progressive overload has been clear for hundreds or thousands of years for human fitness, but the scientific study of how physical activity affects our bodies started early in the 1900's. In 1922 two men Archibald Hill and Otto Meyerhof shared the [Nobel Prize in Physiology or Medicine](#) for their scientific work creating modern exercise physiology. The two men researched the production of heat and carbohydrate metabolism in muscular tissue.

Their work serves as a basic understanding of muscular physiology even though many of their ideas have since been refined and corrected. The often-misunderstood concept of "lactic acid" forming during exercise and causing a burning sensation in muscles leading to muscle soreness was published by Archibald Hill. Exercise physiologists now know lactate (aka lactic acid) is not responsible for the burning feeling or the soreness. "Lactic acid" is quickly converted through cellular respiration and does not build up in human bodies. Lactate is produced during muscular metabolism but quickly moved to the liver to be recycled into more ATP, heat, and metabolic by products.

Listen to sports broadcasts or other athletic settings and see how often you can hear this century-old misconception reiterated.

Modern outcomes: Performance vs Return to Standard

The pursuits of modern exercise physiology research can broadly be split into two categories: pushing the limits of human performance or returning diseased or injured populations to a healthy baseline. In the United States much more public funding is devoted to studying and aiding a diseased or injured population. There are of course exceptions to this with Olympic training centers or highly funded performance-based programs like the military and NASA.

An exercise physiologist could also focus on athletic equipment or clothing to increase performance or speed. A few examples of this would be working with an engineer and athletes to design a more aerodynamic bicycle for cycling races. Here is a [video](#) showing wind tunnel testing on bike parts.

During the 2008 Olympic games 25 swimming world records were broken, which is unusual. Almost all the athletes were wearing a new swimsuit that covered nearly the entire body that had been engineered to reduce drag in the water while swimming. This "[Speedo LZR Racer](#)" was inspired by studying the skin of sharks and has since been banned from competitive swimming.

Critical Thinking

With ever advancing sporting equipment and knowledge of how to train the human body, how do you think sporting records should be kept? It seems to make sense that almost all of the records from the 1900s will be broken in this century, does that mean the athletes of today are better than the athletes of the past?

Exercise physiologists may also be interested in studying physical training programs to produce maximal results for the goals of the athletes. Are front squats or back squats better at developing explosive leg power? Is it more beneficial to complete 4 or 5 sets in weight lifting for [muscle hypertrophy](#)? These are simple examples of what an exercise physiologist may design research to test.

Common Lab equipment and tests found in a kinesiology lab at most colleges could include:

Physical evaluation tools to measure height, weight, and blood pressure.

Measuring and determining [body composition](#) is widely used in research as body composition is highly correlated with many chronic diseases. Body composition is the ratio of fat mass and non-fat mass (bone, muscle, and organ) in a person's body. Healthy levels of body fat percentage differ between men and women. Men need less fat mass but should remain above 3-5% as an absolute minimum. Most male athletes will have between 6% to 14% body fat. Women need more fat mass for menstrual cycle health, with minimums between 10-13%. Most female athletes will have between 14-20% body fat.

There are a variety of ways to measure body composition. Most labs or gyms will have a [bioelectrical impedance analysis](#) machine that uses a weak electric current to estimate body composition. [BodPods](#) or [hydrostatic weighing](#) use air or water volume displacement to estimate body composition. The current gold standard in body composition assessment is a [DEXA](#), or dual energy x-ray absorptiometry scan. This uses x-ray to calculate fat and fat free mass.

Less accurate tests for body composition include the [Body Mass Index](#) (BMI), which mathematically scores a person based on height and weight. Highly muscled athletes can score higher than expected because of their extra muscle weight. Caliper and girth measurements can be used to estimate body composition as well but have a high user error rate and are generally seen as less reliable compared to other body composition assessment tools.

A [Metabolic cart](#) with treadmill and or bike to test cardiovascular fitness. A metabolic cart will use a mask connected to a participant's face to measure oxygen inhalation and carbon dioxide exhalation as they ride or run. This gas measurement can be used to evaluate VO2 max, determining the ratio of carbohydrates to fats being used to produce energy, and overall energy expenditure.

A [VO2 max](#) test is a very common lab procedure in a kinesiology college education. The exact details of the test can vary but in general a person is hooked up to a metabolic (meaning they have a mask on their face gathering data on gas they breath in and out) The person will perform cardiovascular exercise on a bike or treadmill of increasing intensity until they cannot continue. The test usually takes about 10-15 minutes. The higher a person's VO2 max the [more fit](#) and healthy they are. Scores reported as milliliters of oxygen per minute used per kilogram of body weight of the participant.

A force plate or [force platforms](#) are used to measure ground reaction forces generated by a person. These can be used to measure explosive power, jumping height, and balance.

Most kinesiology labs will also have a wide variety of strength training equipment to be used to evaluate a wide range of research studies.

Here is a [video](#) tour of an exercise physiology lab.

Skeletal Muscular Contraction

Two requirements must be met for skeletal muscular contraction to occur. First, there must be in place a neuromuscular junction.

The [neuromuscular junction](#) is the site where a motor neuron's terminal meets a muscle fiber. The neuromuscular junction is where the muscle fiber first responds to signaling by the motor neuron. Every skeletal muscle fiber must be activated, or stimulated, by a nerve ending at the neuromuscular junction so that a change in membrane potential occurs.

Excitation signals from the neuron are the only way to functionally activate the fiber to contract; they generate an electrical current, called an [action potential](#), in the sarcolemma (plasma membrane) of the muscle fiber.

The action potential thus generated is linked to contraction, which is why the second requirement for skeletal muscular contraction is referred to as excitation-contraction coupling.

Excitation-contraction coupling: All living cells have membrane potentials, or electrical gradients across their membranes. The inside of the membrane is usually around -70 mV, relative to the outside. This is referred to as a cell's resting membrane potential. Neurons and muscle cells can use their membrane potentials to generate electrical signals. They do this by controlling the movement of charged particles, called ions, across their membranes to create electrical currents. This is achieved by opening and closing specialized proteins in the membrane called ion channels. Although the currents generated by ions moving through these channel proteins are very small, they form the basis of both neural signaling and muscle contraction.

This will be covered in greater detail in chemistry or physiology required coursework for your kinesiology degree.

Both neurons and skeletal muscle cells are electrically excitable, meaning that they can generate action potentials. An action potential is a special type of electrical signal that can travel along a cell membrane as a wave. This allows a signal to be transmitted quickly and faithfully over long distances.

Although the term excitation-contraction coupling confuses or scares some students, it comes down to this: for a skeletal muscle fiber to contract, its membrane must first be “excited”, it must be stimulated to fire an action potential. The muscle fiber action potential, which sweeps along the sarcolemma as a wave, is “coupled” to the actual contraction through the release of calcium ions from the [sarcoplasmic reticulum](#).

In skeletal muscle, this sequence begins with signals from the somatic motor division of the nervous system. In other words, the “excitation” step in skeletal muscles is always triggered by signaling from the nervous system (Figure 1).

Signaling begins when a neuronal action potential travels along the axon of a motor neuron, and then along the individual branches of the axon, terminating at individual neuromuscular junctions. Membrane potential changes cause calcium channels in the membrane of the neuron to open, allowing calcium ions to diffuse into the neuron's cytosol. This influx of Ca^{2+} causes vesicles in the neuron to fuse with its plasma membrane, releasing their contents, the neurotransmitter [acetylcholine](#) (ACh) into the space between the neuron and the muscle fiber, called the synaptic cleft. It is the exocytotic release of acetylcholine from these vesicles that is ultimately calcium-ion dependent.

The associated axon terminal at each neuromuscular junction releases acetylcholine (ACh). The acetylcholine molecules diffuse across a minute space called the synaptic cleft and bind to acetylcholine receptors located within the motor end-plate of the sarcolemma on the other side of the synapse. Once acetylcholine binds, a channel in the acetylcholine receptor (called a ligand-gated ion channel) opens and positively charged ions can pass through into the muscle fiber, causing it to depolarize, meaning that the membrane potential of the muscle fiber becomes less negative (closer to zero, and this continues so that there is a temporary reversal of charge with the inside of the membrane briefly positive relative to the outside).

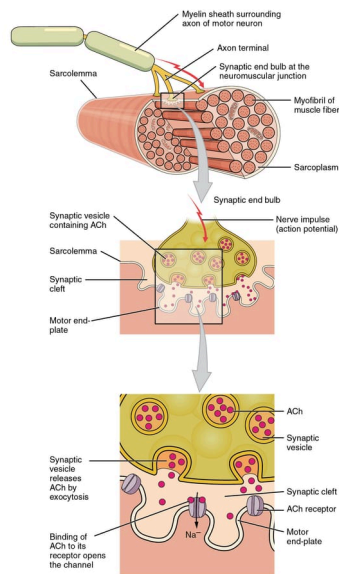


Figure 1. Artistic rendering of muscle fiber activation from ACh release at the motor end plate. "Motor End Plate" by Douglas College Biology Department is licensed under [CC BY 4.0](#)

At the neuromuscular junction, the axon terminal releases acetylcholine. The motor end-plate is the location of the acetylcholine-receptors in the muscle fiber sarcolemma. When acetylcholine molecules are released, they diffuse across a minute space called the synaptic cleft and bind to the receptors.

As the membrane depolarizes, another set of ion channels called voltage-gated sodium channels are triggered to open. Sodium ions enter the muscle fiber, and an action potential rapidly spreads (or "fires") along the entire membrane to initiate excitation-contraction coupling.

Things happen very quickly in the world of excitable membranes (just think about how quickly you can snap your fingers as soon as you decide to do it). Immediately following depolarization of the membrane, it repolarizes, re-establishing the negative membrane potential. Meanwhile, the acetylcholine in the synaptic cleft is degraded by the enzyme acetylcholinesterase (AChE) so that the acetylcholine can no longer bind to an acetylcholine receptor, thereby avoiding unwanted extended muscle excitation and contraction.

Propagation of an action potential along the sarcolemma is still part of the excitation portion of excitation-contraction coupling; it is this excitation that triggers the release of calcium ions from its storage in the cell's sarcoplasmic reticulum. For the action potential to reach the membrane of the SR, there are periodic invaginations that run deep within the sarcolemma, called transverse tubules ([T-tubules](#)). A T-tubule along with SR membranes on either side of it is referred to as a triad (Figure 2). Triads surround and enclose the cylindrical structure known as myofibril, which contains actin and myosin.

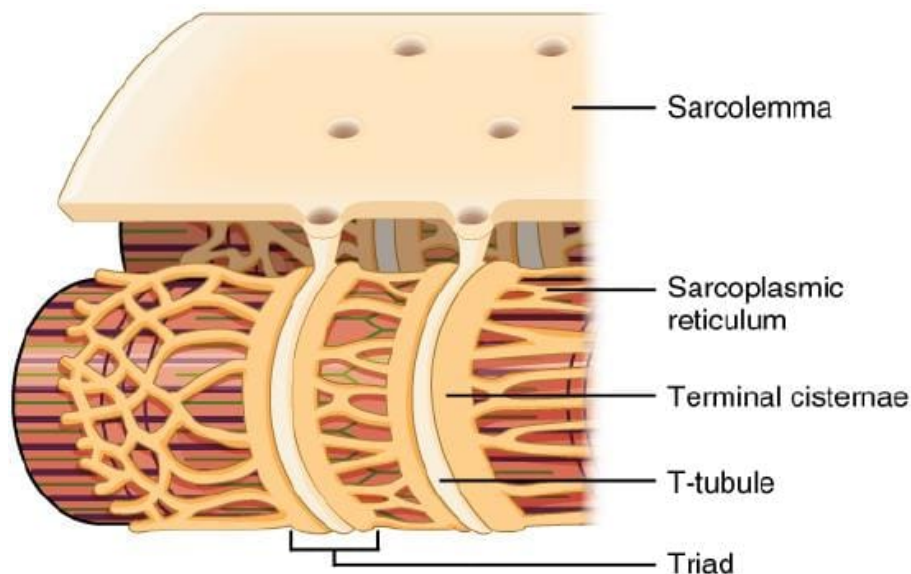


Figure 2. Close up view of T-Tubule. "The T-Tubule" by Douglas College Biology Department is licensed under [CC BY 4.0](#)

Narrow T-tubules permit the conduction of electrical impulses. The SR functions to regulate intracellular levels of calcium. Two terminal cisternae (where enlarged SR connects to the T-tubule) and one T-tubule comprise a triad—a “threesome” of membranes, with those of SR on two sides and the T-tubule sandwiched between them.

T-tubules thus carry the action potential into the interior of the cell. The action potential triggers the opening of calcium channels in the membrane of adjacent SRs, causing calcium ions to diffuse out of the SR and into the sarcoplasm. It is the arrival of Ca^{2+} in the sarcoplasm that initiates contraction of the muscle fiber by its contractile units, or sarcomeres.

Skeletal Muscle Fiber Contraction and Relaxation

Once again, the sequence of events that result in the contraction of an individual muscle fiber begins with an electrical signal – an action potential – traveling down a motor neuron innervating the muscle fiber. Calcium’s role in initiating the release of acetylcholine from the synaptic end bulb has already been described.

When acetylcholine reaches the muscle fiber’s sarcolemma, it binds to closed acetylcholine-gated ion channels that now open as a result. In the area where these ion channels open, the sarcolemma of the muscle fiber will depolarize as positively charged sodium ions (Na^+) enter, triggering an action potential that spreads to the rest of the sarcolemma. The whole sarcolemma will depolarize, including the T-tubules.

Embedded in the walls of the T-tubules of skeletal muscle fibers are voltage-sensitive proteins that are connected to calcium channels in the membrane of the adjacent sarcoplasmic reticulum (SR). When the action potential travels along each T-tubule, the voltage-sensitive proteins there change shape, pulling on the calcium channels of the SR and opening them. This allows Ca^{2+} ions to be released from their storage in the SR (where their concentration is higher), out to the cytosol (sarcoplasm) of the muscle fiber. The Ca^{2+} ions then initiate contraction, which is sustained by ATP (Figure 3).

Troponin and **tropomyosin** are the two major proteins that regulate skeletal muscle contraction via Ca^{2+} ions binding. Tropomyosin is a long, rod-like molecule which shields (blocks) the myosin-binding sites on actin. Troponin, which has a binding site for Ca^{2+} , is a globular protein whose role is to keep the longer tropomyosin in its place.

Upon binding of Ca^{2+} to troponin, troponin changes its conformation (overall three-dimensional shape) and loses its hold on tropomyosin, thereby exposing the myosin-binding sites on actin.

Therefore, as long as calcium ions remain in the sarcoplasm to bind to troponin, which in turn keeps the myosin-binding sites on actin “unshielded,” and as long as ATP is available to drive the cross-bridge cycling and the pulling of **actin** strands by **myosin**, the muscle fiber will continue to shorten to an anatomical limit.

Muscle contraction usually stops when signaling from the motor neuron ends, which repolarizes the sarcolemma and T-tubules,

and closes the voltage-gated calcium channels in the SR. Calcium ions are then pumped back into the SR, which causes the tropomyosin to re-cover the binding sites on the actin strands. A muscle also can stop contracting when it runs out of ATP and becomes fatigued (Figure 4).

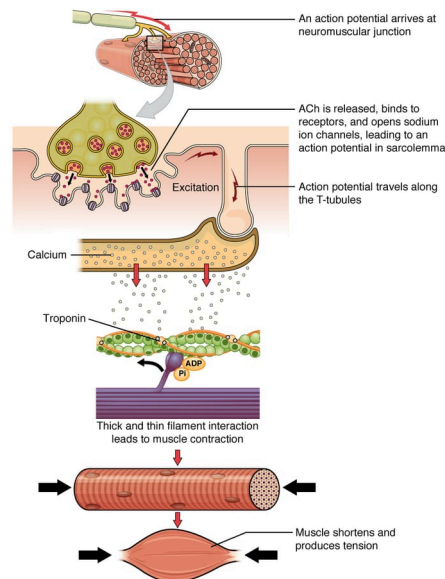


Figure 3. Demonstration of ACh release causing muscle contraction. "Contraction of a Muscle Fiber" by Douglas College Biology Department is licensed under CC BY 4.0

A cross-bridge forms between actin and the myosin heads triggering contraction. As long as Ca^{2+} ions remain in the sarcoplasm to bind to troponin, and as long as ATP is available, the muscle fiber will continue to shorten.

The molecular events of muscle fiber shortening occur within the fiber's sarcomeres (Figure 5). The contraction of a striated muscle fiber occurs as the sarcomeres, linearly arranged within myofibrils, shorten as myosin heads pull on the actin filaments.

The region where thick and thin filaments overlap has a dense appearance, as there is little space between the filaments. This zone, where thin and thick filaments overlap, is very important to muscle contraction, as it is the site where filament movement starts. Thin filaments, anchored at their ends by the Z-discs, do not extend completely into the central region that only contains thick filaments, which are themselves anchored at their bases at a spot called the M-line. A myofibril is composed of many sarcomeres running along its length; thus, myofibrils and muscle cells shorten (contract) as the sarcomeres contract.

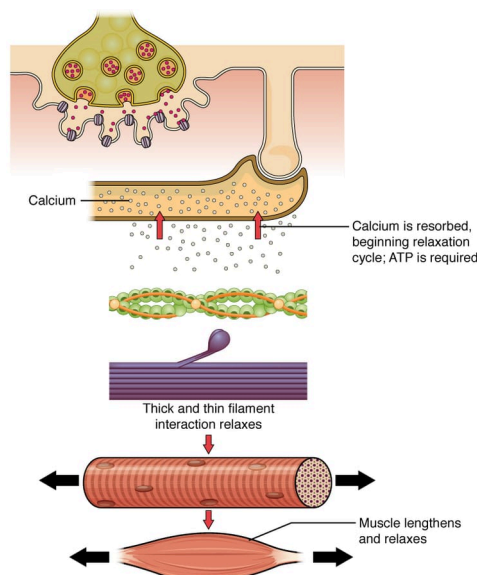


Figure 4. Demonstration of calcium's role in relaxing muscle tension. "Relaxation of a Muscle Fiber" by Douglas College Biology Department is licensed under CC BY 4.0

Calcium ions are pumped back into the SR, which causes the tropomyosin to block the binding sites on the actin strands. A muscle may also stop contracting when it runs out of ATP and becomes fatigued.

The **sliding filament model of contraction**: When signaled by a motor neuron, a skeletal muscle fiber contracts as the thin filaments are pulled and then slide past the thick filaments within the fiber's sarcomeres. This process is known as the sliding filament model of muscle contraction (Figure 5). The sliding can only occur when myosin-binding sites on the actin filaments are exposed by a series of steps that begins with Ca^{2+} entry into the sarcoplasm.

Recall that to initiate muscle contraction, tropomyosin has to expose the myosin-binding site on an actin filament to allow cross-bridge formation between the actin and myosin microfilaments. The first step in the process of contraction is for Ca^{2+} to bind to troponin so that tropomyosin can slide away from the binding sites on the actin strands. This allows the myosin heads to bind to these exposed binding sites and form cross-bridges. The thin filaments are then pulled by the myosin heads to slide past the thick filaments toward the center of the sarcomere. But each head can only pull a very short distance before it has reached its limit and must be "re-cocked" before it can pull again, a step that requires ATP.

For thin filaments to continue to slide past thick filaments during muscle contraction, myosin heads must pull the actin at the binding sites, detach, re-cock, attach to more binding sites, pull, detach, re-cock, etc. This repeated movement is known as the cross-bridge cycle.

Each cross-bridge cycle requires energy, which is provided by ATP.

Cross-bridge formation occurs when the myosin head attaches to the actin while adenosine diphosphate (ADP) and inorganic phosphate (P_i) are still bound to myosin (Figure 6a,b). P_i is then released, causing myosin to form a stronger attachment to actin, after which the myosin head moves toward the M-line, pulling the actin along with it, and releasing the ADP. As actin is pulled, the filaments move approximately 10 nm toward the M-line. This movement is called the power stroke, as movement of the thin filament occurs at this step (Figure 6c). In the absence of ATP, the myosin head will not detach from actin.

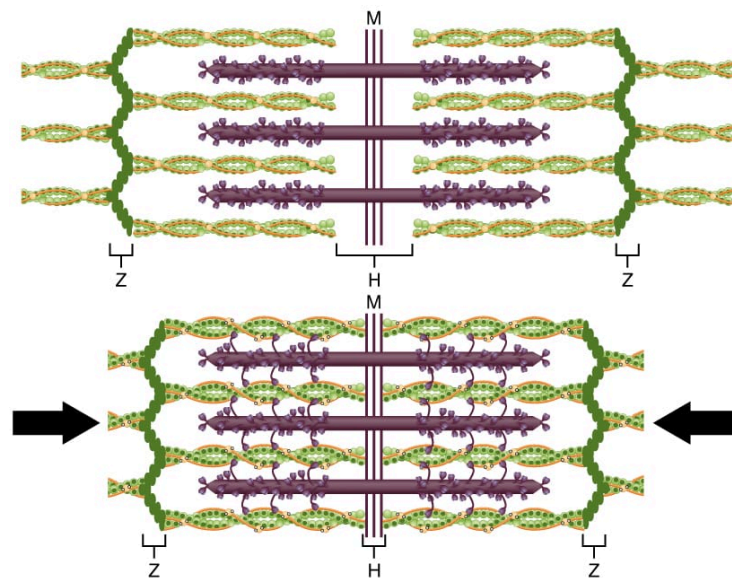


Figure 5. A close up drawing of how muscle contracts. "The Sliding Filament Model of Muscle Contraction" by Douglas College Biology Department is licensed under CC BY 4.0

When a sarcomere contracts, the Z lines move closer together, and the I band (only the portion of actin filaments not overlapping with myosin filaments) becomes smaller. The A band (the length of the myosin filaments) stays the same width. At full contraction, the thin and thick filaments overlap.

One part of the myosin head attaches to the binding site on the actin, but the head has another binding site for ATP. ATP binding causes the myosin head to detach from the actin (Figure 6d).

After this occurs, ATP is converted to ADP and P_i by the intrinsic ATPase activity of myosin. The energy released during ATP hydrolysis changes the angle of the myosin head into a cocked position (Figure 6e). When the myosin head is cocked, it is said to be in a high-energy configuration and is capable of further movement as long as ATP is available.

Note that each thick filament of roughly 300 myosin molecules has multiple myosin heads, and many cross-bridges form and break continuously during muscle contraction. Multiply this by all the sarcomeres in one myofibril, all the myofibrils in one muscle fiber, and all of the muscle fibers in one skeletal muscle, and you can understand why so much energy (ATP) is needed to keep skeletal muscles working. In fact, it is the loss of ATP that results in the **rigor mortis** observed soon after someone dies. With no further ATP production possible, there is no ATP available for myosin heads to detach from the actin-binding sites, so the cross-bridges stay in place, causing the rigidity in the skeletal muscles.

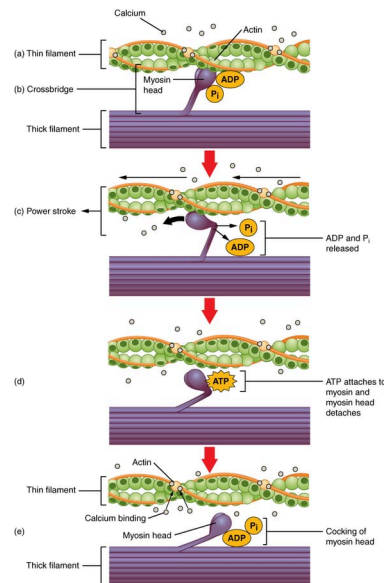


Figure 6. Demonstration of one myosin head using ATP to contract. "Skeletal Muscle Contraction" by Douglas College Biology Department is licensed under [CC BY 4.0](#). (a) The active site on actin is exposed as calcium binds to troponin. (b) The myosin head is attracted to actin, and myosin binds actin at its actin-binding site, forming the cross-bridge. (c) During the power stroke, the phosphate generated in the previous contraction cycle is released. This results in the myosin head pivoting toward the center of the sarcomere, after which the attached ADP is released. (d) A new molecule of ATP attaches to the myosin head, causing the cross-bridge to detach. (e) The myosin head hydrolyzes ATP to ADP and phosphate, which returns the myosin to the cocked position.

ATP supplies the energy for muscle contraction to take place. In addition to its direct role in the cross-bridge cycle, ATP also provides the energy for the active-transport utilizing Ca^{2+} pumps housed in the SR membranes. Muscle contraction does not occur without sufficient amounts of ATP. The amount of ATP stored in muscle is very low, only sufficient to power a few seconds worth of contractions.

Therefore, as it is broken down, ATP must be regenerated and replaced quickly to allow for sustained contraction: ATP can be regenerated through three mechanisms: [creatine phosphate metabolism](#), [anaerobic pathway](#) and [aerobic cellular respiration](#).

(a) Creatine phosphate is a molecule that can store energy in its phosphate bonds. In a resting muscle, excess ATP transfers its energy to creatine, producing ADP and creatine phosphate. This acts as an energy reserve that can be used to quickly create more ATP. When the muscle starts to contract and needs energy, creatine phosphate transfers its phosphate back to ADP to form ATP and creatine. This reaction is catalyzed by the enzyme creatine kinase and occurs very quickly; thus, creatine phosphate-derived ATP powers the first few seconds of muscle contraction. However, creatine phosphate can only provide approximately 15 seconds worth of energy, at which point another energy source must be used (Figure 7).

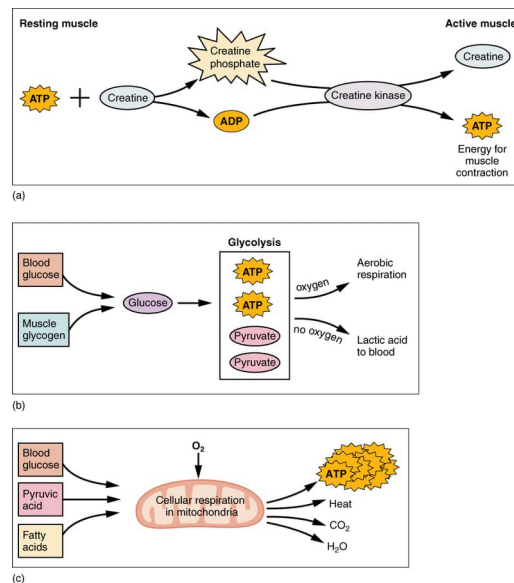


Figure 7. Detailed diagram of muscle metabolism. "Muscle Metabolism" by Douglas College Biology Department is licensed under [CC BY 4.0](#)

(a) Some ATP is stored in a resting muscle. As contraction starts, it is used up in seconds. More ATP is generated from creatine phosphate for about 15 seconds. (b) Each glucose molecule produces two ATP and two molecules of pyruvic acid, which can be used in aerobic respiration or converted to lactic acid. If oxygen is not available, pyruvic acid is converted to lactic acid, which may contribute to muscle fatigue. This occurs during strenuous exercise when high amounts of energy are needed but oxygen cannot be sufficiently delivered to muscle. (c) Aerobic respiration is the breakdown of glucose in the presence of oxygen (O₂) to produce carbon dioxide, water, and ATP. Approximately 95 percent of the ATP required for resting or moderately active muscles is provided by aerobic respiration, which takes place in mitochondria.

(b) The Anaerobic Pathway: As the ATP produced by creatine phosphate is depleted, muscles turn to glycolysis as an ATP source. Glycolysis is an anaerobic (non-oxygen-dependent) process that breaks down glucose (sugar) to produce ATP. Because glycolysis cannot generate ATP as quickly as creatine phosphate, the switch to glycolysis results in a slower rate of ATP availability to the muscle. The sugar used in glycolysis can be provided by blood glucose or by metabolizing glycogen that is stored in the muscle. The breakdown of one glucose molecule produces two ATP and two molecules of pyruvic acid, which can be used either in aerobic respiration if sufficient oxygen is available, or when oxygen levels are low, converted to lactic acid (Figure 7b).

The lactic acid produced may contribute to muscle fatigue but not the burning feeling of tired muscles or muscle soreness. This conversion allows the recycling of the coenzyme NAD⁺ from NADH, which is needed for glycolysis to continue. This occurs during strenuous exercise when high amounts of energy are needed but oxygen cannot be sufficiently delivered to muscle. Glycolysis itself cannot be sustained for very long (approximately one minute of muscle activity), but it is useful in facilitating short bursts of high-intensity output. This is because glycolysis does not utilize glucose very efficiently, producing a net gain of two ATPs per molecule of glucose, and the end product of lactic acid.

Critical Thinking

Have you heard of lactic acid before? Why do you think this myth is so pervasive?

(c) Aerobic cellular respiration is the breakdown of glucose or other nutrients in the presence of oxygen to produce carbon dioxide, water, and ATP. Approximately 95 percent of the ATP required for resting or moderately active muscles is provided by aerobic respiration, which takes place in mitochondria. The inputs for aerobic respiration include glucose circulating in the bloodstream, pyruvic acid, and fatty acids. Aerobic respiration is much more efficient than anaerobic glycolysis, producing approximately 32 to 34 ATPs per molecule of glucose versus two (net) from glycolysis. However, aerobic respiration cannot be sustained without a steady supply of O₂ to the skeletal muscle (Figure 7c). To compensate, muscles store a small amount of excess oxygen in a protein called [myoglobin](#), allowing for more efficient muscle contractions and less fatigue. Aerobic training also increases the efficiency of the circulatory system so that O₂ can be supplied to the muscles for longer periods of time.

Relaxing skeletal muscle fibers begins with the motor neuron, which stops releasing its chemical signal, acetylcholine, into the synapse at the neuromuscular junction. The muscle fiber will repolarize, which closes the gates in the SR where Ca²⁺ was being released. ATP-driven pumps will move Ca²⁺ out of the sarcoplasm back into the SR. Ca²⁺ no longer binds to troponin, resulting in the covering of the myosin-binding sites on the thin filaments by tropomyosin, which is now once again held in its place by

troponin. Without the ability to form cross-bridges between the thin and thick filaments, the muscle fiber loses its tension and relaxes.

Skeletal muscles are rarely completely relaxed, or flaccid. Even if a muscle is not producing movement, it is contracted a small amount to maintain its contractile proteins and produce muscle tone. This continuous partial contraction of a muscle that causes the muscle to resist passive stretching while at rest is referred to as muscle tone. The tension produced by muscle tone allows muscles to continually stabilize joints and maintain posture.

Muscle tone is accomplished by a complex interaction between the nervous system and skeletal muscles that results in the activation of a few motor units at a time, most likely in a cyclical manner. In this manner, muscles never fatigue completely, as some motor units can recover while others are active.

The absence of the low-level contractions that lead to muscle tone is referred to as hypotonia or atrophy and can result from damage to parts of the central nervous system, such as the cerebellum, or from loss of innervations to a skeletal muscle, as in poliomyelitis. Hypotonic muscles have a flaccid appearance and display functional impairments, such as weak reflexes or flaccid paralysis, where a person loses the ability to move affected muscles of the body. Conversely, excessive muscle tone is referred to as hypertonia, accompanied by hyperreflexia (excessive reflex responses), often the result of damage to upper motor neurons (found in the cerebral cortex and brainstem) of the central nervous system. Hypertonia can present with muscle rigidity (as seen in [Parkinson's disease](#)) or spasticity, a phasic change in muscle tone, where a limb will “snap” back from passive stretching (as seen in some strokes). Severe cases of this condition can lead to a specific type of paralysis, called spastic paralysis.

Physical training alters the appearance of skeletal muscles and can produce changes in muscle performance. Conversely, a lack of use can result in decreased performance and muscle appearance. Although muscle cells can change in size, new cells are not formed when muscles grow. Instead, structural proteins are added to muscle fibers in a process called hypertrophy, so cell diameter increases. The reverse, when structural proteins are lost and muscle mass decreases, is called atrophy. Age-related muscle atrophy is called [sarcopenia](#). Cellular components of muscles can also undergo changes in response to changes in muscle use.

Although [atrophy](#) due to disuse can often be reversed with exercise, muscle atrophy can also be the result of any of a number of genetic diseases, called muscular dystrophy, that result in increasing weakness of muscles and loss of muscle tissue over time. Although there are medications that can slow muscle degeneration and reduce damage to dying muscle cells, the atrophy due to muscular dystrophy is irreversible. Muscle atrophy with age, referred to as sarcopenia, is also irreversible. This is a primary reason why even highly trained athletes succumb to declining performance with age. This decline is noticeable in athletes whose sports require strength and powerful movements, such as sprinting, whereas the effects of age are less noticeable in endurance athletes such as marathon runners or long-distance cyclists. As muscles age, muscle fibers die, and they are replaced by connective tissue and adipose tissue (Figure 8). Because those tissues cannot contract and generate force as muscle can, muscles lose the ability to produce powerful contractions. The decline in muscle mass causes a loss of strength, including the strength required for posture and mobility. This may be caused by a reduction in FG fibers that hydrolyze ATP quickly to produce short, powerful contractions. Muscles in older people sometimes possess greater numbers of SO fibers, which are responsible for longer contractions and do not produce powerful movements. There may also be a reduction in the size of motor units, resulting in fewer fibers being stimulated and less muscle tension being produced.

Sarcopenia can be delayed to some extent by exercise, as training adds structural proteins and causes cellular changes that can offset the effects of atrophy. Increased exercise can produce greater numbers of cellular mitochondria, increase capillary density, and increase the mass and strength of connective tissue.

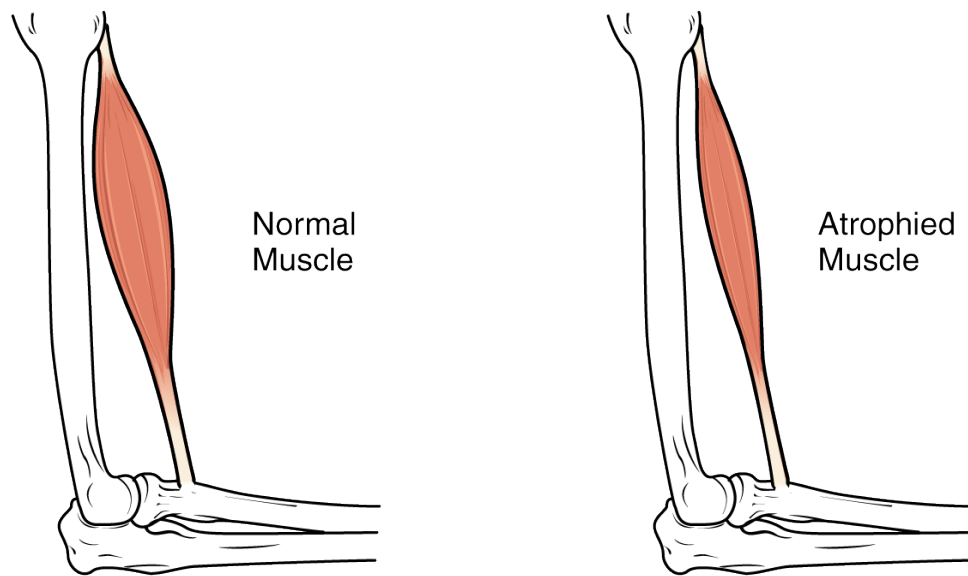


Figure 8. A normal muscle shrinking after atrophy. "Atrophy" by Douglas College Biology Department is licensed under CC BY 4.0

Muscle mass is reduced as muscles atrophy with disuse, such as being immobilized in a cast after a bone break.

The effects of age-related atrophy are especially pronounced in people who are sedentary, as the loss of muscle cells is displayed as functional impairments such as trouble with locomotion, balance, and posture. This can lead to a decrease in quality of life and medical problems, such as joint problems because the muscles that stabilize bones and joints are weakened. Problems with locomotion and balance can also cause various injuries due to falls.

Cardiac muscle tissue is only found in the heart. Highly coordinated contractions of cardiac muscle pump blood into the vessels of the circulatory system. Similar to skeletal muscle, cardiac muscle is striated and organized into sarcomeres, possessing the same banding organization as skeletal muscle (Figure 9). However, cardiac muscle fibers are shorter than skeletal muscle fibers and usually contain only one nucleus, which is in the central region of the cell. Cardiac muscle fibers, similarly to skeletal muscle fibers, also possess many mitochondria and myoglobin, as ATP is produced primarily through aerobic metabolism. Cardiac muscle fiber cells are also extensively branched and are connected to one another at their ends by intercalated discs. An intercalated disc allows the cardiac muscle cells to contract in a wave-like pattern so that the heart can work as a pump.

Intercalated discs are part of the sarcolemma and contain two structures important in cardiac muscle contraction: gap junctions and desmosomes. A gap junction forms channels between adjacent cardiac muscle fibers that allow the depolarizing current produced by cations to flow from one cardiac muscle cell to the next. This joining is called electric coupling (as opposed to excitation-contraction coupling), and in cardiac muscle it allows the quick transmission of action potentials and the coordinated contraction of the entire heart. This network of electrically connected cardiac muscle cells creates a functional unit of contraction called a syncytium. The remainder of the intercalated disc is composed of desmosomes. A desmosome is a cell structure that anchors the ends of cardiac muscle fibers together, so the cells do not pull apart during the stress of individual fibers contracting (Figure 10).

Contractions of the heart (heartbeats) are controlled by specialized cardiac muscle cells called pacemaker cells that directly control heart rate. Although cardiac muscle cannot be consciously controlled, the pacemaker cells respond to signals from the autonomic nervous system to increase or decrease heart rate. The pacemaker cells can also respond to various hormones with the effect of modulating heart rate and thus also controlling blood pressure.

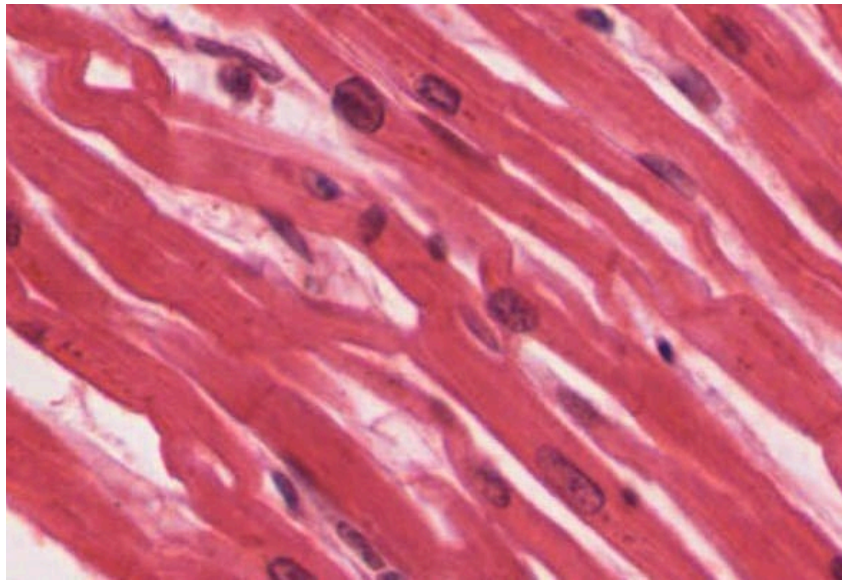


Figure 9. True microscopic view of cardiac muscle. "Cardiac Muscle Tissue" by Douglas College Biology Department is licensed under CC BY 4.0

The functional syncytium (the wave of contraction that allows the heart to work as a unit) begins with the [pacemaker cells](#). This group of cells is self-excitable and able to depolarize to threshold and fire action potentials on their own, a feature called [autorhythmicity](#); they do this at set intervals which determine heart rate. As they are connected with gap junctions to surrounding muscle fibers and the specialized fibers of the heart's conduction system, the pacemaker cells are able to transfer the depolarization to the other cardiac muscle fibers in a manner that allows the heart to contract in a coordinated manner.

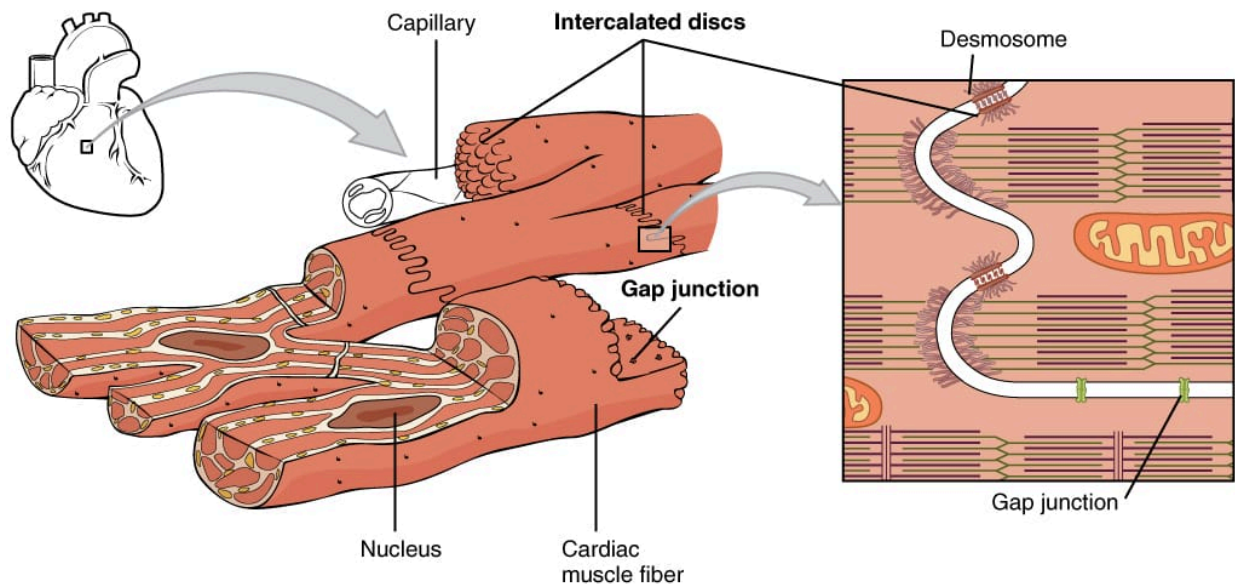


Figure 10. Artistic close-up of cardiac intercalated discs. "Cardiac Muscle" by Douglas College Biology Department is licensed under CC BY 4.0

Intercalated discs are part of the cardiac muscle sarcolemma and they contain gap junctions and desmosomes.

Critical Thinking

After learning in detail how skeletal muscles contract, do you have any new ideas on how or why you might change your personal training or nutritional intake?

In cardiac cells, unlike skeletal muscles, extracellular Ca^{2+} is required to initiate release of calcium from the [sarcoplasmic](#)

reticulum (SR). The SR in cardiac muscle fibers is simpler than that of skeletal muscle fibers, lacking terminal cisterns, and there is no direct physical link between proteins in the T-tubule and proteins in the SR membrane, so depolarization of the T-tubule membrane cannot directly cause Ca^{2+} release from the SR. Instead, cardiac muscle cells have voltage-gated calcium channels in the sarcolemma and along the T-tubules that open when the membrane is depolarized, allowing Ca^{2+} to enter the cardiac muscle fiber from the extracellular fluid. This calcium then causes the opening of calcium-gated calcium channels in the SR membrane that release additional Ca^{2+} into the sarcoplasm. This mechanism allows cardiac muscle to have a relatively long-lasting depolarization “plateau” in its fibers. This sustained depolarization (and Ca^{2+} entry) provides for a longer contraction than is produced by an action potential in skeletal muscle.

Smooth muscle (Figure 11), so named because the cells do not have striations, is present in the walls of hollow organs like the urinary bladder, uterus, stomach, intestines, and in the walls of passageways, such as the arteries and veins of the circulatory system, and the tracts of the respiratory, urinary, and reproductive systems. Smooth muscle is also present in the eyes, where it functions to change the size of the iris and alter the shape of the lens. It is also present in the skin where it causes hair to stand erect in response to cold temperature or fear.

Smooth muscle fibers are spindle-shaped (wide in the middle and tapered at both ends, somewhat like a football) and have a single nucleus; they range from about 30 to 200 μm (thousands of times shorter than skeletal muscle fibers), and they produce their own connective tissue, endomysium. Although they do not have striations and sarcomeres, smooth muscle fibers do have thick and thin filaments composed of myosin and actin contractile proteins. These thin filaments are anchored by dense bodies. A dense body is analogous to the Z-discs of skeletal and cardiac muscle fibers and is tethered, or fastened, to the sarcolemma. Calcium ions are supplied by the sarcoplasmic reticulum (SR) in the fibers and by sequestration from the extracellular fluid through membrane indentations called caveolae.

Because smooth muscle cells do not contain troponin, cross-bridge formation is not regulated by the troponin-tropomyosin complex but instead by the regulatory protein calmodulin. In a smooth muscle fiber, external calcium ions passing through opened calcium channels in the sarcolemma, and additional Ca^{2+} released from SR, bind to **calmodulin**. The Ca^{2+} -calmodulin complex then activates an enzyme called myosin (light chain) kinase, which, in turn, activates the myosin heads by **phosphorylating** them (converting ATP to ADP and P_i , with the P_i attached to the head). The myosin heads can then attach to actin-binding sites and pull on the thin filaments. The thin filaments are anchored to the dense bodies, which also have cord-like intermediate filaments attached to them. In fact, intermediate filaments appear as a network throughout the sarcoplasm and are connected to each other through dense bodies. Thus, as the thin filaments slide past the thick filaments, they pull on the dense bodies, which in turn pull on the network of intermediate filaments throughout the sarcoplasm. This arrangement causes the entire muscle fiber to contract in a manner which sees its ends being pulled toward the center, causing the midsection to bulge inward, like a corkscrew (Figure 12).

Although smooth muscle contraction relies on the presence of calcium ions, smooth muscle fibers have a much smaller diameter than skeletal muscle cells. Smooth muscle fibers have a limited calcium-storing SR but have calcium channels in the sarcolemma (like cardiac muscle fibers) that open during the action potential along the sarcolemma. The influx of extracellular calcium ions, which diffuse into the sarcoplasm to reach the calmodulin, accounts for most of the Ca^{2+} that triggers contraction of a smooth muscle cell.

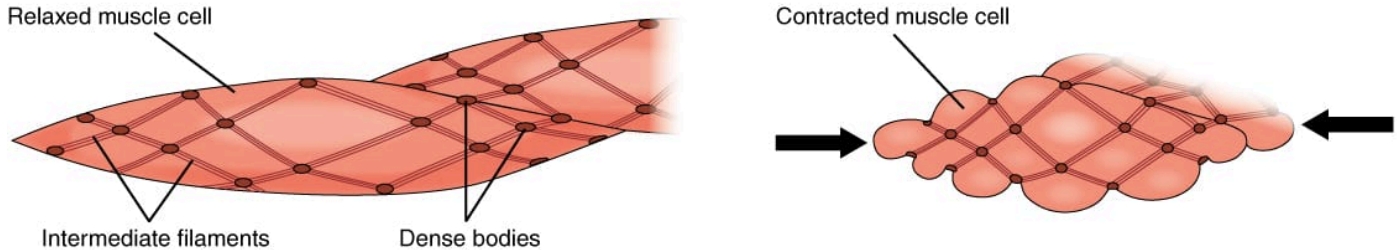
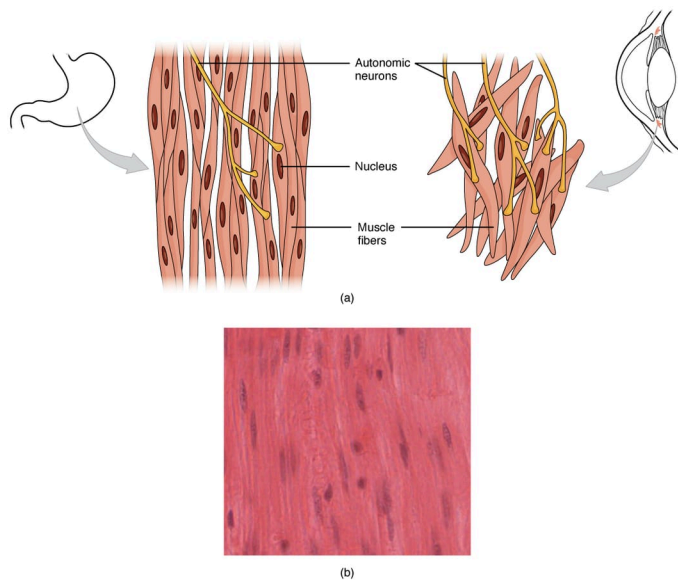


Figure 11. Drawing and microscopic view of smooth muscle tissue. "Smooth Muscle Contraction" by Douglas College Biology Department is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)

The dense bodies and intermediate filaments are networked through the sarcoplasm, which cause the muscle fiber to contract.

Muscle contraction continues until ATP-dependent calcium pumps actively transport calcium ions back into the SR and out of the cell. However, a low concentration of calcium remains in the sarcoplasm to maintain muscle tone. This remaining calcium keeps the muscle slightly contracted, which is important in certain tracts and around blood vessels.

Because most smooth muscles must function for long periods without rest, their power output is relatively low, but contractions can continue without using large amounts of energy. Some smooth muscles can also maintain contractions even as Ca^{2+} is removed and myosin kinase is inactivated/dephosphorylated. This can happen because a subset of cross-bridges between myosin heads and actin, called latch-bridges, keep the thick and thin filaments linked together for a prolonged period, and without the need for ATP. This allows for the maintaining of muscle "tone" in smooth muscle that lines arterioles and other visceral organs with very little energy expenditure.

Smooth muscle is not under voluntary control; thus, it is called involuntary muscle. The triggers for smooth muscle contraction include hormones, neural stimulation by the autonomic nervous system, and local factors like localized histamine release and pH levels.

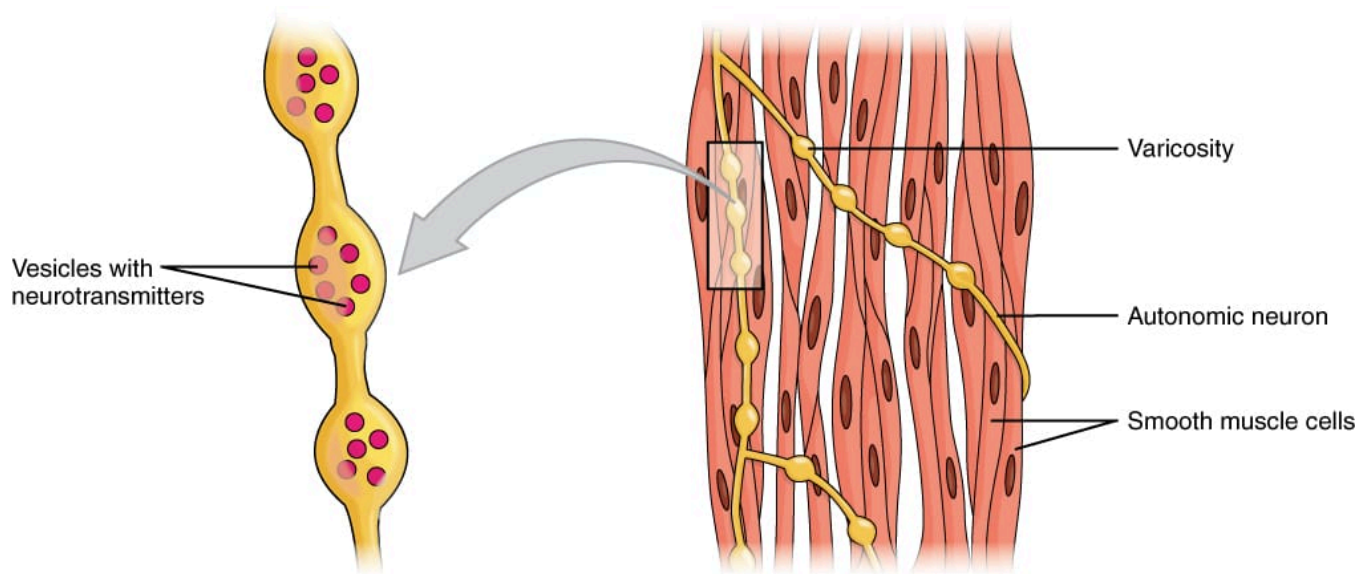


Figure 12. Drawing of autonomic neurons in smooth muscle. "Motor Units" by Douglas College Biology Department is licensed under [CC BY 4.0](#)

A series of axon-like swelling, called varicosities or “boutons,” from autonomic neurons form motor units through the smooth muscle.

Different autonomic nerves release various neurotransmitters on smooth muscle. For example, some nerves release acetylcholine that causes contraction of smooth muscle around some respiratory ducts and thus constriction of these airways. Other nerves release norepinephrine that causes relaxation of smooth muscle and thus widening of the airways. The same neurotransmitter can even cause opposite effects depending partly on the tissue where it acts and/or the variant of neurotransmitter receptor on target cells. Although norepinephrine causes relaxation of smooth muscle and thus widening of some airways, it also causes contraction of smooth muscle and thus constriction of most blood vessels. Autonomic neurons innervating smooth muscle release their neurotransmitters from swellings along their axons, called varicosities, that tend to result in less specific localization of the released neurotransmitter than at a neuromuscular junction (Figure 12).

Several hormones also affect the activity of smooth muscles, either by encouraging contraction or relaxation. For example, in the digestive system, cholecystokinin induces relaxation of the smooth muscle around the hepatopancreatic sphincter causing it to open. Conversely, gastrin stimulates contraction of smooth muscle in the stomach to enhance the churning activity of the stomach. Within the reproductive system, [oxytocin](#) stimulates uterine smooth muscle contraction to facilitate childbirth.

Smooth muscle arranged in layers around a hollow organ generally produces slow, steady contractions known as peristalsis that allow substances, such as food in the digestive tract, to move through the body. One layer of smooth muscle is parallel to the longitudinal axis of the lumen and the other layer is wrapped around the lumen in a circular fashion. A third layer of longitudinal muscle ([ureters](#)) or obliquely arranged muscle (stomach) is present in some organs. This action and arrangement of smooth muscle layers causes mixing and/or unidirectional propulsion of materials through the lumen. Movement of substances through lumens by peristalsis occurs in some organs (uterus, urinary bladder, esophagus, stomach, small and large intestines) and ducts (ureters, uterine tubes, vas deferens, bile ducts).

Smooth muscle is found throughout the body around various organs and tracts. Smooth muscle cells have a single nucleus and are spindle shaped. Smooth muscle cells are non-striated, but their sarcoplasm is filled with actin and myosin, along with dense bodies in the sarcolemma to anchor both thin filaments as well as a network of intermediate filaments, which during contraction, are together involved in pulling the sarcolemma toward the fiber's middle, shortening it in the process.

If learning about the physiology of the human body is of interest to you, you may want to consider focusing on an exercise science or exercise physiology [degree](#) and career. Many schools will have programs for [exercise science](#), often thought of as the core of a kinesiology foundation.

Chapter 7 will transition into physical education and pedagogy, once thought of as all kinesiology was.

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1.7: Physical Education and Pedagogy

Learning Objectives

1. Be able to describe what pedagogy is.
2. List 3 ways a student may be more motivated to participate in PE
3. To be able to create an inclusive PE lesson plan.

Physical education (PE) is often looked down on by other professionals in the education world because they mistakenly think that PE is monitored recess, requiring no thought or skill as a teacher. They could not be more wrong.

Successfully motivating young children to be physically active while teaching complex motor skills oftentimes with limited and minimal equipment could be the hardest thing in kinesiology.

Critical thinking

As a college student taking kinesiology classes you likely enjoyed PE in middle school and high school. Reflect on what you liked about it, what you think could have been improved, and importantly why do you think some of your classmates did not like PE classes.

Pedagogy, the method by which teachers or coaches teach theories, concepts, and movements is included in college-level physical education curricula. It is important to understand the method of how things are explained and why that method is used. It is the development of how to become a good teacher or coach. An Olympic heptathlete may be a phenomenal athlete but without pedagogical education, they may not be a good coach to upcoming athletes because they cannot accurately or efficiently transfer knowledge to their students. Content knowledge and usually experience playing the sport is also critical for the ability of a teacher to teach. In upper-division college pedagogy classes, much of the class time is spent actively playing sports to allow future teachers the experience to understand and adjust drills or sports rules to allow for learning in their classes. If a person has never played lacrosse, it will be hard for them to design a lesson to teach a student how to throw a lacrosse ball using a lacrosse stick. This activity content knowledge becomes even more important when a teacher needs to adjust or modify standard drills quickly to account for students struggling with the concept or picking up the skills quickly.

Physical Education was first deemed an academic discipline in 1964 by Franklin Henry for collegiate study, but the inclusion of physical activity and education in an academic school setting dates to at least 386 BC. Plato included physical lessons on wrestling and boxing at his school named Akademia starting at age 7.

As previously discussed, countries have used physical education classes to prepare their boys for the physical requirements of war. After the American Civil War, many states passed laws requiring schools to include physical education programs. This theme continued when a third of all military recruits were declared physically unfit for combat during World War 1.

By World War II physical education for men and women had become common in American schools and President Roosevelt introduced the National School Lunch program to help improve school children's nutritional intake.

In more current times PE classes are being cut or reduced across the nation to allow students more time to focus on academic pursuits. Many students are not meeting the **recommended** 60 minutes of aerobic activity per day due to these PE class reductions and cultural changes away from a lot of outdoor play at home. Physical activity during school hours is associated with many positive benefits for students including **on-task behavior**, **academic achievement**, and **cognitive functions**. This is also correlated with **increased childhood obesity**. A PE teacher will have to be the student's #1 advocate for the importance of physical activity. Working with school administration to retain or extend PE hours will be a constant part of the job.

With limited time, **limited funding**, and likely limited respect at grade school, a PE teacher's job can be very difficult, but essential and if efficiently managed a great benefit for the students.

The old stereotypical PE teacher of dodgeball tournaments and just rolling a cart of basketballs into the gym to let the students is

how PE earned a bad name, and the goal of modern PE teachers should be to create an inclusive educational setting for students to learn and develop physical skills and fitness.

There are many concepts to overcome in PE to create an ideal lesson for students to learn and be physically active, here are a few:

Skill or fitness differences: With a large class of students there will be a range of preexisting skill abilities, fitness levels, and enthusiasm. **Kinesthetic sense** is the ability of a person to effectively understand how their body is positioned and moving in space relative to other parts of their body or equipment. Development of a student's kinesthetic sense with movement and skill drills will improve how the student performs difficult abilities across multiple sports. A high level of kinesthetic sense is usually what makes some people more "athletic" than others.

Increasing students' enthusiasm to participate in physical activity can be challenging. There are a lot of unseen social pressures that students will try to adhere to. What if a girl is the best athlete in the class? What if you play so hard that you sweat and smell bad in class after PE? Are students "cool" if they try hard?

Depending on the rules of the school, a few easy ways to increase student motivation is by giving them a bit of responsibility over the social dynamics of the classes. Equally, divide students into long term teams (more on this in the next paragraph) and allow them to pick team names, colors, and a group cheer. Maybe during an art class, they could work together to create a team logo that will hang in the gym. In some sports at older ages, it may be appropriate to alter the rules based on gender, making female participation more valuable to the team's success to encourage full group participation. Without a locker room for changing students should be active enough during lessons to sweat which may cause some social anxiety. This will require some creative thinking between the PE teacher, school administration, and the student's parents for each unique situation.

Students with lower skill or fitness abilities are often pushed to the side by more skilled or fit students that can take over the entire game. This will often cause these marginalized students to lose interest in PE. The PE teacher needs to select teams that equally distribute the higher skill and fitness students between all groups, and redivide teams as needed. There can also be an alteration of rules for all sports and activities. There is no reason that a basketball unit needs to follow the NBA rules. Maybe all the players on a team need to touch the ball before it can be shot for a goal.

It might also be a good idea to not give an exhaustive list of all the rules of any sport (see the ultimate frisbee [rules](#)), focusing on 3 or 4 important rules to make sure the game is played the same by everyone is more important than memorizing all of the rules. Lots of rules can be bent or broken to meet the needs of the PE teacher.

Critical thinking

How would you motivate a middle school PE class during an ultimate frisbee unit? Standard rules here. How would you encourage motivation? How would you select teams? Would you implement any unique rules?

A non-traditional physical education "alternative" that has grown in popularity is Adventure Based Learning ([ABL](#)). ABL is an experiential learning approach that combines outdoor activities, problem-solving, and teamwork to promote personal and group growth. It is a learner-centered, activity-based approach that emphasizes practical and hands-on experiences.

In adventure-based learning, participants are taken out of their comfort zones and placed in novel and challenging situations that require them to work together, communicate effectively, and solve problems collaboratively. The activities are usually designed to be fun and engaging, but also offer opportunities for learning and growth. These activities are usually physical in nature, but not the traditional sports practice for a PE lesson.

Activities in adventure-based learning may include a range of outdoor activities such as rock climbing, camping, canoeing, hiking, and ropes courses. These activities are designed to challenge participants physically, mentally, and emotionally, and often require them to overcome fears, take risks, and work together to achieve a common goal. While a PE teacher may not have access to a rock-climbing course or a river to take students canoeing, very similar outcomes of ABL can be found with activities performed in a school with very low budget costs. Splitting a class of students into a few groups, asking each group to stand on a tarp on the ground and then see how many times they can fold it in half without stepping off the tarp would be an ABL lesson.

The activities in adventure-based learning are usually structured to promote reflection and discussion among participants. This is often facilitated by a trained instructor or facilitator who helps participants debrief their experiences and connect them to broader learning goals. Through reflection and discussion, participants can identify their strengths, areas for improvement, and strategies

for future success.

Benefits of Adventure-Based Learning

Adventure-based learning has been shown to have a range of benefits for participants. These benefits include:

1. **Personal Growth:** Participants in adventure-based learning often report increased self-confidence, self-awareness, and self-esteem as a result of overcoming challenges and achieving goals.
2. **Teamwork and Collaboration:** Adventure-based learning requires participants to work together and communicate effectively to achieve common goals. This can lead to improved teamwork and collaboration skills that can be applied in other areas of life. ABL also allows lower-skilled or fit students to feel like a valuable part of the team leading to greater class participation.
3. **Problem-Solving:** Adventure-based learning activities often require participants to solve problems and make decisions under pressure. This can help develop critical thinking and problem-solving skills.
4. **Physical Fitness:** Many adventure-based learning activities are physically demanding and can promote physical fitness and well-being.
5. **Environmental Awareness:** Adventure-based learning often takes place in outdoor settings, which can help promote environmental awareness and appreciation.

Equipment and participation: One of the largest challenges that may be outside the power of the PE teacher to change is what [equipment](#) and facilities are available to the students during PE. It's pretty hard to teach a swimming unit without a pool. While fundraising or asking for an increased budget may allow the purchase of additional sports equipment it is best to assume that equipment limitations will not allow each student to have their own soccer ball, baseball bat, or badminton racquet.

Lessons need to be planned around what equipment or facilities are available to allow for many touches per student of that equipment. An 11 on 11 full-field soccer match with 1 ball is not an example of a good PE lesson because most of those 22 students will not interact with the ball or [develop any skills](#). A lesson like this will quickly be taken over by the most confident students and most will turn into bystanders. A much better example of a soccer lesson would involve groups of 3 students working together to dribble a ball down a small length of the field before shooting at the soccer goal. Multiple groups could be active at the same time as you “release” each group to go every 10 seconds. If you have a large class, then you could divide the field into two sections left and right and have 2 groups progress down the field every 10 seconds. This adjustment will include many more students in the activity and give each student more touches on the equipment allowing them to develop skills for game time.

Content Knowledge of the sport/activity: It is crucial that a PE have some content knowledge of the activity they plan to teach. How do you hold the hockey stick? What is the “[kitchen](#)” rule in pickleball? Teaching physical movements must come from at least a basic experience of performing those skills oneself so they can be properly explained and demonstrated. This personal experience with the sport is valuable when quickly modifying drills or activities to make them more difficult if a student or group of students is overly successful and becoming bored with the challenge. Or if an activity is more difficult than anticipated and many students are continually failing, how can it be adjusted to make students successful? Finding a balance between what is challenging but still usually achievable will reward student success without making the victory hollow.

How long would a group of students stay motivated shooting layups in basketball? Or how many missed half-court shots would it take to dissuade students from continuing to try?

A typical sport unit in PE could be 4-6 weeks long (depending on how many days per week the students have PE) with most of that time being spent in skill development and practice of the sport. Older students can even practice theory and strategy. Ending a sport unit with a [round robin tournament](#) day can allow for a demonstration of learned skills and teamwork. Knowing that a competitive game is how each unit ends may motivate some students to practice and work hard during the skill development lessons. These competition days should still have modified rules and even teams to encourage as much participation from all students as possible.

The minutes per day and days per week that students can be physically active in PE classes are diminishing, unfortunately. Understanding what is possible with the time available and adjusting the lesson and unit plans to fit within the time restraints is important for developing a K-12 PE program. Hopefully, the school administrative bodies will reverse the trend to minimize school PE programs.

Traditionally PE was “an easy A” if you showed up to class and put some effort in. Today a successful PE teacher should have ways of assessing their students as they learn and develop relevant skills and fitness in each unit. These assessments should be used as a rubric for students to earn their grades rather than a grade being given based on how sweaty a student got during class time.

Here is an example of throwing a ball.

Student Name: _____ Date: _____

Criteria	Excellent	Good	Fair	Poor	Score
Grip	Holds the ball with the correct grip and hand placement	Mostly holds the ball with the correct grip and hand placement	Occasionally holds the ball with the correct grip and hand placement	Incorrectly holds the ball	
Wind-up	Uses a smooth, efficient wind-up to generate power	Mostly uses a smooth, efficient wind-up to generate power	Occasionally uses a smooth, efficient wind-up to generate power	Does not use a wind-up or uses an inefficient wind-up	
Footwork	Uses proper footwork to transfer weight and generate power	Mostly uses proper footwork to transfer weight and generate power	Occasionally uses proper footwork to transfer weight and generate power	Does not use proper footwork or uses incorrect footwork	
Throwing Motion	Throws with a fluid, overhand motion, using the whole body to generate power	Mostly throws with a fluid, overhand motion, using the whole body to generate power	Occasionally throws with a fluid, overhand motion, using the whole body to generate power	Throws with a choppy or awkward motion, using only arm strength	
Accuracy	Throws with consistent accuracy and hits target consistently	Mostly throws with consistent accuracy and hits target mostly consistently	Occasionally throws with consistent accuracy and hits target occasionally	Does not throw with consistent accuracy or misses target frequently	
Total Score					

Comments:

- Excellent: Student consistently demonstrates mastery of the skill and performs at an exceptional level.
- Good: Student demonstrates a solid understanding of the skill and performs well, but may have some areas for improvement.
- Fair: The student demonstrates a basic understanding of the skill but needs more practice and improvement in some areas.
- Poor: The student has difficulty with the skill and needs significant improvement in several areas.

This assessment sheet can be used by the instructor to grade each student's throwing ability based on specific criteria. The instructor can provide feedback to the student on their strengths and areas for improvement and can use the scores to track progress over time.

Critical Thinking

Create your own assessment chart for a skill or movement other than throwing.

Taking all of that into account you will need to design flexible (what if it rains?) daily lesson plans.

Critical Thinking

Here is an example PE lesson plan, what is good what would you change?

Title: Soccer: Dribbling and Passing Fundamentals

Grade Level: Middle School (6th-8th)

Objectives:

- Students will be able to demonstrate proper dribbling and passing techniques in soccer.

- Students will be able to apply these skills in small-sided games.

Materials:

- Soccer balls
- Cones
- Pinnies
- Goals (optional)

Procedure:

1. Introduction (5 minutes)
 - The instructor introduces the lesson by explaining that today's focus will be on the fundamental skills of dribbling and passing in soccer.
 - The instructor reviews the rules of soccer and explains that these skills are essential to playing the game effectively.
2. Skill Development (20 minutes)
 - The instructor demonstrates and explains proper dribbling and passing technique, emphasizing the importance of using the inside of the foot and keeping the ball close to the body while dribbling, and passing the ball with the inside of the foot while aiming for a target.
 - Students practice these skills in pairs, dribbling and passing back and forth to each other while moving around cones or other obstacles.
 - The instructor provides feedback and corrections as necessary.
3. Small-Sided Games (25 minutes)
 - Students are divided into teams and play small-sided games (3v3 or 4v4) on a reduced-size field or grid.
 - The instructor emphasizes the importance of using proper dribbling and passing techniques during the game and encourages students to work together as a team to score goals.
 - The instructor observes the games and provides feedback and corrections as necessary.
4. Cool-Down (5 minutes)
 - Students perform a brief cool-down activity, such as light stretching or walking, to reduce heart rate and prevent injury.

Assessment:

- The instructor assesses students' progress based on their ability to demonstrate proper dribbling and passing technique during the practice activities and small-sided games.
- The instructor may also use a rubric or checklist to assess student's performance on specific skills.

Modification:

- The instructor can modify the difficulty level of the activities based on the skill level of the students.
- For example, beginners may need more practice with basic dribbling and passing skills before playing small-sided games, while more advanced students can be challenged with more complex game situations or drills.

Critical Thinking

Design a lesson plan for your favorite sport. Make variations of the lesson plan for working with children vs skilled adults. Also, how would your lesson plan need to change if you had either unlimited equipment vs minimal equipment (as in how would you teach soccer if you only had 2 soccer balls, or how would a basketball lesson change if you only had one hoop).

Share your lesson plan with a fellow student and discuss why you designed it the way you did.

Moving forward in this career path may also require a teaching credential to teach at a public K-12 school. Different states and private schools could have different requirements so make sure and research the school and local laws at which you would like to work.

Earning a teaching credential is similar to going to graduate school, and a certain amount of student teaching hours are required.

[Here](#) is a quick look at how to earn a teaching credential in California.

Chapter 8 will get us off the field and back into the lab looking at human biomechanics.

1.8: Biomechanics

Learning Objectives

1. Describe each level type.
2. Understand muscle antagonist movement.
3. Describe how human biomechanics may be examined.

Biomechanics is the study of how the body physically moves through the lens of physics and mechanical principles. As such it combines multiple areas of study including biology, physics, engineering, and kinesiology to explain and study how the body moves and responds to internal and external forces. Biomechanics also helps us understand the “how” and “why” in many other fields of kinesiology. Many physical skills can be broken down into physical directions of the body. Imagine writing down the motion of the body of someone throwing a ball.

Some of the key concepts in advanced biomechanics of the human body include

1. **Kinematics**: The study of motion, including linear and angular motion, displacement, velocity, and acceleration.
2. **Kinetics**: The study of forces and their effects on motion, including Newton's laws of motion and the concept of momentum.
3. **Joint mechanics**: The study of the structure and function of joints, including the types of joints, their movements, and the forces acting on them.
4. **Muscle mechanics**: The study of the properties of muscle tissue and their role in generating force and movement.
5. **Biomechanical modeling**: The use of mathematical models and simulations to study and predict movement patterns and forces in the body.
6. **Performance analysis**: The use of biomechanical analysis to evaluate and optimize human performance in sports and other activities.
7. **Injury prevention and rehabilitation**: The use of biomechanical analysis to identify and address factors that contribute to injury, and to design interventions to prevent or treat injuries.

Critical Thinking

Before moving on, what are some ways your understanding of biomechanics would be important for other fields of kinesiology? For example, how would a PE teacher use biomechanics to explain how to kick a soccer ball to a grade school kid?

One of the main goals of biomechanics is to understand the factors that influence movement efficiency and athletic performance. This includes examining the effects of muscle strength, joint range of motion, and other factors on movement like injuries. Biomechanics also study how the body responds to external forces impacting movements like tripping, carrying a weighted backpack, or slippery walking surfaces.

The basics of physics and biomechanics combine understanding movement (review of Chapter 1) and how the physical body works as a system of simple machines (our muscles, bones, and joints from Chapter 5).

Sir Isaac Newton developed three laws of motion that are the foundation of understanding physical movement. Simply stated they are as follows:

1. The Law of Inertia. If a body is at rest or moving, it will remain at rest or moving until acted upon by an outside force.
2. Force is equal to mass x acceleration. This law describes the relationship between something's mass, acceleration, and force.
3. The Law of Action and Reaction. For every action, there is an equal and opposite reaction.

Skeletal muscles do not work by themselves. Muscles are arranged in pairs (**agonist muscle groups**) based on their functions. For muscles **attached** to the bones of the skeleton, the connection determines the force, speed, and range of movement. These characteristics depend on one another and can explain the general organization of the muscular and skeletal systems.

The skeleton and muscles act together to move the body.

Have you ever used the back of a hammer to remove a nail from wood? The handle acts as a lever and the head of the hammer acts as a **fulcrum**, the fixed point that the force is applied to when you pull back or push down on the handle. The effort applied to this system is the pulling or pushing on the handle to remove the nail, which is the resistance to the movement of the handle in the system. The resistance is also sometimes called the load. Our musculoskeletal system works in a similar manner, with bones being stiff levers and the articular endings of the bones, encased in synovial joints, acting as fulcrums. The resistance would be an object or body part being moved, or any resistance to a movement (e.g. your head when you are lifting it). The effort, or applied force, comes from contracting particular skeletal muscles.

The characteristics and operation of a particular lever system are mainly determined by distances and forces. The two opposing forces are effort and resistance. There are two main distances to consider: (1) the effort arm, which is the distance from the fulcrum to the insertion point of the skeletal muscle delivering most of the effort, and (2) the resistance arm, which is the distance between the fulcrum and the bulk of the resistance.

In order for the movement to occur (e.g. when lifting a weight in your hand), the effort produced by one or several muscles needs to overcome the resistance. When the lever system is balanced, the two opposing forces applied at their respective distances from the fulcrum work to maintain a body posture or carry a particular weight without moving it. Thus, in a balanced lever system, the effort times of the effort arm is equal to the resistance times of the resistance arm. This is the basic formula used to calculate relationships between forces and distances in a lever system:

$$\text{Effort} \times \text{Effort arm} = \text{Resistance} \times \text{Resistance arm}$$

Lever systems that can move heavy loads over short distances using little effort are referred to as “power levers”. Conversely, lever systems that can quickly move light loads over large distances using a large amount of effort are referred to as “speed levers”. The location of the insertion point of a muscle (or muscles) delivering the effort relative to the resistance determines whether a lever system operates as a power lever or speed lever. For example, a lever system with a muscle insertion point close to the joint (fulcrum) and a resistance far away from the joint will move a particular object relatively fast over a large distance with a great range of motion. However, the muscle(s) involved need(s) to deliver a large effort for the movement to occur. Another lever system with a resistance close to the fulcrum which is supported by a muscle (or muscles) inserted far away from the fulcrum will require a small effort to support or move the resistance. However, the resistance will only be moved over a short distance and slowly.

Critical Thinking

While moving through the rest of this chapter take periodic breaks and experiment with moving your own body and talking about the concepts with other classmates.

There are several types of lever systems in the body, identified as either first-class, second-class, or third-class levers.

First-class levers are the simplest types of levers, where the two forces, the effort, and the resistance, are applied on opposite sides of the fulcrum (Figure 2). In the body, the best example of a first-class lever is the way your head is raised off your chest (Figure 3). The posterior neck muscles produce the effort, the facial skeleton is the resistance, and the atlantooccipital joint behaves as the fulcrum.

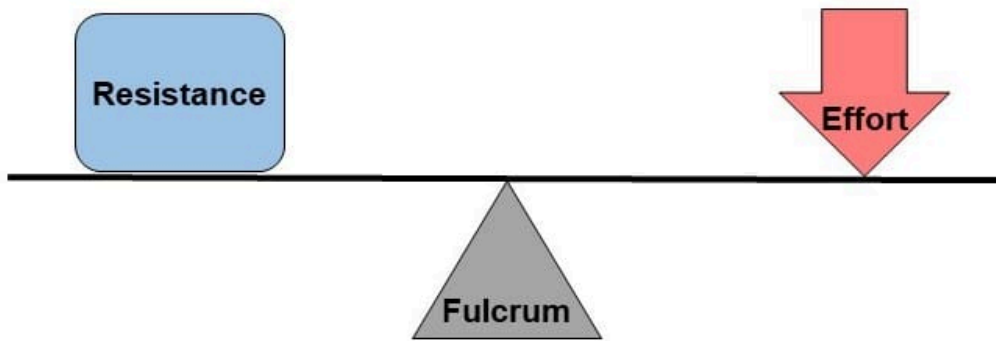


Figure 1: Resistance being balanced by equal effort across a fulcrum. "First Class Lever" by Douglas College Biology Department is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)

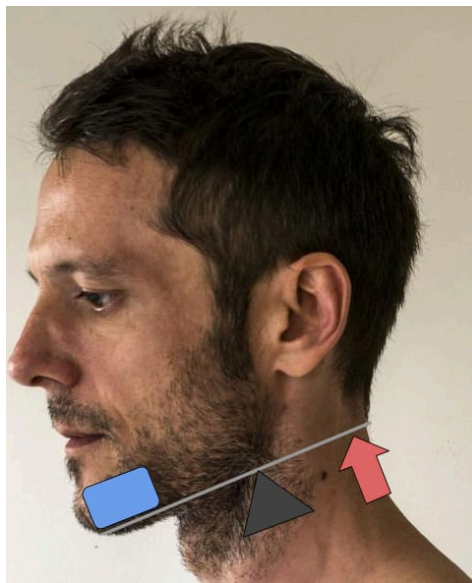


Figure 3. Graphical overlay showing a first class lever system in the human neck. First-class lever as seen in the body. (credit: sarahmckinnon/flickr.com, original image: celtibere/pixabay.com)

Second-class levers have resistance between the effort and the fulcrum (Figure 4). The effort is closer to the resistance than the fulcrum, which allows a large resistance to be moved by a small amount of effort. However, this means that the resistance will be moved at a relatively slow pace, and can only be moved a short distance. Any time you stand up on your toes, as shown in Figure 5, you are using a second-class lever. The weight of your body acts as the resistance, your calf muscles produce the effort, and the joints in the balls of your feet act as fulcrums.

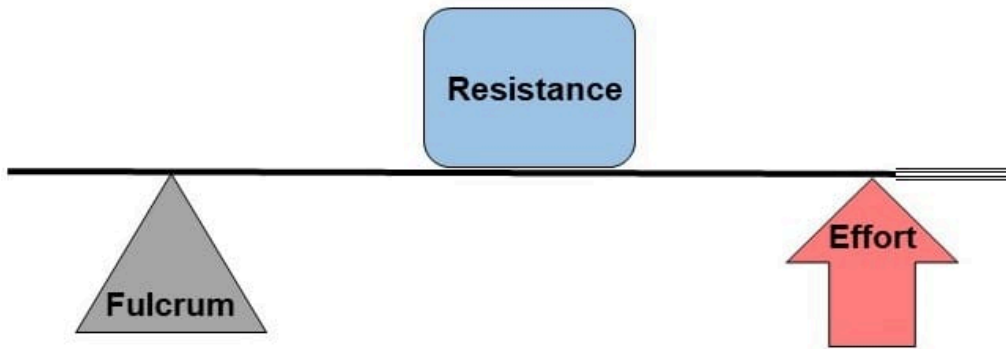


Figure 4. Resistance being held up by effort. "Second Class Lever" by Douglas College Biology Department is licensed under [CC BY 4.0](#)

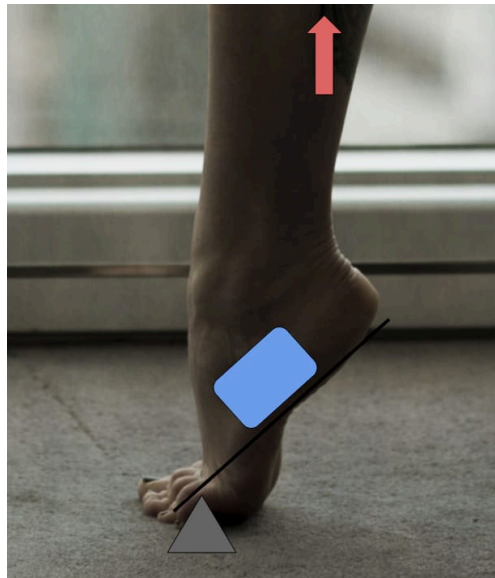


Figure 5. Graphical overlay showing a second class lever system in the human ankle. (credit: sarahmckinnon/flickr.com, original image: thenarratographer/flickr.com)

Third-class levers are the most common type of lever in your body (Figure 6). The effort is applied between the fulcrum and the resistance, which allows the resistance to be moved relatively quickly over large distances. When you lift your hand by flexing your biceps brachii, you are using a third-class lever. The elbow joint acts as the fulcrum, the biceps brachii produces the effort, and the weight of your hand is the resistance being lifted (Figure 7).

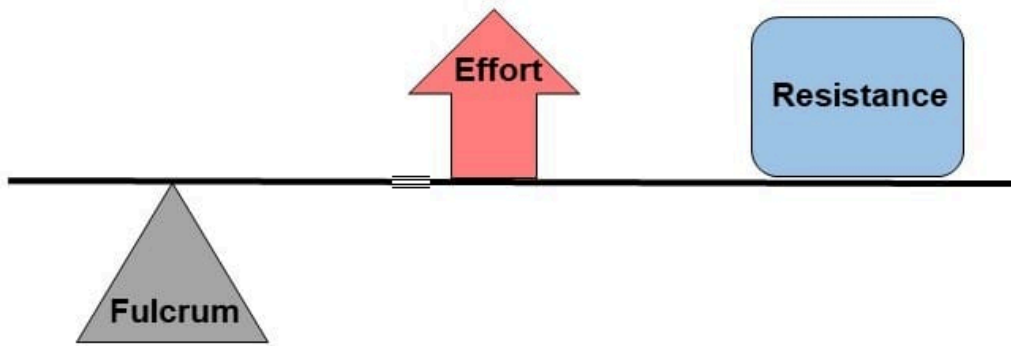


Figure 6. Effort pulling resistance up. "Third Class Lever" by Douglas College Biology Department is licensed under CC BY 4.0

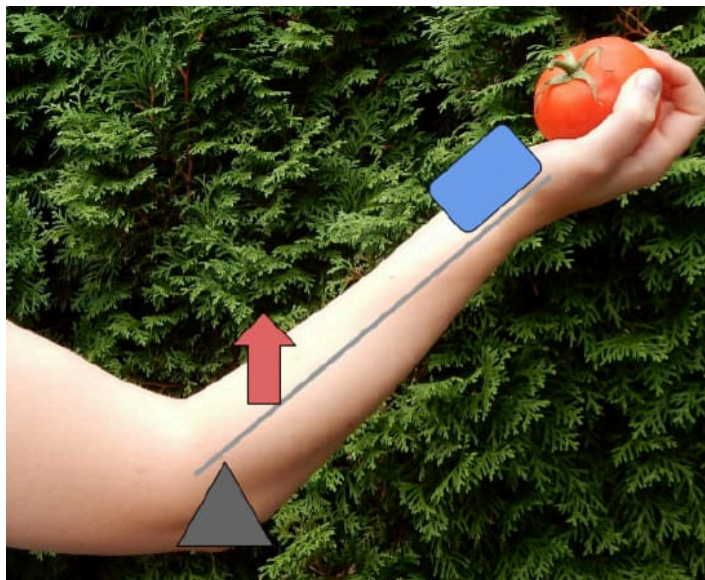


Figure 7. Graphical overlay showing a third class lever system in the human elbow. (credit: sarahmckinnon/flickr.com)

To move the skeleton, the tension created by the contraction of the fibers in most skeletal muscles is transferred to the tendons. The tendons are strong bands of dense, regular connective tissue that connect muscles to bones. The bone connection is why this muscle tissue is called skeletal muscle.

To pull on a bone, that is, to change the angle at its synovial joint, which essentially moves the skeleton, a skeletal muscle must be attached to a fixed part of the skeleton. The moveable end of the muscle which attaches to the bone being pulled is called the muscle's **insertion**, whereas the end of the muscle attached to a fixed (stabilized) bone is called the origin.

Watch this [video](#) on how proper use of levers and fulcrum arms can improve human movement.

Muscular Antagonism

Although a number of muscles may be involved in an action, the principal muscle involved is called the prime mover, or **agonist**. To lift a cup, a muscle called the biceps brachii is the prime mover; however, because this muscle can be assisted by the brachialis, the brachialis is called a synergist in this action (Figure 1). A synergist can also be a fixator that stabilizes the bone that is the attachment for the prime mover's origin.

A muscle with the opposite action of the prime mover is called an antagonist. Antagonists play two important roles in muscle function: (1) they maintain body or limb position, such as holding the arm out or standing erect; and (2) they control rapid movement as in shadow boxing without landing a punch, and thereby check the motion of a limb.

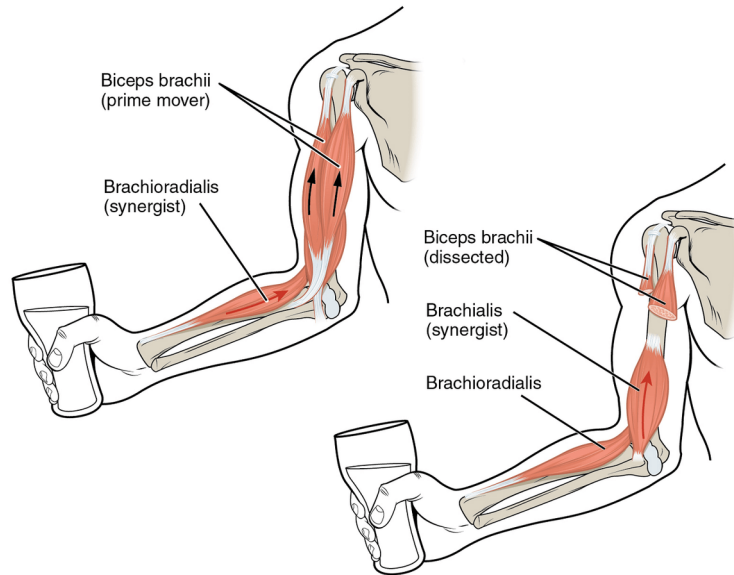


Figure 1. Drawing of how the arm lifts a glass of water. "Prime Movers and Synergists" by Douglas College Biology Department is licensed under CC BY 4.0

The biceps brachii flexes the lower arm. The brachioradialis, in the forearm, and brachialis, located deep to the biceps brachii in the upper arm, are both synergists that aid in this motion.

For example, to extend the knee, a group of four muscles called the quadriceps femoris in the anterior compartment of the thigh is activated. These muscles would be called the agonists of knee extension. However, to flex the knee, an opposite or antagonistic set of muscles called the hamstrings is activated. Flexing the knee involves the hamstrings muscles as the agonists and the quadriceps femoris muscles as the antagonists. As you can see, the terms agonist and antagonist are associated with a particular movement, and these terms can be reversed for opposing movements. See Table 1 for a list of some common agonists and antagonists.

Agonist	Antagonist	Movement
Biceps brachii (in the anterior compartment of the arm)	Triceps brachii (in the posterior compartment of the arm)	The biceps brachii flexes the forearm, whereas the triceps brachii extends it
Hamstrings (group of three muscles in the posterior compartment of thigh)	Quadriceps femoris (group of four muscles in the anterior compartment of thigh)	The hamstrings flex the leg, whereas the quadriceps femoris extend it
Flexor digitorum superficialis and flexor digitorum profundus (in the anterior compartment of the forearm)	Extensor digitorum (in the posterior compartment of the forearm)	The flexor digitorum superficialis & profundus flex the fingers and hand at the wrist, whereas the extensor digitorum extends the fingers and hand at the wrist

Muscles without Attachments to the Skeleton

Some skeletal muscles do not pull on the skeleton to cause movements. For example, the muscles that produce facial expressions have their insertions and origins in the skin, and muscles contract to form a smile or frown, form sounds or words, or raise eyebrows. There are also such skeletal [muscles in the tongue](#), as well as in the external urinary and anal sphincters that allow for voluntary regulation of urination and defecation, respectively. Another example is the diaphragm, which contracts and relaxes to change the volume of the pleural cavities without moving the skeleton.

In addition to studying the mechanics of movement, human biomechanics also investigates the effects of different movements on the body. For example, researchers may study the impact of running on the joints and muscles or the effect of lifting heavy objects on the spine. By understanding these effects, biomechanics can develop strategies to reduce the risk of injury and improve performance.

Most likely you are currently in a seated position, hopefully in a comfortable position. Using biomechanics to address the body positioning of a person while working is called [ergonomics](#). Ergonomics strives to allow workers to be optimally efficient at their job while in a safe position. Clearly more physically demanding and dangerous jobs are problematic with people developing acute injuries and research is done on all aspects of that job. As an example: is it more ergonomic for a police officer to wear an [equipment belt or vest](#)?

More day-to-day tasks are also studied for ergonomics, from anti-fatigue mats, the correct height of standing desks, and how far away a computer monitor should be from your eyes. Repetitive use injury ([RSI](#)) is pain or injury caused by continual repeated movement of the body, like typing on a keyboard. All these ergonomic issues stem from optimal human biomechanics and creating equipment to suit the needs of workers.

Critical Thinking

What are some objects you interact with daily that may have been designed with a biomechanical perspective? Are there any objects that you use that clearly need some redesign?

There are many tools and techniques used in the study of human biomechanics. These include motion analysis systems, which use cameras and other sensors to track the movement of the body, and force plates, which measure the forces acting on the body during movement. Bio mechanists also use computer modeling and simulations to study movement and predict the effects of different forces on the body. The modern smart phone is becoming so powerful and equipped with high quality cameras that many [apps](#) can accurately track and record body movement.

Human biomechanics is a complex and multifaceted field that plays a vital role in understanding how the body moves and the factors that influence movement efficiency and performance. By studying the mechanics of movement and the effects of different movements on the body, bio mechanists are able to develop strategies to improve performance and reduce the risk of injury.

If this chapter was of particular interest to you, biomechanics may be the ideal focus of your kinesiology education leading to a [career](#) as a biomechanist.

Chapter 9 continues along a similar path as biomechanics but investigates how the mind controls movement of the body.

1.9: Motor Control

Learning Objectives

1. Explain the divisions of the nervous system.
2. Explain how reflexes work.
3. Discuss how muscle strength is controlled.

Human motor control can be thought of simply as how your brain consciously and subconsciously controls your physical body. Motor control is the process by which the central nervous system plans, directs, and executes the movement of the body. This involves the coordination of using sensory information to move muscles and joints. In Chapter 6 the physiology of muscle contraction was detailed, in this chapter, we will review how those mechanisms are used for a human to perform coordinated physical tasks.

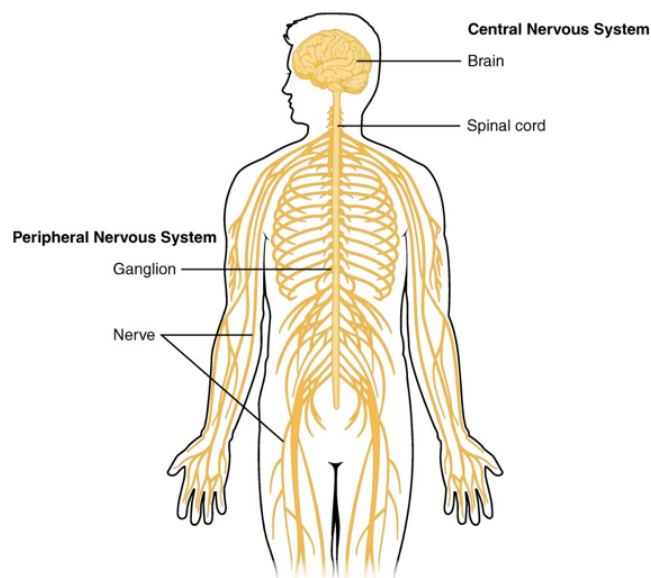


Figure 1. Central and Peripheral Nervous System The structures of the PNS are referred to as ganglia and nerves, which can be seen as distinct structures. The equivalent structures in the CNS are not obvious from this overall perspective and are best examined in prepared tissue under the microscope. Anatomy & Physiology. Authored by: OpenStax College. Provided by: Rice University. Located at: <http://cnx.org/contents/14fb4ad7-39a...f2482e3e22@9.1>

The nervous system can be divided into two major regions: the central and peripheral nervous systems. The **central nervous system** (CNS) is the brain and spinal cord, and the **peripheral nervous system** (PNS) is everything else (Figure 1). The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column. It is a bit of an oversimplification to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. There are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. Depending on different aspects of the nervous system, the dividing line between central and peripheral is not necessarily universal.

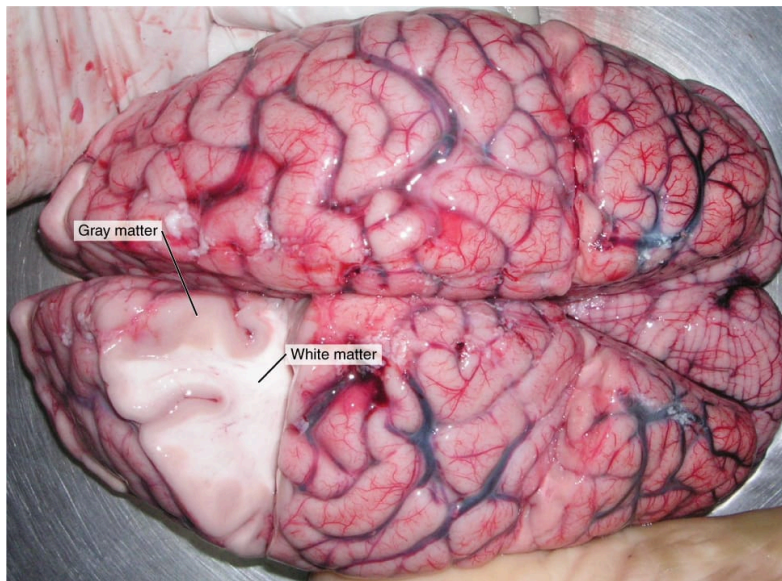


Figure 2. Gray Matter and White Matter A brain removed during an autopsy, with a partial section removed, shows white matter surrounded by gray matter. Gray matter makes up the outer cortex of the brain. (credit: modification of work by "Suseno"/Wikimedia Commons)

Looking at nervous tissue, there are regions that predominantly contain cell bodies and regions that are largely composed of just axons. These two regions within nervous system structures are often referred to as **gray matter** (the regions with many cell bodies and dendrites) or **white matter** (the regions with many axons). Figure 2 demonstrates the appearance of these regions in the brain and spinal cord. The colors ascribed to these regions are what would be seen in “fresh,” or unstained, nervous tissue. Gray matter is not necessarily gray. It can be pinkish because of blood content, or even slightly tan, depending on how long the tissue has been preserved. But white matter is white because axons are insulated by a lipid-rich substance called **myelin**. Lipids can appear as white (“fatty”) material, much like the fat on a raw piece of chicken or beef. Gray matter may have that color ascribed to it because next to the white matter, it is just darker—hence, gray.

The distinction between gray matter and white matter is most often applied to central nervous tissue, which has large regions that can be seen with the unaided eye. When looking at peripheral structures, often a microscope is used, and the tissue is stained with artificial colors. That is not to say that central nervous tissue cannot be stained and viewed under a microscope, but unstained tissue is most likely from the CNS—for example, a frontal section of the brain or cross section of the spinal cord.

Usually, the first step in motor control is the input of a stimulus or conscious thought. Examples of these could be seeing a frisbee flying towards you, the smell of baking cookies, or the thought that what is currently on TV is boring. This initiates movement of the body to react to that stimulus, typically from the cerebral cortex in the brain that is responsible for higher-order cognitive processes. Higher-order cognition refers to mental processes like problem-solving, reasoning, creativity and decision-making. The brain processes the stimulus input and activates specific muscles in the body through motor neurons, which are specialized nerve cells that transmit stimulus from the brain to activate muscular contraction. The muscle contraction then moves the body and solves the problem. If a frisbee is flying toward you, you raise your arm to catch it. The nostril that could most strongly smell the cookies indicated the direction of the baking and your neck turns in that direction to allow a better vision of the food. The boring TV channel is replaced by pressing the button down on the remote resting in your hand.

Critical Thinking

How does this “automatic” movement help in day-to-day life? How would driving a car, writing with a pencil, or tying your shoes be if you had to think about each exact movement?

Once a movement has been initiated, it is carried out by the activation of specific muscle contractions to flex or extend joints and move the body. The activation of these muscles is controlled by motor neurons, which are specialized cells in the central nervous system that transmit signals to the muscles to contract. This is covered in more detail in Chapter 6. Movement and the activation of these motor neurons is influenced by a variety of factors covered below:

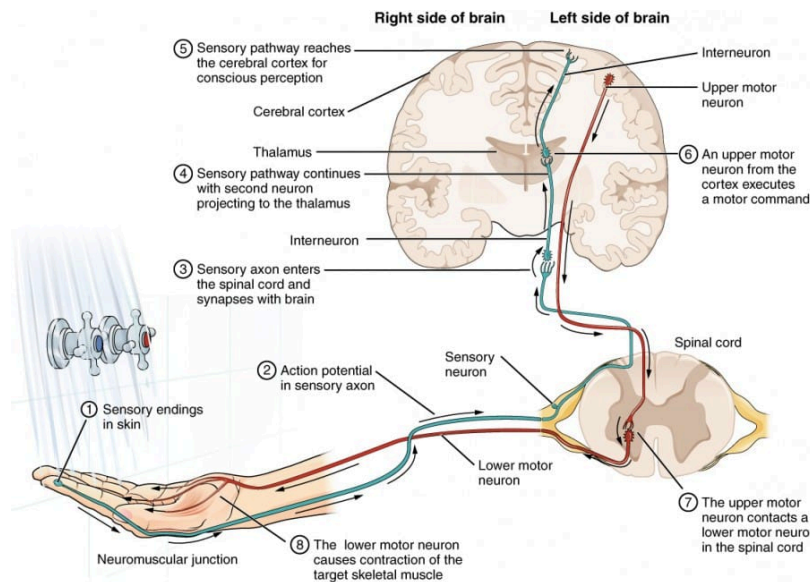


Figure 3. The pathway of sensory and motor neurons from the hand to the brain and back. Anatomy & Physiology. Authored by: OpenStax College. Provided by: Rice University. Located at: <http://cnx.org/contents/14fb4ad7-39a...f2482e3e22@9.1>

Reflexes are automatic involuntary responses to stimuli that do not require conscious thought or effort. If you touch something very hot your body will automatically pull your hand away through a series of reflex arcs. **Reflex arcs** are neural pathways that do not need to travel to the cerebral cortex for conscious thought. They directly link sensory receptors to motor neurons to allow for a quicker response. These automatic involuntary responses help maintain human upright balance and reduce physical tissue damage when we do something like accidentally touching a hot pan as the hand can be pulled back faster than if we had to think to do it.

Neurons that carry information from sensory receptors from all over the body towards the central nervous system are called **afferent neurons**. **Efferent neurons** transmit motor information from the central nervous system to the muscles of the body to trigger movement.

The brain gets sensory feedback from muscles to understand where and what the body is doing in space and in relation to objects around it.

Critical Thinking

Stand up and close your eyes. Move your body around and stop in unusual body positions. If you have a classmate, have them move your arms or hands around. Even with your eyes closed your brain knows where your limbs are and how the body is positioned. How do you think this is done?

Proprioception refers to the ability to sense the position and movement of our own body parts without relying on visual or auditory cues. This is made possible by specialized receptors located in our muscles, tendons, and joints that provide information about the position, movement, and tension of our muscles and connective tissues. **Muscle Spindles** are small sensory receptors in muscle tissue that relay the change in length and speed of muscle fiber stretch to the central nervous system. This information is critical for controlling the precise movements of our body.

Golgi Tendon Organs are responsible for monitoring the tension or force that is applied to a muscle. They work by detecting the amount of stretch in the tendon caused by the contraction of the muscle fibers. When the tension in the tendon becomes too high, the Golgi tendon organs send a signal to the spinal cord, which in turn sends a signal to the muscle fibers causing them to relax. This is known as the Golgi tendon reflex.

The Golgi tendon reflex is an important protective mechanism that helps to prevent excessive tension or force from being applied to muscles, which could lead to injury. It is also involved in regulating muscle tone and maintaining posture. Proprioception allows us to perform coordinated movements and maintain balance and posture.

Kinesthetic sense, is the ability to sense the position and movement of our body parts in relation to each other and to the environment around us. It involves the integration of information from multiple sensory systems, including proprioception, vision, and the vestibular system (which provides information about balance and spatial orientation). Kinesthetic sense allows us to navigate through our environment, interact with objects, and perform complex tasks that require hand-eye coordination.

Together, proprioception and kinesthetic sense play crucial roles in motor control, movement planning, and body awareness. They are essential for activities such as sports, dance, and surgery, where precise control of movement and position is required. Disorders of proprioception and kinesthetic sense can lead to difficulties with movement control, balance, and posture, and can significantly impact a person's quality of life.

Muscle activation patterns are developed through a complex and dynamic process that involves a combination of genetic predispositions, experience, and neural plasticity.

At the genetic level, motor patterns are influenced by inherited traits that affect the development and function of the nervous system, including the formation and function of neural circuits that control movement. These genetic factors provide a foundation for motor development, but they do not determine the outcome.

Experience also plays a critical role in the development of motor patterns. Infants and children explore their environment and engage in various physical activities that challenge and refine their motor skills. Through repetition and practice, neural circuits involved in movement control are strengthened and optimized, leading to the development of more efficient and precise motor patterns.

In addition, neural plasticity plays an important role in the development of motor patterns. Neural plasticity refers to the brain's ability to reorganize and adapt in response to changes in the environment or experiences. Through this process, neural circuits involved in movement control can be modified and refined to optimize motor patterns.

Motor patterns are also shaped by feedback from sensory systems, such as vision and proprioception, which provide information about the body's position and movement in space. This feedback helps to refine motor patterns and improve their accuracy and precision.

The development of motor patterns is a complex and dynamic process that is influenced by a variety of factors. By understanding the interplay between genetics, experience, and neural plasticity, researchers can better understand how motor patterns are developed and how they can be optimized through early intervention and rehabilitation.

Critical Thinking

Balance test. Eyes open and eyes closed. Two feet vs one foot. Why is one harder?

Balance is the ability to maintain the body's center of mass over the base of support during static or dynamic movements. The visual system plays an important role in balance control by providing information about the body's position and movement in space.

Closing one eye can significantly impair balance because it reduces the amount of visual information available to the brain. With both eyes open, the brain uses the information from **both eyes** to create a three-dimensional image of the environment, which helps to accurately estimate the body's position and movement. When one eye is closed, the amount of visual information is reduced, which can result in inaccurate estimates of the body's position and movement and can make balance control more challenging.

In addition, closing one eye can also affect the vestibular system, which is responsible for detecting changes in head position and movement. The vestibular system relies on information from the inner ear, and it works together with the visual system to maintain balance. When one eye is closed, the vestibular system may receive conflicting information about the body's position and movement, which can further impair balance control.

Overall, closing one eye can make balance control more challenging because it reduces the amount of visual information available to the brain and can affect the vestibular system's ability to accurately detect changes in head position and movement. However, with practice and adaptation, the brain can learn to compensate for the loss of visual information and improve balance control when one eye is closed.

A [homunculus](#) is a representation of the human body within the brain, specifically in the primary motor and sensory cortex. The term "homunculus" comes from the Latin word for "little man." In the primary motor cortex, the homunculus is a distorted representation of the body's motor functions, with different areas of the cortex controlling different body parts. The amount of space devoted to each body part is proportional to the complexity and precision of its movement. For example, the areas responsible for the hands, fingers, and face are relatively larger than the areas for the torso or legs, reflecting the greater precision and complexity of their movements.

Similarly, in the primary sensory cortex, there is a homunculus that represents the body's sensory functions, with different areas of the cortex processing information from different parts of the body. The amount of space devoted to each body part is again proportional to the complexity and density of its sensory receptors.

The homunculus is important because it provides a detailed map of how the brain processes sensory and motor information from the body. By understanding the organization of the homunculus, researchers can better understand how the brain controls movement and processes sensory information, and how these processes may be disrupted in conditions such as stroke or traumatic brain injury. The homunculus is also important in clinical settings, as it provides a way to map the location of sensory or motor deficits in patients, allowing for more targeted rehabilitation interventions.

Critical Thinking

How do we engage and control muscle contraction? How do you not snap a pencil in half when writing. Even though your hand is strong enough to do so.

The ability to control muscle strength is due to the fine-tuning of motor commands sent from the brain to the muscles. These commands are generated in the primary motor cortex and are transmitted through [descending motor pathways](#) in the spinal cord to the muscles. The strength of the motor command determines the force produced by the muscle.

In order to perform fine motor skills like using a pen, the motor commands sent to the muscles need to be precisely controlled to produce the appropriate level of force. The brain achieves this control by activating specific groups of motor neurons in the spinal cord that innervate the muscle fibers. The number and frequency of motor neurons activated determine the force produced by the muscle.

When performing fine motor tasks, the brain can precisely adjust the number and frequency of motor neurons activated to produce the appropriate level of force for the task. This is achieved through a process called motor unit recruitment, where the brain activates only a small number of motor units (a motor neuron and the muscle fibers it innervates) to produce a low level of force. As the required force increases, the brain activates additional motor units to produce a greater force.

This precise control of motor unit recruitment allows for the execution of fine motor skills without overexerting the muscles and risking damage to the object being manipulated, such as a pen. Additionally, the brain can monitor the amount of force being produced and adjust the motor commands accordingly to maintain the appropriate force level for the task. This helps prevent accidental over-exertion and breakage of objects.

The challenge of upright walking:

Upright walking, also known as bipedalism, is challenging because it requires several adaptations to the anatomy and physiology of the human body. These adaptations include changes to the structure and function of the spine, pelvis, legs, and feet.

One reason why upright walking is evolutionarily rare is that it requires a significant reconfiguration of the body's anatomy and physiology. In order to walk upright, the spine must be reconfigured to form an S-shaped curve, which places the center of gravity over the pelvis and allows for better balance while walking. The pelvis must also be modified to be shorter and broader, which helps support the weight of the upper body while walking. The legs and feet must also be adapted to bear the weight of the body and provide stability during movement.

These adaptations take time to evolve and are not easily achieved through natural selection. In addition, bipedalism requires a higher level of coordination and balance than quadrupedal movement, which is the typical mode of locomotion for most mammals. This increased demand for coordination and balance may have also made bipedalism a difficult trait to evolve.

Despite these challenges, the benefits of bipedalism may have made it an advantageous trait for early hominids. Upright walking

allowed for greater efficiency in travel and foraging, as well as better surveillance of predators and prey. Overtime, natural selection may have favored individuals with adaptations for upright walking, leading to the evolution of modern humans and our unique ability to walk upright.

Motor control is a complex process involving the coordination of neural structures and pathways to produce coordinated movements of the body. Understanding the neural mechanisms of motor control is essential for enhancing athletic performance and rehabilitation from injury. Through motor learning, individuals can acquire and refine motor skills to perform daily activities, participate in sports, and recover from injury.

If the motor control topics discussed in this chapter captured your attention then a future as a [biomechanistic](#) may be for you.

In Chapter 10 we explore personal and group training.

1.10: Personal/Group Training

Learning Objectives

1. Describe progressive overload.
2. Give tips on muscle recovery.
3. Being able to coach and make corrections on common exercise movements.

Personal and/or group training is a common and great job for anyone interested in kinesiology to get started along a career path. A multitude of options exists for growth and specialization in personal/group training allowing a student of kinesiology to follow their passion and interest. There will also be many job openings in personal or group training in populated areas. This process can help build experience and education leading to jobs in the other branches of kinesiology, but a career in personal and group training can be viable and rewarding long term as well.

Many people without an athletic or kinesiology background incorrectly group personal trainers (this chapter), athletic trainers (Chapter 11), and physical therapists (Chapter 12) together as the same job, or do not quite know the difference. After completing these three chapters you should be able to clearly identify the differences and similarities in these roles.

Critical Thinking

What is your current understanding of the differences and similarities between personal trainers, athletic trainers, and physical therapists? Please summarize below:

While personal and group training are similar there are a few obvious differences. Personal training involves one client, and the entire workout should be custom-built to their needs and wants. Personal training also allows for the programming to start at the beginning to focus on the client's weaknesses and build up in difficulty after learning and progress are made.

Group training will involve less personalization (but getting like-minded people together will make the workouts more enjoyable and effective) with each person doing the same workout. A quality group trainer will be able to provide modifications to all levels of fitness and ability in their classes.

Personal training also usually exists as an add-on for someone that is already a member of a gym. This has multiple benefits for you as a trainer because all the equipment you need is provided for you by the gym and your client has access to the gym during non-personal training sessions so you can assign "homework" for them to complete individually. This can lead to faster results and a happier client. The downside of this trainer-client-gym set up is that the gym could require sales minimums as part of your job, and the gym will likely take a portion of the payment the client is paying for your training.

A personal trainer could also set up a private business and travel to their clients to do mobile training. The benefit from this is that the trainer keeps all the payment, but they have to provide equipment, and insurance, and handle all the sales/recruitment of clients. A few pieces of versatile equipment, a trainer's imagination, and kinesiology knowledge can allow a trainer to only need a little equipment to provide a great workout. A few kettlebells and sandbags are a great starting point.

A third but less common economic setup for personal training is renting space from a fitness center or gym to bring their clients into. They do not need a membership and equipment is provided, but rental costs can cut into profit.

Group training typically is offered by gyms as classes that members sign up for in advance. Gyms like CrossFit, F45, or RushCycle only offer group class workouts, meaning members cannot come in at non-class times to do their open gym workouts. Big box gyms like LA Fitness, 24 Hour Fitness, or Planet Fitness focus on open gym hours and offer a plethora of equipment but may have side rooms for group training classes like spin or Zumba. Many trainers will specialize in one form of group class fitness, earning different certifications in that specialty. Group training typically costs the client less per hour compared to personal training, but a group trainer could earn more than a personal trainer if they have many people interested in their classes.

The COVID-19 pandemic forced personal and group trainers to create ways to train their clients virtually, and this is still a growing

trend that allows a trainer to reach more clients while working remotely.

Goal setting: Understanding what a person wants to achieve from training is vitally important to creating an appropriate program for each individual and keeping the client coming back for more training.

Before starting with any clients, a trainer should have them sign a medical release form and/or be cleared by a doctor if they have any serious pre-existing medical conditions that would limit participation in exercise or would put their health at risk. There are many great measurements and evaluations to start with in Chapter 3 of this textbook.

When building an exercise program or plan the two most important aspects are that the person following the program enjoys the activities and that the design aligns with their personal goals. Michael Phelps was a competitive swimmer and the most decorated Olympian of all time, and multiple world records. Phelps has been very open with his training [regime](#) and [diet](#), but it does not mean that this is the ideal training plan for anyone else because their goals, available time, and current fitness levels will all be different.

SMART goals are a great start for understanding a client's reasons for wanting to start a workout program, but there are many ways to help set goals; this is just one example.

SMART goals are useful for turning the generic "I want to lose weight" into personal information that a trainer can use to create an impactful program for the client to be successful.

Each of the letters in the acronym SMART works to create a detailed individualized goal.

S= Specific, give an exact detail to what is desired. From "I want to get into better shape" to "I want to be able to play soccer with my son". This should provide detail, and possibly motivation, as to why this person wants to start training. A trainer can use these details to better design a training program for a client.

M=Measurable, pick a number and unit to measure at the start of training to determine when the client has been successful. Change "I want to run faster" to "I want to be able to run a mile in 8 minutes or less" Being able to measure the goal and progress will motivate a client to continue with training as they see the results of their hard work.

A=Attainable, realistic check on whether is this possible to do in a healthy manner and timeline. Healthy and sustainable fat loss for an adult human is about 1 to 2 pounds per week at a maximum. The more the person has to lose the faster they can start to lose the initial weight, but as they get closer to a healthy body weight the harder and slower fat loss will be. Can a person that has not worked out in a decade run a 3-hour marathon next weekend? Very unlikely.

R=Relevant, how does this exercise tie in with the rest of their life's goals? Most people do not love working out, and usually do it to accomplish something necessary. Does their next vacation include a lot of hiking? Did they just find out their cholesterol levels are higher than average, and their doctor recommended more physical activity?

T=Timely, what is the timeline to successfully have completed or attained this goal? Setting a date can help motivate people. Without a specific target date, work can always start tomorrow, so it never starts.

Critical Thinking

Set your own SMART goals, 1 fitness/health-related and 1 education-related.

Individual programming

The next part of the chapter will cover topics a personal or group trainer will need to understand to be able to build a workout program and modify specific exercise movements to accommodate clients.

Medical clearance, safety, and training liability is very important and should be covered during the first meeting between trainer and client. The Par-Q test is a great questionnaire to cover if a person is ready for physical activity.

Warm-up and cool-down "Commonly, the warm-up and cool-down involve doing an activity at a slower speed or lower intensity. A warm-up before moderate- or vigorous-intensity aerobic activity allows a gradual increase in heart rate and breathing at the start

of the episode of activity. A cool-down after movement allows a gradual decrease at the end of the episode. Time spent doing warm-up and cool-down may count toward meeting the aerobic activity guidelines if the activity is at least moderate intensity (for example, walking briskly as a warm-up before jogging). A warm-up for muscle-strengthening activity commonly involves doing exercises with lighter weight. Stretching is often incorporated during the warm-up and cool-down, and helps reduce the risk of injury, as well as improving flexibility.”

Balance and stability are the foundation of human movements. Starting with balance and stability movements is a great place to start with a physical assessment of a new client, especially an elderly member. Even elite athletes can benefit from advanced balance and stability exercises. Balance can be challenged by performing movements on one leg, on unstable bases, or by having the client close their eyes.

Stability can be taxed using small power bands during regular movements attempting to pull the client off center. This will require clients to activate stabilizing muscles as well as the dominant muscles for a moment. These off-axis forces are great for training athletes with speed and agility.

The cover of this textbook was inspired by the [Milo of Croton](#). Milo was likely a real Greek athlete that has had his feats of strength exaggerated over time into legend. Legend tells of Milo training for the Olympics by purchasing a newly born calf and carrying it over his shoulders up a mountain. Milo does this each day, and as the calf grows and gets slightly heavier each day, Milo can progressively overload his muscles and continually build strength until he is able to carry a full-grown bull up a mountain on his shoulders. The concept of progressive overload is one of the most fundamental ideas about kinesiology and building strength without injury.

Challenging a muscle with small increases in weight over time is how humans develop strength. Human muscle fiber is damaged during strenuous exercise and then repaired during sleep. The repair process makes the fiber slightly larger, thus stronger.

FITT stands for Frequency, Intensity, Time, and Type. These are the four key components that you need to consider when creating a workout schedule. By adjusting these variables, you can customize your workout to meet your specific goals and needs.

- Frequency: How often do you exercise
- Intensity: How hard you exercise
- Time: How long do you exercise
- Type: The type of exercise you do

Critical Thinking

Using FITT principles create your workout plan based on your fitness goals and the exercise you like.

Mobility and flexibility are often used interchangeably, but they are two different concepts when it comes to fitness and movement.

Flexibility refers to the ability of a muscle or group of muscles to lengthen, allowing for a greater range of motion at a joint. This is typically achieved through stretching exercises, such as static stretching or dynamic stretching.

Mobility, on the other hand, refers to the ability of a joint to move freely through its full range of motion. This is determined not only by the flexibility of the muscles surrounding the joint but also by the health and integrity of the joint itself, as well as the neuromuscular system that controls the joint's movement.

While both flexibility and mobility are important for optimal movement and performance, they address different aspects of the movement. Flexibility is important for preventing injury and improving movement quality, while mobility is important for maintaining joint health and preventing movement restrictions.

Including both flexibility and mobility exercises in your workouts can help ensure that your body is moving optimally and efficiently. Flexibility exercises can help improve your range of motion and reduce the risk of injury, while mobility exercises can help improve joint health and prevent movement restrictions.

For example, including dynamic stretching before a workout can help improve flexibility and prepare your body for movement, while including mobility exercises such as foam rolling, or joint mobilization drills can help improve joint health and reduce the risk of injury over time.

Unilateral movements are exercises that work one side of the body at a time, such as single-leg squats or single-arm dumbbell presses. Including unilateral movements in your workouts is important for several reasons:

1. **Balance and Stability:** Unilateral movements require more balance and stability than bilateral movements, as your body has to work harder to maintain proper form and alignment. This can help improve your overall balance and stability, which can be beneficial for everyday activities as well as sports performance. **Symmetry:** By working on each side of your body independently, you can help identify and correct any imbalances or weaknesses that may exist between your left and right sides. This can help improve overall symmetry and reduce the risk of injury.
2. **Core Strength:** Unilateral movements engage your core muscles more than bilateral movements, as your core muscles have to work harder to stabilize your body during the exercise.
3. **Variety:** Including unilateral movements in your workouts can help add variety and challenge to your routine, which can help prevent boredom and keep you motivated.
4. **Rehabilitation:** Unilateral movements can be useful for individuals recovering from an injury or surgery, as they allow you to focus on one side of the body at a time and gradually work your way back to bilateral movements.

Overall, incorporating unilateral movements into your workouts can help improve balance, symmetry, core strength, and variety, and can be especially useful for individuals recovering from an injury or surgery.

Isometric exercises are exercises that involve contracting a muscle or group of muscles without moving the joint. Instead of lifting weights or performing reps, you hold a static position, engaging your muscles to maintain that position for a certain period. Examples of isometric exercises include planks, wall sits, and static bicep curls.

There are several reasons why isometric exercises are important to include in your workouts:

1. **Strength:** Isometric exercises are a great way to build strength, as they recruit a high number of muscle fibers and can be held for longer periods than traditional weightlifting exercises. By increasing strength, you can improve your ability to perform everyday activities as well as sports and fitness-related activities.
2. **Joint Stability:** Isometric exercises can help improve joint stability, which is important for preventing injuries and improving overall movement quality. By holding a static position, you can strengthen the muscles and connective tissues around a joint, reducing the risk of injury.
3. **Time Efficiency:** Isometric exercises can be performed anywhere and require little to no equipment, making them a convenient and time-efficient way to get a workout in.
4. **Rehabilitation:** Isometric exercises can be useful for individuals recovering from an injury or surgery, as they allow you to work the muscles without placing too much stress on the injured area.

Core exercises are important because they help to strengthen and stabilize the muscles in your torso, including your abdominals, back muscles, and hip muscles. A strong core is essential for proper movement and posture, and it can help to improve your athletic performance, prevent injuries, and reduce back pain.

Here are some reasons why you should add core exercises to your workout routine:

1. **Improved Posture:** Core exercises can help improve your posture by strengthening the muscles in your torso that support your spine. This can help you maintain proper alignment throughout the day, reducing the risk of pain and injury.
2. **Reduced Risk of Injury:** A strong core can help stabilize your spine and pelvis, reducing the risk of injury during movements such as lifting heavy objects, twisting, and bending.
3. **Better Athletic Performance:** Many athletic movements, such as running, jumping, and throwing, require a strong core for optimal performance. By including core exercises in your workout routine, you can improve your strength, power, and agility, which can translate into improved athletic performance.
4. **Reduced Back Pain:** A weak core can contribute to back pain by placing additional stress on the spine. By strengthening the muscles in your torso, you can reduce the risk of back pain and improve your overall spinal health.
5. **Improved Balance and Stability:** Core exercises can help improve your balance and stability by strengthening the muscles that help you maintain proper alignment and control your movements.

Exercise	Coaching Cues	Common Mistakes	Modifications (easier)	Progressions (harder)
Squat	Hips down back; chest up; drive up through heels	Dropping chest down; hips not low enough; feet not shoulder-width	Reduce weight; box squats; move weight to back squat position	Move weight overhead; add weight; staggered or pistols
Deadlift	Hip hinge, send hips back; keep shoulders back	Rounding back; dropping hips; weight away from body	Remove staggered/single leg; reduce weight	Make single leg; increase range of motion; add weight
Good morning	Hip hinge, send hips back; keep shoulders back	Doing a squat; rounding upper back/shoulders	Less weight; reduce range of motion	More weight; increase range of motion
Lunge	Big step forward/backward; front knee not passing forward over toes	Not taking large enough step; dropping chest down; narrow feet together	Remove jump or weight	Add jump/180 jump; add weight; overhead weight
Sled push	Hips and shoulders in line with wrists; drive through feet	Staying too high; bending arms/shoulders	Less weight; push from higher handle	More weight; push from lower handle
Box jump	Land both feet together on box; triple extension	Landing single leg at a time; not landing full foot on box; not standing up at the top; not watching landing	Step downs; step-ups; toe touches	Increase box height
Hamstring curl	Hips up; slide feet out and pull back to hips	Dropping hips	Slide one foot out at a time; hands out wide; cleaning sliders	Bring hands up off the ground
Pull up	Palms facing forward; two fluid movements (scapular retraction then pull up)	Not using back muscles; single moment of pulling straight up	Jumping pull-ups; negatives; banded; mixed grip	Corncocks; weighted pull-ups
Chin-up	Palms facing toward you; contract biceps to assist	Not using biceps	Jumping chin-ups; negatives; banded	Single-arm
Row	Elbow stays close to ribs; pinch shoulder blades together; elbow straight up to ceiling	Feet staggered incorrectly if bent over	Lighter weight	Single-arm; heavier
Push-up	Hands slightly wider than shoulder-width, strong straight core, elbows close to ribs or wider, elbow twist under body	Fingers not pointing forward, hips too high	Dropping to knees, incline push-ups	Decline push-ups, diamonds, banded push-ups
Bench press	Elbows out wide to 90 degrees or slightly below shoulders, palms facing down, dumbbells straight up and down	Dumbbells moving out too wide, rotated palms	Lighter weight	Increase weight, alternating single-arm reps
Incline press	Elbows out wide to 90 degrees or slightly below shoulders, palms facing down, dumbbells straight up and down	Dumbbells moving out too wide, rotated palms	Move to flat press, lighter weight	Increase weight, alternating single-arm reps
Push press	Hip dip and drive to create momentum through legs, head moves back as bar travels up, head pushes through window	Not using legs, lifting too heavy and arching low back	Lighter weight	Strict press, full thruster

Exercise	Coaching Cues	Common Mistakes	Modifications (easier)	Progressions (harder)
Crunches	Keep feet on ground, lift shoulders up and forward, hands should not pull on head	Using arms to pull head up, lack of spinal mobility, pulling head with hands		Add a plate for plate raises, alter to crunch and twist
Flutter kicks	Feet and shoulders off ground, feet move in small or large pattern	Heels touch the ground	Hands under hips	Holding weight up and behind the head
V ups	Fingers and toes touch in air around midbody, heels and toes do not touch ground	Breaking into two movements	Heels tap the ground	Add object to pass back and forth from hands to feet
Plank	Tight core, ankles, hips, and shoulders all in a straight line	Hips too high or low	Low plank	Side plank, leg lifts, add weight plate to back

Complex Movements	Coaching Cues	Common Mistakes	Modifications (easier)	Progressions (harder)
Cleans	Elbows high and to the outside, weight stays close to the body, deadlift form to start, finish in the front rack	Bicep curl, weight away from the body, squatting the weight up	Stiff weight (not sandbag), less weight	More weight
Snatches	One fluid movement ground to overhead, start in a deadlift position, explode up from the ground, the bar stays close to the body, elbows high out to the outside until they punch up to the ceiling	Doing a clean and press, weight heading too far back overhead, squatting the weight up, weight too far away from the body	Break the movement into a clean and press	Squat snatch
Thrusters	One fluid movement from front rack squat to overhead, use the momentum from your legs to power the bar overhead, the head moves out of the way of the bar	Separating the movement into two phases, not dropping into a full squat	Lighter weight	More weight
KB Swings	Momentum from the hips and glutes should drive the KB up, KB goes to eye level, arms out straight and guiding the weight	Using the shoulders to lift the weight, not “hiking” the Kb back between the legs	Lighter KB or DB	Single-arm

Critical Thinking

Using the above charts for common exercises, create a simple workout plan of 3 or 4 exercises and coach a classmate through them. The classmate performing the movements should intentionally make mistakes to allow the coach to make corrections.

Working with limited space or equipment is a common challenge for personal trainers, especially when working with clients who prefer to exercise at home. Here are some ways a personal trainer might adjust their approach:

1. Make use of bodyweight exercises: Exercises that use only the client's body weight can be done anywhere and are effective for building strength, endurance, and flexibility. Personal trainers can design workouts that incorporate bodyweight exercises such as push-ups, squats, lunges, planks, and burpees.
2. Incorporate resistance bands: Resistance bands are lightweight and portable pieces of equipment that can be used to add resistance to exercises. Personal trainers can teach clients how to use resistance bands to perform a variety of exercises, such as bicep curls, rows, and chest presses.
3. Use furniture or household items: A personal trainer can get creative and use household items as equipment, such as chairs for step-ups or tricep dips, a sturdy table for inverted rows, or a backpack filled with books for weightlifting.

4. Utilize outdoor space: If a client has access to a park or backyard, a personal trainer can incorporate outdoor activities such as running, jumping jacks, sprints, and agility drills.
5. Design a circuit training program: Circuit training is a workout program that combines multiple exercises in a sequence. A personal trainer can design a circuit training program that includes exercises that use minimal equipment and space, which allows the client to get an effective workout in a small area.

Muscle recovery is an important aspect of any workout routine. After exercise, the body needs time to recover and repair muscle tissue. Here are some muscle recovery tips to help you maximize the benefits of your workouts:

1. Hydrate: Drink plenty of water before, during, and after your workout to help your body stay hydrated.
2. Stretch: Stretching can help reduce muscle soreness and improve flexibility. Focus on stretching the muscles you worked on during your workout.
3. Foam roll: Using a foam roller can help release muscle tension and improve circulation, reducing soreness and stiffness.
4. Take a rest day: Give your body time to rest and recover by taking a day off from exercise or doing low-impact activities like walking or yoga.
5. Get enough sleep: Sleep is essential for muscle recovery. Aim for 7-8 hours of sleep per night to help your body repair and regenerate muscle tissue.
6. Eat a balanced diet: Eating a balanced diet with plenty of protein can help your muscles recover and grow stronger.
7. Ice or heat: If you experience soreness or inflammation, try using ice or heat therapy to relieve pain and reduce swelling.

Remember, everyone's body is different, so it's important to listen to your body and adjust your recovery routine as needed. By taking care of your body after exercise, you can help maximize the benefits of your workouts and avoid injury.

For many kinesiology students, personal or group training is an ideal job while in college to use as a steppingstone to build experience in the field working with clients. It is also possible to continue in this area of kinesiology for a lifelong career through gym ownership or online training and exercise program design.

If this field of work and study is of interest to you earning a personal training certification will be critical to starting a job. Many companies do certifications but the top three are [ACE Fitness](#), [NASM](#), and [NSCA](#).

Chapter 11 focuses on athletic training which is often confused with personal training.

1.11: Athletic Training

Learning Objectives

1. Evaluate the role of an athletic trainer on a sport team.
2. Understand different methods of muscle recovery.
3. Describe CTE.

Do you love sports and the sports environment? Maybe you grew up as an athlete and do not want to move away from that lifestyle. Athletic training could be for you!

Athletic training is a section of kinesiology but also a job title. Athletic trainers are healthcare professionals usually working with an athletic sports team or school. Athletic trainers can provide services including “prevention, examination, diagnosis, treatment, and rehabilitation of emergent, acute or chronic injuries and medical conditions” (1). Athletic trainers can work in elite-level sports including the Olympics, professional sports, and college athletics, but there are also job opportunities in high schools and youth sports programs. Depending on the circumstances, you as an athletic trainer could be working solo or as part of a team and will be working closely with coaches, strength and conditioning trainers, and possible data analytics.

Athletic trainers are front-line medical workers, working with athletes. Often athletic trainers work and operate in the “training room” which is a healthcare facility with highly specialized medical technology in the athletic facilities. The goal of an athletic trainer is to keep their athletes healthy and able to participate in sporting competitions. Keeping athletes healthy and able to perform at their best is critical to the success of elite-level teams, and athletic trainers are valued as a key part of that function. Overall health also includes recovering from a player getting sick, not just physical injury.

When an athlete gets hurt during a game or practice the athletic trainer is the first to rush out, assess, diagnose, and start treatment of the injury. This process is multifaceted because consideration needs to be made if the athlete can safely return to the current game, or if the athlete is out of competition for a longer timeline, and how to start treatment immediately. There can be a lot of pressure from the athlete and coach to clear a player for return to competition immediately, especially when the outcome of the game could depend on it.

Ultimately your role as an athletic trainer is to protect the long-term health of your athletes, even if that means a lost game or missed playoff opportunity.

Consider contact sports like rugby, American football, or ice hockey (the three sports with the highest incidence of concussions) and how important the role of an athletic trainer is to protect the athletes; short and long-term health. There is a danger of soft and hard (bone or teeth) tissue injury in all sports and physical activity, but head (brain) injuries are especially dangerous. Different sports and leagues will have variations of concussion protocol but there will be some common aspects of agreed-upon rules and procedures to follow a head impact which will include:

The NFL concussion test protocol consists of several steps designed to identify and evaluate players who may have suffered a concussion. The protocol is designed to be comprehensive and includes a range of tests and assessments to help determine whether a player is ready to return to play.

The protocol includes the following steps:

1. Baseline testing: Before the start of the season, all players undergo baseline testing, which includes cognitive and physical tests, to establish a player's normal functioning in various areas.
2. Sideline evaluation: If a player is suspected of having a concussion during a game or practice, they are immediately removed from play and evaluated on the sidelines by medical personnel. The evaluation includes a series of questions, physical tests, and a check of vital signs.
3. Concussion assessment: If a concussion is suspected, the player undergoes a more comprehensive concussion assessment, which includes a series of cognitive and physical tests. The test evaluates memory, concentration, balance, and coordination.

Cognitive tests: These tests are designed to evaluate different aspects of brain function, such as memory, attention, and reaction time. Some of the most common cognitive tests used in the assessment of concussion include the [SCAT5](#) (Sport

Concussion Assessment Tool), [ImPACT](#) (Immediate Post- Concussion Assessment and Cognitive Testing), and [King-Devick](#) test.

Balance and coordination tests: These tests are used to evaluate a player's ability to maintain balance and coordination, which can be affected by concussion. Some of the most common balance and coordination tests used in the assessment of concussion include the BESS ([Balance Error Scoring System](#)) and [tandem gait test](#).

Symptom evaluation: Symptoms such as headaches, dizziness, nausea, and sensitivity to light or noise are commonly associated with concussion. A medical professional will ask about the presence of these symptoms, and evaluate their severity and duration.

Physical examination: An athletic trainer will evaluate a player's physical condition, including coordination, strength, reflexes, and vision, to identify any signs of concussion.

Neurological examination: An athletic trainer may perform a neurological examination to assess a player's brain function, including reflexes, vision, and hearing.

4. **Return-to-play protocol:** Once a player is diagnosed with a concussion, they are subject to a return-to-play protocol before they can return to the field. This involves a gradual increase in physical activity and monitoring for symptoms. The protocol includes five stages, each of which must be completed before a player can progress to the next stage. The stages are:
 - Rest and recovery
 - Light aerobic exercise
 - Sport-specific exercise
 - Non-contact drills
 - Full-contact practice
5. **Medical clearance:** Before a player can return to the field, they must be cleared by the team's medical staff including athletic trainers. This includes a final assessment of the player's symptoms, cognitive and physical testing, and medical imaging if necessary.

You can view the NFL's full protocol [here](#)

[Chronic Traumatic Encephalopathy](#) (CTE) is a neurodegenerative disease associated with repeated physical head trauma. CTE is found in many athletes that participated in contact sports or fighting sports like boxing and military veterans. CTE was first known as "punch drunk syndrome" in boxers almost 100 years ago. In the last 20 years, awareness and research on CTE have increased. CTE usually onsets years after the athlete leaves play and starts slowly with symptoms including short-term memory loss, frequent mood swings, and more than normal confusion or disorientation. Symptoms can escalate to slurred speech, memory problems, and depression. CTE can increase the risk of developing Alzheimer's, Parkinson's, and suicide rates. A Hall of Fame NFL player [Junior Seau](#) committed suicide by shooting himself in the chest so his brain could be studied for CTE and hopefully advance the safety protocols and protective equipment for future athletes.

Critical Thinking

An infamous story about how competition and physical health can come to battle in sports was showcased in the 1985 NFL season. Hall of Fame player Ronnie Lott was a critical part of his team's defense, and near the end of the regular season, Ronnie injured his pinky and would require surgery, ending his playing time for the season. Rather than sit out for the rest of the season and risk his team missing playoffs, Ronnie had half of his pinky amputated. He was cleared to play for the following game. Unfortunately, his team still lost, and Ronnie has publicly stated that he regrets his choice.

How would you handle the pressure of an athlete, coach, or parent of an athlete insisting that they need to go back into the game to impress the college scout/win the game/make it to the playoffs when you have deemed it dangerous for their health to return to the competition?

Dealing with injuries inherently means an athletic trainer will be placed in a situation to be potentially exposed to another person's blood or bodily fluids, which can transmit disease. Following safety and blood exposure plans is critical for an athletic trainer's personal health. Using gloves, masks, and other personal protective equipment at all times when needed is important.

One of the reasons that personal trainers, athletic trainers, and physical therapists are commonly confused for being the same job is that each of these professionals will work one on one with a client/athlete to create a customized plan to reach their goals.

In athletic training, you will design a unique rehabilitation program for each athlete consisting of different recovery methods and rehabilitative training including:

Physical training using resistance bands, focused unilateral lifts, and agility exercises all targeted on the recovery of an athlete's injury.

These unique training combined with preventive measures during sporting practice or games including specialized warm-up procedures and athletic taping for support and limiting range of motion are crucial aspects of an athletic trainer's expertise to help their athletes recover and return to play as fast as safely possible.

If you end up specializing in athletic taping you will be required to learn and practice many different taping procedures, here is a [video](#) on an ankle being taped.

Critical Thinking

What do you do when you have sore muscles? Why?

Let's take a deeper look into some of these recovery methods.

Ice has been used for centuries to help reduce inflammation (swelling) and pain of soft tissue injuries. Ice has also been a common treatment for post-exercise recovery to reduce muscular soreness. Typically, ice is either applied locally in a bag and secured to the body with plastic for 10-20 minutes. Keeping ice directly on the skin for prolonged times can cause tissue damage or frostbite. Ice baths have also been popular in recent years with a large tub of cold water and ice used to submerge a person's entire body. Recent research calls into question the effectiveness of cold therapy, so time will tell if ice remains in the athletic training tool kit.

Heat is generally used to loosen up tight or injured muscles and accelerate the "warm up" process prior to all-out competition. Heat can also increase blood flow to an area, increasing healing. Ice has shown better results at reducing swelling due to injury if used immediately compared to heat treatment which may be better for older injuries.

Transcutaneous electrical nerve stimulation (**TENS**) is a non-invasive therapy that uses electrical impulses to alleviate pain. It involves applying electrodes to the skin over the area of pain or along the path of the affected nerves, which are then connected to a small, battery-operated device. The device delivers low-voltage electrical currents that stimulate the nerves and muscles in the affected area.

The exact mechanism of how TENS works is not completely understood, but it is believed to work by stimulating the production of endorphins, which are the body's natural painkillers. TENS may also work by blocking pain signals from reaching the brain or by stimulating the release of other neurotransmitters that can help reduce pain.

TENS is commonly used to treat various types of pain, including back pain, neck pain, joint pain, muscle pain, and nerve pain. It is often used as a complementary therapy in combination with other pain management techniques, such as physical therapy, medications, and relaxation techniques.

TENS is generally considered safe when used as directed by a healthcare professional, although it may not be suitable for everyone, such as individuals with pacemakers or certain other medical conditions. Side effects are usually mild and may include skin irritation, muscle twitching, or headache.

Myofascial release is a manual therapy technique that is used to treat muscle pain, stiffness, and dysfunction. It involves applying sustained pressure to specific areas of the body to release tension in the fascia, which is the connective tissue that surrounds and supports muscles, bones, and organs.

The goal of myofascial release is to restore mobility and function to the affected area by reducing the restrictions and adhesions in the fascia. This is achieved by applying gentle, sustained pressure to the affected area for a period, typically several minutes.

Myofascial release can be performed using a variety of techniques, including manual pressure, stretching, and massage. Objects like foam rollers or lacrosse balls are also commonly used to apply targeted physical pressure.

Other muscle recovery techniques like [scrapping](#), [acupuncture](#), and [cupping](#) have shown poor to mixed results and are not widely

practiced.

While likely a requirement for all careers in kinesiology, staying up to date on a CPR/First Aid/AED certification is crucial for the emergency response care provided by an athletic trainer.

AED is an acronym for Automated External Defibrillator, and this is a tool that can deliver an external electric shock to an individual with an irregular heartbeat or a stopped heart. All modern AEDs have audio directions to assist with use during an emergency.

The American Red Cross classes can be booked [here](#). First Aid covers the treatment of physical trauma to the body including cuts, burns, and electric shock.

Taking a CPR class is critical for your full understanding and ability to act quickly in an emergency but a basic overview of what you would learn in a certification class is included.

CPR is an acronym for Cardiopulmonary Resuscitation and combines chest compressions and rescue breathing. CPR would be administered on someone that is not breathing normally (or at all) or whose heart has stopped.

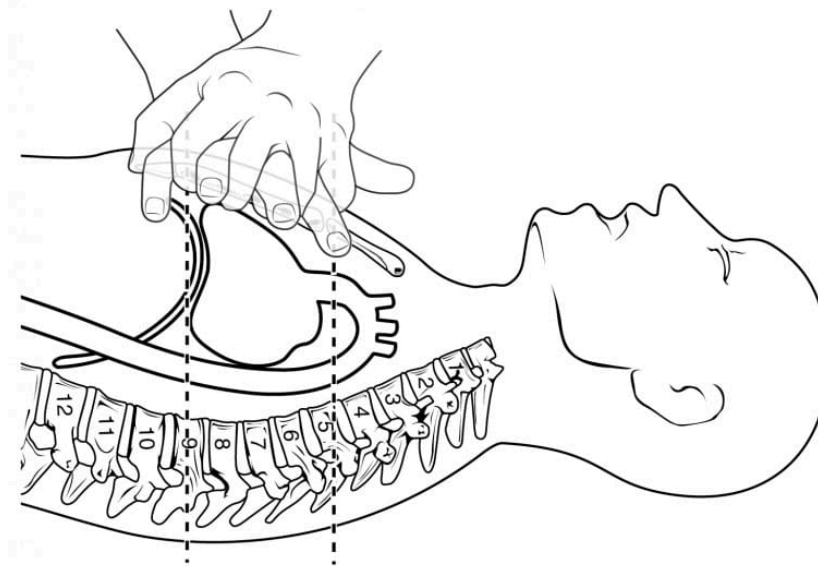


Figure 1. Proper Hand Placement for CPR. "CPR" by Anna Chruscik is licensed under [CC BY-SA 4.0](#)

Personal Protective Equipment (PPE) is important for athletic trainers because it helps to minimize their risk of injury and exposure to potentially harmful substances while performing their job duties. Athletic trainers' job requires them to be in close proximity to their clients, which increases their risk of injury and exposure to infectious agents.

Some of the common PPE used by athletic trainers include gloves, face masks, eye protection, gowns, and shoe covers. These protective items can help to prevent the spread of infectious diseases such as COVID-19, hepatitis and other viruses.

Athletic trainers are responsible for the health and wellbeing of their clients, and their own health is equally important. By using appropriate PPE, they can protect themselves and their clients from potential harm and ensure that they can continue to provide the highest level of care possible.

Blood transfusions were considered risky procedures until Karl Landsteiner, an Austrian biologist, and physician, discovered the major human blood groups in 1900. Antigens are organic substances that the body does not recognize as part of its own tissue and trigger an immune response. Antigens can be large proteins or other organic molecules such as carbohydrates, lipids, and nucleic acids. When incompatible blood is infused, erythrocytes with foreign antigens appear in the bloodstream and trigger an immune response. Antibodies, or immunoglobulins, produced by certain B lymphocytes called plasma cells attach to the antigens on the plasma membranes of the infused erythrocytes. IgM antibodies, which are large, can cause direct destruction of incompatible red blood cells by activating a group of plasma proteins called complement. This type of RBC destruction is called intravascular hemolysis and results in an acute hemolytic transfusion reaction that can be fatal with as little as 10 mL of incompatible red blood cells.

The ABO blood group name is made up of three letters, but the ABO blood typing system is concerned with only two antigens - A and B. These antigens are carbohydrate-based, and their presence or absence on the surface of red blood cells is determined by genetics. Blood type A is designated for people whose erythrocytes have only A antigens on their surfaces, while blood type B is for those with only B antigens. Blood type AB is for people who have both A and B antigens on their erythrocytes, while blood type O is for those who have neither A nor B antigens.

The Rh blood group is categorized based on the presence or absence of a second erythrocyte antigen known as Rh, which was first discovered in rhesus macaque, a type of primate that is used in research because of its similarity to humans. Although many Rh antigens have been identified, the D antigen is the most clinically significant.

Individuals who have the Rh D antigen on their erythrocytes, which accounts for about 85 percent of Americans, are classified as Rh positive (Rh+), while those who lack it are Rh negative (Rh-). It's important to note that the Rh group is distinct from the ABO group, which means that individuals may or may not have Rh antigen on their RBCs, regardless of their ABO blood type. When determining a patient's blood type, the Rh group is indicated by adding positive or negative to the ABO type. For example, A positive (A+) refers to ABO group A blood with the Rh(D) antigen present, while AB negative (AB-) refers to ABO group AB blood without the Rh(D) antigen.

To avoid transfusion reactions, it is best to transfuse only matching blood types; that is, a type B+ recipient should ideally receive blood only from a type B+ donor.

A person with O-negative blood can donate to all other blood types safely and a person with AB-positive blood can receive blood from all other blood types.

While blood transfusions are out of the realm of an athletic trainer it is important to remember how unique and different each person is. A treatment or technique that was successful with one person may not be successful with everyone else.

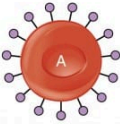
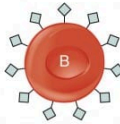
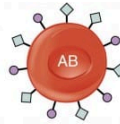
	Blood Type			
	A	B	AB	O
Red Blood Cell Type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red blood Cell	 A antigen	 B antigen	 A and B antigens	None
Blood Types Compatible in an Emergency	A, O	B, O	A, B, AB, O (AB+ is the universal recipient)	O (O is the universal donor)

Figure 2. A chart of different possible blood types. "Blood Types" by Anna Chruscik is licensed under [CC BY-SA 4.0](#)

A [career](#) in athletic training will require a Masters degree in kinesiology or athletic training and an accumulation of clinical hours as well as passing a board certification exam.

In Chapter 12 we will cover physical therapy, like athletic training but not the same.

1.12: Physical Therapy

Learning Objectives

1. Define Physical Therapy.
2. Describe how a PT might use common fitness equipment in uncommon ways.
3. Know the difference between mobility and flexibility.

Physical therapy has a long history that can be traced back to ancient Greece, where Hippocrates used massage and hydrotherapy to treat his patients. In the 19th century, physical therapy emerged as a formal profession, and the first physical therapy school was established in Sweden in 1813 by [Pehr Henrik Ling](#). In the United States, physical therapy began to develop as a profession after World War I, when many soldiers returned home with injuries and disabilities that required rehabilitation.

A modern physical therapist is a licensed healthcare provider that uses physical means to treat a disease or injury as opposed to pharmaceutical drugs or surgery. Oftentimes a person will be referred to physical therapy by their primary care medical doctor. Physical therapists can provide treatment to help someone recover from a wide range of medical issues including rehab after a stroke, recovery from a traumatic incident like a car crash, or even learning how to use an artificial limb.

The role of the physical therapist is to evaluate and assess the needs of the patient, develop a treatment plan, and guide the patient through the rehabilitation process. This may include working with the patient to improve their strength, flexibility, or joint range of motion as well as addressing any pain or dysfunction. Physical therapists also educate their patients on how to continue the rehabilitation treatment on their own at home for long-term preventative care.

Physical therapists can improve the lives of people of all ages from a young athlete recovering from surgery or sports injury to an elderly person improving their strength and balance to prevent a fall.

In 1921 physical therapy became a recognized profession in the United States with the establishment of the American Physical Therapy Association (APTA). A doctorate in physical therapy (DPT) is required to practice in the United States, as well as pass national and state certification exams. According to APTA - "Physical therapists and physical therapist assistants help people to maximize their quality of life. They work with people of all ages and abilities and in a variety of settings. They help people rehabilitate from devastating injuries, manage chronic conditions, avoid surgery and prescription drugs, and create healthy habits."

Becoming a PT

Schools and Requirements

A career in physical therapy will usually involve some specialization in working with a particular population or in a specific area. Some of the different specializations may include pediatrics, adult, geriatric, home health, hospital acute care, outpatient, burn/wound care, orthopedics, cardiac rehab, neurological and private practice.

"If exercise could be packed into a pill, it would be the single most widely prescribed, and beneficial, medicine in the nation, but when asked 4 out of every 5 adult Americans say they have never been advised by a physician to exercise"

-[Robert Butler](#) M.D

Physical therapists are that cross-over point between medical doctors and kinesiologists, using physical movement and exercise to recover and strengthen the body from many ailments. A physical therapy office often looks more like a gym than a hospital room, with a wide variety of equipment to treat different health issues.

Physical therapy can be used to treat a wide range of conditions from minor musculoskeletal injuries like sprains and strains to more serious bone fractures and joint dislocations. Physical therapists can also work with patients with neurological conditions from a stroke or spinal cord injury.

Physical therapists use a variety of techniques to treat their patients including exercises, stretches, and hands-on therapy. Exercise is an important component of physical therapy as it can improve muscular strength and cardiovascular conditioning. Cardiovascular health improvements are beneficial for patients with respiratory conditions. Hands-on therapy, also known as manual therapy, involves the use of the therapist's hands or a tool to physically manipulate the patient's soft tissue and joints. Massage and joint mobilization are manual therapy techniques. Electrotherapy is the use of electrical stimulation to promote healing and pain reduction. A PT may also use heat or cold to reduce pain and inflammation.

What "tools" does a PT use?

Free weights, much like those at your gym, but using lighter weights focusing on recuperation. Free weights can be used focusing on unilateral movements, rebuilding strength, or in combination with other equipment. Functional training activities are designed to improve a person's ability to complete daily tasks like walking, standing from a seated position, and reaching to grab objects.

Unstable equipment to stand to focus on developing or recuperating strength in the foot, ankle, and core all essential for maintaining balance while moving in an upright manner. The less stable the equipment is the more difficult maintaining balance is, and the appropriate device needs to be used for the goals of the patient. Here is an example of some balance-related exercises that could be used in PT. If some of these moves are too difficult for a person to complete have them stand next to a wall to place their hand on for assistance until they feel confident in their abilities.

Level of Difficulty	Exercise
1	Standing on one foot with eyes open
2	Standing on one foot with eyes closed
3	Standing on one foot while turning head from side to side
4	Standing on one foot while raising the opposite arm and leg
5	Standing on one foot on a balance board
6	Single leg Deadlift
7	Walking heel-to-toe in a straight line
8	Standing on one foot with a weighted ball toss
9	Side plank with leg lift
10	Pistol squat

Critical Thinking

Try out the movements in the chart above, do you agree with their ranked difficulty? Would you reorder the list? Why? What are a few other useful balance exercises?

Inflated large [exercise balls](#) create instability in a variety of exercises. Also known as "yoga balls" can be used seated to engage the core and pelvic floor muscles, a great replacement for an office chair. A wide variety of other exercises can be performed using this tool to either make some activities easier (a squat with the ball on the wall for extra stability and form control) or make other activities harder (a push-up with feet elevated on top of the ball).

Resistance bands are essentially giant rubber bands that can be used to create a changing amount of tension across a movement as the band is stretched further. Resistance bands can be used in place of [free weights](#) for many exercises if the actual weight is of concern, but they can also be used to apply different pressures during movements when anchored or held by the physical therapist. These are also great options for patients to use at home because they are relatively inexpensive and not a burden to travel with (as a set of kettlebells would be).

Suspension trainers (common brand TRX) are long adjustable fabric straps with handles usually anchored high on a wall or off of a pull-up bar that can be used for a huge [number of exercises](#) without the need of weights. These can be great for offering more control in movements when compared to a resistance band. Suspension trainers can be used to modify or progress movements as the client needs.

Stretching straps are also fabric straps but are used to allow individuals to hold stretching positions they might not be able to achieve without them.

Common household items can also be put to great use by a resourceful physical therapist. Many people develop [plantar fasciitis](#) (inflammation of connective tissue on the bottom of the foot) and a great way to treat and strengthen the feet is to do [toe curls](#) with a towel on the ground under the foot, slowly pulling the towel under your foot by grabbing the towel and curling the toes.

A common misconception is that mobility (also referred to as range of motion) is the same as flexibility. While these terms might have been used interchangeably some years ago, now they are thought of as two distinct but related measures of movement.

Flexibility is the ability of muscle tissue to passively lengthen. The more flexible a muscle is the longer it can lengthen. An overly simple idea here is if someone can bend forward and touch their toes, or maybe even put their palms flat on the ground. That person would be said to have more flexible hamstrings than a person that could not touch their toes. The physiology of how the muscle fibers stretch was covered in Chapter 6.

Mobility is the ability of a joint to move through a range of motion. That range could be limited by injury, swelling, pain, or other issues restricting movement. It is a normal part of aging for humans to lose mobility and flexibility as we get older or get injured. Improving flexibility and mobility is very important for a person to maintain normal or healthy activity and function. [Yoga](#) poses can be a great tool for improving flexibility and mobility.

Three other closely related aspects of human movement that a physical therapist could focus on would be balance, stability, and posture.

Balance is the ability to move under control and maintain an upright posture. Moving predominantly on two legs is a challenge. Humans, birds, and some apes are the only animals that walk upright bipedally, on two legs. In Chapter 9, balance and upright posture were covered in detail. Many neurological or musculoskeletal issues can disrupt a person's ability to balance, making the simple task of walking impossible.

Joint stability refers to the ability of a joint to maintain proper alignment and control movement within its normal range of motion. Joints rely on a complex interplay of bones, ligaments, tendons, muscles, and other tissues to achieve stability.

When a joint is stable, it can withstand normal forces and stresses without excessive movement or deviation from its normal position. This helps prevent injury and damage to the joint and surrounding tissues. For example, a stable knee joint is less likely to suffer ligament sprains or cartilage damage during physical activity.

Conversely, when a joint is unstable, it is more vulnerable to injury and damage. This can occur when the structures supporting the joint are weakened or compromised, or when there is abnormal movement or alignment of the joint. For example, an unstable shoulder joint may be more susceptible to dislocations or rotator cuff injuries.

Posture is the anatomically ideal position for your body to be in while standing, sitting, or laying down. Upright posture combines balance, stability, and dozens of muscles working together to prevent you from falling over. Many people suffer from [postural problems](#) from sitting at a computer desk or looking down at a phone for many hours a day.

The spine can be incorrectly bent or curved in three different classifications, [kyphosis](#), [lordosis](#), and [scoliosis](#). Depending on the severity, these could have a minimal health impact or all the way up to severe life impairment.

Critical Thinking

How are mobility and flexibility different? Why are they important? What are some examples of when a physical therapist might focus on one or the other?

Many people without an athletic or kinesiology background incorrectly group personal trainers (Chapter 10), athletic trainers (Chapter 11), and physical therapists (this chapter) together as the same job, or do not quite know the difference. Now that you have completed these three chapters you should be able to clearly identify the differences and similarities in these roles.

Critical Thinking

What is your current understanding of the differences and similarities between personal trainers, athletic trainers, and physical therapists? Please summarize below and compare your answers to what you wrote in Chapter 10.

1.13: Sports and Sports Management

Learning Objectives

1. Discuss how coaching and PE pedagogy are different.
2. Define sport.
3. Discuss the different roles a coach has.

Coaching and Sport Management

Most people that start a sports management career start as an athlete themselves and then move on to coaching the next generation of upcoming athletes. After coaching some individual teams, they will continue into sport management as athletic directors or facilities directors overseeing many teams, and coaches, and possibly managing the facilities used by those teams.

Education and a career as a coach closely aligns with the content from chapter 7 covering physical education and pedagogy. Teaching a PE class and coaching an athletic team will be similar, but with a major difference in that the athletes want to be there and are willing to put in the effort to become better.

Education and a career in sports management are the furthest from “kinesiology” that we will cover in this textbook, as it is closer to business management, but that business happens to be sport/athletics.

It is important to discuss the differences (if there are any) between hobbies, games, and sports.

Sports are usually considered physical activities in which two sides (individuals or teams) compete against each other with well-defined rules that both sides understand. The rules of sports are usually well established and standardized across regions, meaning that if you played basketball in California or in France you would expect the basketball to be the same size, shape, and weight as well as the court to be the same size with the same rules for moving, scoring, and what constitutes a foul. Sports are often very competitive, and rules are enforced by a referee or judge. With sports, the motivation to compete and excel can be external, meaning their external rewards like a paying job or scholarship that motivate individuals to continue playing and practicing beyond the joy of the activity.

Games can also be physically active in which two sides compete against each other, but with usually less defined rules, or using unique made-up rules. Think of a childhood game you played like tag; it is likely that the area you grew up in had different regional rules compared to another state or country of a similar game. Most likely the rules of your local schoolyard were passed down from older kids to younger kids year after year, slowly changing as the space or equipment in your schoolyard changed. Games usually do not have a referee or judge to observe and enforce rules but rely on participants being honest about catching a ball or being tagged out. The participants of games usually continue to play for internal motivation, meaning they derive joy from playing and want to continue getting better because it makes them happy to improve.

The term hobbies act as a catch-all for activities that do not neatly fall into “sports” or “games”. Hobbies do not necessarily have to be physically active or competitive, like painting. Hobbies are also likely done because of internal motivation and bring happiness to the person performing them, but many people make their living painting art so the lines are blurred.

Critical Thinking

How would you define the following activities between sport, game, or hobby, and why?

1. NBA Basketball
2. Pickup basketball at a park
3. Cheerleading
4. NASCAR
5. Chess

6. eSports

Answer available at the end of this section.

As discussed earlier in this textbook, the development of games and sports came from a societal need to train their boys to be warriors. As the study of the human movement grew and developed, more schools and universities started to incorporate athletics and intercollegiate competition. This growth has continued in current times with the [NCAA](#) reporting 560,000 student-athletes in the 2013-2014 academic year, which is more than double from 1990.

During the early 1900s opportunities for women to participate in sports were limited by social constraints. At first female participation was only allowed for activities that could be completed without sweating, like [archery](#). Archery was one of the first women's Olympic events in 1904. Women's sport participation continued to be limited for the next century. As recently as the 1960s women were prohibited from running a [marathon](#) because it was incorrectly believed that much running would cause fertility issues for women.

Racial segregation in America also impacted a wide range of divisions in sport participation as well for people of color. A notable victory in showing racial equality was in the 1936 Olympics when [Jesse Owens](#) won four gold medals in the 100 meters, 200 meters, long jump, and on the 4x100-meter relay. This was all done in front of Adolf Hitler who had thought to promote his idea of Aryan racial superiority.

Inclusion and equality are critical topics to be continually discussed in sports and sport management.

Critical Thinking

Have you experienced or seen inequality in sports? How could this injustice be eliminated in sports?

A coach has many "jobs" of leading a team to success, from recruiting athletes (when allowed), to planning and coaching the sport, to handling internal conflict among the athletes.

College coaches recruit athletes through a variety of methods, including.

1. Evaluating performance at high school games and tournaments: College coaches often attend high school games and tournaments to evaluate potential recruits. They look for athletes who demonstrate skill, athleticism, and a strong work ethic.
2. Attending showcase events and camps: Many college coaches also attend showcase events and camps where they can watch multiple athletes compete in a single location. These events often draw large numbers of athletes and can be a great way for coaches to evaluate a large pool of potential recruits.
3. Online scouting: With the rise of online video and social media, many college coaches also use the internet to scout potential recruits. Athletes can create online profiles and upload videos of their performances, making it easier for coaches to evaluate their skills and athleticism.
4. Contacting high school coaches: College coaches often reach out to high school coaches to inquire about potential recruits. High school coaches can provide valuable insights into an athlete's character, work ethic, and performance.
5. Hosting campus visits: Once coaches have identified potential recruits, they often invite them to visit their campus. During these visits, coaches can showcase their facilities, introduce athletes to current team members, and provide information about the school's academic programs.
6. Building relationships with athletes and their families: Finally, college coaches often build relationships with athletes and their families to help them make an informed decision about where to attend school. Coaches may offer guidance on the college application process, provide information about financial aid and scholarships, and answer any questions the athlete or their family may have.

Professional and college coaches use a variety of methods to recruit athletes, including evaluating performance at high school games and tournaments, attending showcase events and camps, online scouting, contacting high school coaches, hosting campus visits, and building relationships with athletes and their families. By using these methods, coaches can identify and recruit top talent to their teams. Money can also make a huge impact.

Signing day

As a coach, building practice plans is an essential part of preparing your team for competition and helping them improve their skills. Here are some steps you can follow to create effective practice plans:

1. Define your goals: Before you start planning, it's important to have a clear idea of what you want your team to achieve. This might include improving specific skills, working on teamwork, or preparing for an upcoming competition.
2. Break down your goals into smaller objectives: Once you have defined your goals, break them down into smaller, achievable objectives. For example, if your goal is to improve your team's passing skills, you might have objectives such as "improve accuracy," "increase speed," and "work on timing."
3. Choose appropriate drills and exercises: Once you have your objectives, choose drills and exercises that will help your team achieve them. Make sure the drills you choose are appropriate for your team's skill level and address the specific areas you want to improve.
4. Create a schedule: Once you have your drills and exercises, create a schedule that outlines what your team will be doing at each practice. Be sure to include warm-up and cool-down exercises, as well as time for skill-building drills, team-building exercises, and any other activities that will help your team achieve their goals.
5. Make adjustments as necessary: Practice plans are not set in stone, and you may need to make adjustments based on how your team is performing. Pay attention to how your team is responding to the drills and exercises and make adjustments as necessary to ensure they are getting the most out of each practice.
6. Evaluate your progress: After each practice, evaluate your team's progress towards your goals. Make note of areas where your team is excelling and areas where they need more work. Use this information to adjust your practice plans for the next session.

By following these steps, you can create effective practice plans that help your team improve their skills, build teamwork, and prepare for competition. Remember to be flexible and adjust as necessary to ensure your team is getting the most out of each practice session.

[Dealing with internal conflict](#) within a sports team can be challenging for any coach or athletic director. These kinds of rifts can destroy otherwise successful teams. There are many examples of how teams fall apart when their internal cohesion is off.

1. Acknowledge and address the conflict: It's important to acknowledge that there is a conflict within the team and address it head-on. Ignoring it or hoping it will go away on its own is unlikely to be effective.
2. Facilitate communication: Encourage open communication among team members to help them express their concerns, needs, and opinions. It's important to listen to all sides of the conflict and work to find common ground. Promote teamwork: Remind team members that they are a team and that their success depends on everyone working together. Encourage them to focus on the team's goals rather than their individual agendas.
3. Set ground rules: Establish clear ground rules for team behavior, communication, and conflict resolution. Make sure that all team members understand and agree to these rules.
4. Provide support: Provide support and guidance to team members who may be struggling with conflict. This could include one-on-one meetings, counseling, or other resources that may be available.
5. Consider external mediation: If the conflict is particularly difficult to resolve, consider bringing in an external mediator to help facilitate communication and find a resolution.

The coach should strive to create a positive team culture where conflicts are addressed constructively and openly, and team members are empowered to work together to overcome challenges.

The average career path for a coach is very similar to that of an athlete, starting with [youth sports](#) and slowly advancing to older and more competitive leagues as the coach learns and develops their own skills. Considered one of the best coaches of all time [Coach Mike Krzyzewski](#) started as an assistant coach and eventually coached the USA Olympic Men's Basketball team to three gold medals.

Gender pay inequality in professional sports is a hot topic in the athletic world right now.

Professional basketball in America (NBA and [WNBA](#)) shows stark contrasts between what the average player is paid. The average [NBA player](#) makes just over 9.6 million dollars a year, while the average WNBA player makes just under 130 thousand dollars a year. These figures do not include any other income from endorsements or product lines. The total revenue of each league is vastly different as well making some argue that the different pay scales are justified. The NBA profits about 10 billion dollars a year while the WNBA reportedly runs about a 10-million-dollar deficit each year.

Professional tennis players face a significant pay gap between genders as well.

American soccer (football for the rest of the world) is another great comparison for gender pay gaps. Recently [US Soccer](#) has agreed on equal pay for men's and women's national players. Internationally there is still a major gap in pay.

[CrossFit](#) started with and maintains equal reward money for male and female competitors.

The largest argument for unequal pay is that the men's leagues/games earn more money through TV viewership (ad money), ticket sale numbers and prices, and sports merchandise sold.

Critical Thinking

What is your opinion on the athletic gender wage gap? What would be a better solution?

[Title IX](#) is a 1972 law to remove many of the obstacles for girls and women from getting into sports.

"No person in the United States shall, on the basis of sex, be excluded from participation, in be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance."

While Title IX impacts many aspects of public education in the United States, from the scope of coaching and sport management it means that a public school is required to have equal quality sporting equipment, equal facility time, and roughly equal offerings on male and female sports programs. Schools with football programs will sometimes have to offer more female sports to offset the massive cost of football. While Title IX was not specifically designed for athletics it has greatly improved the opportunity for girls to enter athletics.

Classically an athletic director is someone managing the sports teams at a school, usually a high school or college. They will have similar responsibilities as a sports manager or facilities manager for a nonacademic sports team or complex.

Sports management is a field that focuses on the business aspects of sports, including the planning, organizing, and directing of athletic events and programs. It is a multidisciplinary field that draws on kinesiology, business management, and marketing.

One key aspect of sport management is the organization and administration of sporting events, including the responsibilities of building and coordinating schedules, securing facilities, managing budgets, and promoting events to the public. That also includes working with sponsors or vendors, negotiating contracts, and ensuring that all necessary permits and licenses are obtained.

Individuals in sport management as athletic trainers or sports facilities managers will need to develop and implement rules and regulations for their athletes and staff. These rules will cover all aspects of the day-to-day routines but also include drug testing, injury prevention, and facility maintenance.

Sports managers may also play a role in the financial management of the sports organization including setting ticket prices, negotiating contracts with sponsors and broadcasters, or developing a marketing strategy to increase revenue.

All of these external interactions require social skills and finesse in fundraising and making hard financial decisions.

If this chapter was of interest to you and you think combining business with sport is your path forward, consider looking for a Sports Management or Sports Business degree and start to build your experience with youth coaching.

Answers

Critical Thinking

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1.14: Psychology and Sociology of Sport

Learning Objectives

1. Explain what psychology and sociology are, and how they are different.
2. Discuss how stress and sports performance are related.
3. Discuss how sport and violence are connected.

“Citius, Altius, Fortius” is the Olympic motto translated from Latin meaning “Swifter, Higher, Stronger.”

As we learned in Chapter 9 our minds control our actions, meaning how our minds work and think is important to how and why we move our bodies. **Psychology** is the study of the mind and behavioral characteristics of a person. Blending kinesiology with psychology creates the field of sports psychology looking at the mental influence on sports performance, motivation, anxiety, and stress in athletes.

Critical Thinking

What do sports, or competitive physical activity mean to you as a participant or fan?

Sports and games are a vital part of human culture worldwide and have been for as long as humans have existed. Some games we play are less physically active like chess or poker, but many are physically active like kickball or basketball. One thing most games have in common is a competitive aspect that exceeds the physical and enters the mental realm. Many cultures would/do use physical games or activities as rites of passage, especially for boys to become men. As sports are deeply tied to culture, and usually involve more than a single person competing, it is possible to view sports and sport participation through a sociological reference. **Sociology** is the study of society, social groups, and their collective behavior.

The psychological and social aspect of human activity is huge if it is a high school kid shooting the game-winning shot at a home game or the ability of a team to communicate and work towards a common goal. Much of this starts as play as young children and develops into games for older children that have their roots in warfare (As mentioned in Chapter 7). Much as a mother lion will teach its cubs how to hunt by starting with fun and games, human cultures teach their individual members important life skills and fighting through sport and games.

Worldwide the competition in sports is very high starting at a young age for athletes. There can be massive rewards for being the best including college scholarships, multimillion-dollar contracts, fame, and national honor. This can bring the best of an athlete out in hard work, dedication, and a commitment to bettering themselves. This competition can also lead to parents yelling at referees in youth games, athletes cheating, and teams breaking recruitment rules.

Motivation can be subcategorized by its source, internal or external. Internal (intrinsic) motivation is usually driven by the passion or love of the activity. If the pursuit of growth or improvement leads to happiness or pride that effort is made from internal motivation. External (extrinsic) motivation is driven by external rewards such as a college scholarship offer or signing bonus.

One of the most detrimental mental aspects of sports and competition is stress. The worry of not performing at one's best and losing out on those external rewards can be a major cause of stress for athletes. Being tasked with taking the game-winning shot. Understanding that if you do not win the next game the college scouts are not coming to watch you play. Helping athletes find healthy coping mechanisms for this level of stress and anxiety is a key part of sport psychology. Highly stressed or anxious athletes typically perform worse than with their mental health is better balanced. Stress and anxiety chronically affecting athletes can spiral downward as continued lower performance reinforces more and more stress about their performance. This phenomenon is sometimes called the ‘yips’.

A sport psychologist will work with athletes on their mental “game” including drills and exercises for improving concentration, visualization practices, and overcoming mental barriers like the “yips”. In one **study** researchers looked at if visualization could improve basketball free throw shooting accuracy. The results showed a similar improvement to physically shooting free throws daily.

Critical Thinking

Are the rewards associated with being the best in the world at a sport appropriately proportional to the value an athlete brings to their community?

All this pressure to be a top performer can result in cheating. Cheating in sports can take many forms.

The bribing of officials of judges at the top levels of competition is not uncommon. Sports in which athletes are judged and awarded points based on their performance like figure skating or gymnastics are especially susceptible to this form of cheating. In 2002 a cheating scandal in Olympic figure skating was so damaging to the sport that the official rules were changed to combat any future scandals.

Cheating in sports can also happen before games in which one team may try and gain an unfair advantage over their opponent in various ways, including getting access to the other team's playbook of video recording other teams to learn their calls. At higher levels of competition, each sports organization has rules against many of these practices but at the local high school level it can be very hard to enforce or prove.

Cheating during a game by breaking the rules is very common and can happen in many event-specific ways. Each sport has rules that are "agreed" on by all competitors keeping the playing field even. Altering the sports equipment would also be categorized as cheating.

Performance-enhancing drugs (PEDs) are substances that are banned from being used in competition by athletes in that sport. There can be a slight variation on what is or is not banned in a specific sport but most leagues follow closely with the World Anti-Doping Agency (WADA) and their list of prohibited drugs. Notably, CBD has been recently removed from WADA's prohibited drug list but cannabis and THC remain. These drugs generally either allow the athlete to grow muscle tissue faster (anabolic steroids), give the athlete a cardiovascular boost (EPO), improve recovery, reduce pain, or are just illegal drugs (cocaine). Most of these drugs are also shown to cause long-term health repercussions.

Category	Banned Substances
S0 - Non-Approved Substances	Any pharmacological substance that is not addressed by any of the subsequent sections of the list, and with no current approval by any governmental regulatory health authority for human therapeutic use (e.g. drugs under pre-clinical or clinical development or discontinued, designer drugs, veterinary medicines)
S1 - Anabolic Agents	Anabolic Androgenic Steroids (AAS), Other Anabolic Agents such as selective androgen receptor modulators (SARMs)
S2 - Peptide Hormones, Growth Factors, and Related Substances	Erythropoietin (EPO), Growth Hormone (GH) and Insulin-like Growth Factor-1 (IGF-1), Other growth factors and mimetics (e.g. Mechano Growth Factor, Fibroblast Growth Factor, Growth Differentiation Factor 8), Any other substance with similar chemical structure or biological effect(s)
S3 - Beta-2 Agonists	All beta-2 agonists including their D- and L-isomers (e.g. salbutamol, formoterol, and terbutaline) except clenbuterol
S4 - Hormone and Metabolic Modulators	Aromatase inhibitors (e.g. anastrozole, letrozole), Selective estrogen receptor modulators (SERMs) (e.g. tamoxifen, raloxifene), Other anti-estrogenic substances (e.g. fulvestrant), Agents modifying myostatin function(s) including inhibitors of myostatin signalling, Metabolic modulators (e.g. insulin, metformin)
S5 - Diuretics and Masking Agents	All diuretics (e.g. furosemide, hydrochlorothiazide), Masking agents such as plasma expanders (e.g. albumin, dextran) and probenecid
S6 - Stimulants	All stimulants including their D- and L-isomers (e.g. amphetamines, ephedrine, cocaine, methylphenidate)
S7 - Narcotics	All narcotics including their D- and L-isomers (e.g. buprenorphine, codeine, morphine, oxycodone)
S8 - Cannabinoids	All natural and synthetic cannabinoids (e.g. cannabis, hashish, marijuana)
S9 - Glucocorticoids	All glucocorticoids including their D- and L-isomers

With the stress to be the best and the competition for the possible rewards, committees like WADA are important to help preserve athletes' health while chasing greatness. If there were no banned substances an athlete would have to take these drugs to remain

competitive at the top levels of play because everyone else would be reaping the benefits with little thought to future health consequences.

An interesting topic is how some non-cheating unequal advantages are achieved in sports. Some teams live and practice at a much higher altitude above sea level compared to their competition. Living and training at high altitudes results in a greater amount of red blood cells in a person's blood, meaning they can transport oxygen more efficiently to their muscles. When non-adapted athletes from lower altitudes compete they can [perform](#) much poorer than usual. So living and training at a higher altitude does give athletes a distinct non-cheating advantage over the non-altitude adapted competition.

Another clear way for a team to gain a non-cheating edge in the competition is a [home-field advantage](#). Teams at home show a 55% to 65% win rate. Home teams are likely to have a larger and louder audience. Home teams will feel more comfortable in the competition space as they likely practice there daily. Music can be played louder or quieter depending on what team needs to be communicating well at the time.

Many sports involve teamwork, working together as a unit to accomplish the task of that sport to win against an opposing team. This inherently involves many aspects of psychology and sociology. Group communication is done quickly, and effectively, possibly with a very loud crowd surrounding the game, and in a coded way that the other team cannot understand. Usually, this is done with coded play names and hand signs, but these must be practiced and remembered by all members of the team.

Higher performing members of the team are usually selected as team leaders or captains, receive more playing time, and will receive more credit in the press (or popularity at school). How these social inequalities are handled by the team can lead to group cohesion or dissent. As an example: NFL quarterbacks often receive large paychecks, MVP awards, and the most press on ESPN but they understand that without their teammates' none of their success would be possible. It is customary that an NFL quarterback gifts his offensive lineman very nice holiday [presents](#) to show respect, and the value of the lineman's hard work in making the team successful. Team bonding and social inclusion are very important for the group to work together and be successful. Gift-giving can create bonds, but so can [mutual physical suffering](#) from mistakes during practice or games. Most teams train together and if one person makes a mistake that is punished by more running, the whole team receives the punishment. This is a norm from cultural cohesiveness likely from military roots that is seen across the world in different sports and have likely been in practice for all time.

Another psychologically and sociologically impactful aspect of sports is team colors, names, and mascots. This representation of a team and support of that team helps other fans identify each other and know they are part of the same tribe. These team representations are similar to national flags and are proudly worn to represent their allegiance to a specific team. The feelings behind these icons are so strong that they can cause fights or instant friendships between strangers in public. Some fans will even gladly get their team's [logo tattooed](#) on them.

Sports can unite groups together, the desire to work together against a common opponent without life or death stakes brings out the best and worst in humans. Sports also very commonly divide humans by gender. After puberty ages, it is very rare to find coed competitive sports leagues. Gender and sports differences are discussed in depth in Chapter 13.

Violence in Sports

Injury in athletic competition is a daily risk. The physical injury may be minor or serious but if it removes a player from the game for minutes to months it will have a physiological impact on the athlete. If an athlete is pivotal to their team's success, even sitting out for a few minutes to have a possible injury checked (Chapter 11) can feel like the other team is gaining an advantage. If the athlete is injured and has to miss the rest of the game or multiple future games, there can be a big blow to their mental health. Many athletes identify as athletes and feel lost without the ability to train with their team and compete. Serious injuries requiring surgery or months away from the competition can lead to serious mental health decline.

Critical Thinking

How could injured athletes be reassured of their continuing value to the teams? If you were a sports psychologist, how could you turn this "down" time into a benefit for the athlete? (Think visualization, teamwork, communication, and concentration drills)

If a person's mental identity is tied to participation in sports, retirement from sports can be very difficult. If the retirement is

forced from injury or due to aging the league, graduating from school, or a new younger player is hired to replace them, it can be very difficult for an athlete to [find meaning](#) and passion for a new chapter in their life. Many of these athletes have been training and competing in sports from a very young age and could end up feeling like their “life is over” because for years their number one priority has been sport. This is a major hurdle all athletes must eventually face.

If this chapter was of interest to you, and working with athletes on internal motivation, effective teamwork, and stress management sounds exciting you may want to look into pursuing a bachelor's degree in Sports Psychology. After that many states will require a Ph.D. in psychology with post-doctoral work specializing in athletics.

1.15: Future Education and Careers in Kinesiology

Learning Objectives

1. Be prepared to continue your kinesiology education.
2. Understand how to read and digest a research article publication.
3. Find a published study in an area of interest and read it

Hopefully, after reading this textbook you have a great appreciation for how large and varied the field of kinesiology is and have a better idea of what you are personally interested in and want to further pursue in your education and career.

Any field in kinesiology can lead to a rewarding lifelong career but can take years of education and experience along with multiple certifications. These high standards are important because as a kinesiologist you will be working with and informing human beings. Each person you meet is a unique combination of their previous history, injuries, fears, and goals.

There will undoubtedly be much change and advancement in all fields of kinesiology with advancing technology. From more accurate and cheaper personal wearable devices to complete augmented reality simulations for athletic training or rehabilitation environments. Growth and opportunity will continue to expand with a career and education in kinesiology. You could help shape the future of kinesiology!

Kinesiology has become a common and respected major in many American universities. There can be different focuses in each school, so before enrolling in a program it may help to explore their department website and review what research their professors are conducting. If possible, schedule an official visit and visit the campus and labs in person. This is especially true for pursuing a master's or Ph.D.

Remember even once you become a college graduate kinesiologist, maybe even with a few extra certifications, you cannot diagnose people with disease, prescribe treatments, or a regulated diet. Good luck with your future education and career, and welcome to the field of kinesiology!

One more vital skill you will need while pursuing your degree in kinesiology is how to read and evaluate a published research article. Citations for your papers, projects, and presentations will be required to be peer-reviewed research articles on the topics you are discussing. Being able to read and understand these articles is critical. Most if not all kinesiology degrees will include a statistical analysis and research methods class that will go into much greater detail on all of these topics, but here is a great basic start.

Finding quality research articles: your college library will have a database that you can electronically access but <https://pubmed.ncbi.nlm.nih.gov/> is a great website to find information on a wide variety of topics. Many of the cited articles for this textbook were found on PubMed.

Pro tip: check “free full text” for your search so you can find complete articles at no cost. There is some variety of formats for journal publishing, but in general, you can expect to find these major subdivisions in all scientific journals in this order.

Abstract: This is a summary of the entire article; you should be able to read this and understand if that specific article will have the information you are searching for. When searching for information and sources, many times just reading the abstract will give you enough information to understand if the article contains what you are searching for, or if you need to continue looking.

Introduction: The authors should explain the history and current state of the topic or idea they are researching. The authors should also present a case for why this research and possible results are important. After reading the introduction of a paper, a person should feel like they have a general grasp on the presented topic and the outcome of some previous research leading to this paper.

Methods: This section of the paper should explain exactly how the research took place. The who, what, and how of the research was conducted so another scientist could replicate the process exactly. There should be details about the research design, whether was it a cross-over study, a randomized trial, or a survey. In a future research methods course, you will learn much more about these topics. Details on the participants should be presented and explained. The authors should explain clearly how data was

gathered and what was measured along with the statistical math used to evaluate the results.

Results: The data should be presented in a clear and organized way, but without discussion or explanation of what the results might indicate. The authors should detail all significant and non-significant findings. Many times, graphs, charts, or tables can be useful to visually display the data in an easy-to-understand format.

Discussion: This is the section in which the authors will try to explain or interpret their findings. The discussion should be reinforced with other research and findings to build on the body of knowledge in that field. Kinesiology-based research will likely include a discussion of the mechanics or physiology of the body for a suspected or known procedure for the results.

Conclusion: Usually relatively short, in this section the authors will address any unforeseen obstacles that may have hindered the quality of their study. They will also discuss ideas for future research in the same area and what the next questions that need to be answered are.

References: A list of all referenced material cited in the entire paper. This can be very useful for a student to continue “down the rabbit hole.”

Extras: Depending on the publishing journal there will be a few more short sections, acknowledgments, funding sources, grant disclosures, ethics, and conflicting interests. While much shorter in length these can still be very important subsections to read. Is research showing the health benefits of drinking soda valid if it is funded by a soda company?

Critical Thinking

Below is an entire published research article on lifting atlas stones. Review each section at a time and compare your thoughts and notes with a classmate. Did the author clearly explain the entire study in this paper?

<https://pubmed.ncbi.nlm.nih.gov/34557349/>

INDEX

No index terms found.

GLOSSARY

S

Sample Word 1 | Sample Definition 1

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