FITNESS CONCEPTS

K. Varine
Prince George's Community College

Licensing

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K. Varine

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CHAPTER OVERVIEW

2: Healthy Behaviors and Wellness

By Jonathan Howard

Learning Objectives

- Define the nine dimensions of wellness
- Identify health problems in the United States
- Identify the behaviors that promote wellness
- Behavior Modification: how change occurs, barriers to change, and how to successfully
- overcome barriers and make lasting lifestyle changes

2.1: Why Study Wellness?
2.2: Dimensions of Wellness
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2.1: Why Study Wellness?

As most college students do, you have probably set goals. Obviously, your individual goals differ from those of your fellow classmates, but everyone's goals share one common attribute: their intention to improve individual wellbeing. However, there are as many ideas about how to do that as there are individuals. Do your goals involve making more money, achieving better health, improving your relationships? Holistic wellness involves all those aspects of life and more. This chapter explains the importance of overall wellness, which is about more than being physically and mentally healthy, free from illness and disease. In fact, the study of wellness incorporates all aspects of life. Achieving overall wellness means living actively and fully. People in this state exude confidence, optimism, and self-efficacy; they have the energy reserves to do what needs to be done today and to plan for a better tomorrow. The most effective and transformative goals are those designed to achieve the highest level of personal wellness.

2.2: Dimensions of Wellness

Wellness is a familiar term, but what is its true definition? Is it simply the absence of disease? This chapter will define all the components of holistic wellness and describe the factors that contribute to not only a person's physical and mental health, but also their ability to develop, thrive, succeed, enjoy life, and meet challenges head on with confidence and resolve.

To achieve this type of overall wellness, a person must be healthy in nine interconnected dimensions of wellness: physical, emotional, intellectual, spiritual, social, environmental, occupational, financial, and cultural. A description of each dimension follows.

The Nine Dimensions of Wellness

- *Occupational Wellness*
  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.
- *Financial Wellness*
  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
- *Physical Wellness*
  People who are physically well actively make healthy decisions on a daily basis. They eat a nutritionally balanced diet; they try to get an adequate amount of sleep, and they visit the doctor routinely. They make a habit of exercising three to five times per week; they have the ability to identify their personal needs and are aware of their body's limitations. They maintain positive interpersonal relationships and make healthy sexual decisions that are consistent with their personal values and beliefs.
- *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.
- *Intellectual Wellness*
  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.
- *Spiritual Wellness*
  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.
- *Social Wellness*
  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.
- *Environmental Wellness*
  An environmentally well person appreciates the external cues and stimuli that an environment can provide. People who have achieved environmental wellness recognize the limits to controlling an environment and seek to understand the role an individual plays in the environment.
- *Cultural Wellness*
  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.[1]

For more information on the nine dimensions of wellness, click on the link below:

Nine Dimensions of Wellness

A video about the nine dimensions of wellness,

2.3: Health Problems in the United States

Americans today experience health problems that people who lived 100 years ago did not encounter. What are the factors that account for these health problems that have arisen over the past 100 years? Most health problems faced by people in the U.S. are chronic diseases that are preventable and caused by everyday choices and unhealthy lifestyles.

The link below provides more information about the leading causes of death in the United States:

Leading Causes of Death

To see a 2014 chart that shows the leading cause of death by age group, click on the link below:

Leading Cause of Death by Age Group

In the video below, you will learn about the determinants of health as outlined by Healthy People 2020. Healthy People 2020 is a federal advisory committee comprised of non-federal, independent subject matter experts who gather data and provide advice on how to promote health and prevent disease in America:

In the meantime, the Healthy People 2020 program has updated, and been renamed Healthy People 2030 website, which contains data and technical information about the program's objectives. The video below is the announcement for the update

2.4: Behaviors That Promote Wellness

Bad habits are hard to break, but choosing to eat healthier and exercise more provides benefits that go far beyond a more ideal body weight and shape. Being physically fit can stave off many of the diseases and medical conditions discussed in the previous section, including heart disease, the number 1 killer in America. Exercise reduces stress and eases depression. Healthier employees are also more productive. Being physically fit nurtures the mind, body, and spirit and is the cornerstone of wellness. The links below provide information about behaviors within your control that contribute to an improved quality of life and increased wellness.

Six Behaviors That Contribute to Wellness

A video on lifestyle choices and their effect on wellbeing

Behaviors that Contribute to Wellness Presentation

2.5: Behavior Modification

Making permanent lifestyle changes is one of the greatest challenges a person can face. This section will explore how changes to behavior occur, the psychological barriers that hamper efforts to change, and tips for making lasting change.

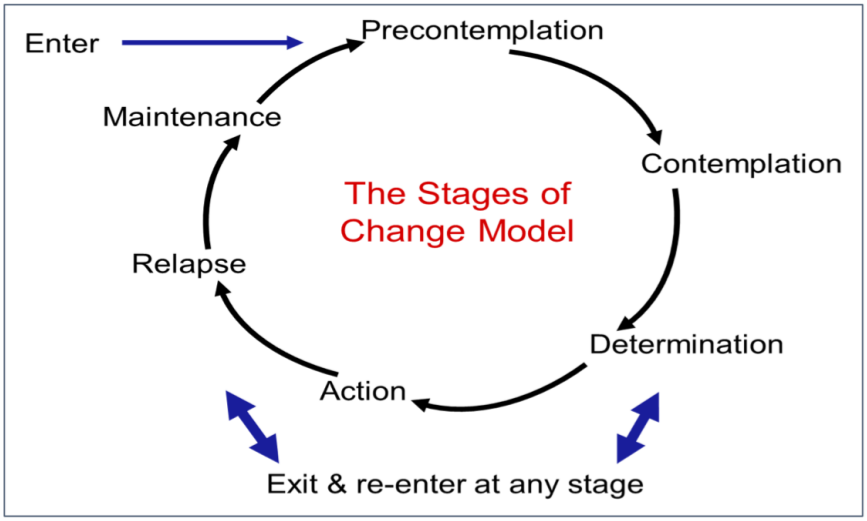
How Changes in Behavior Occur

The Transtheoretical Model, also called the **Stages of Change Model**, was developed by James Prochaska and Carlo DiClemente in the late 1970s. Considered the dominant model for describing how behavior changes occur, it evolved through studies examining the experiences of smokers who quit on their own and comparing them with the experiences of those requiring further treatment. The goal of those studies was to understand why some people were capable of quitting on their own. It was determined that people quit smoking if they were ready to do so. Thus, the Transtheoretical Model (TTM) focuses on the decision-making of the individual and is a model of intentional change. The TTM operates on the assumption that people do not change behaviors quickly and decisively. Rather, change in behavior, especially habitual behavior, occurs continuously through a cyclical process. The TTM is not a theory but a model; different behavioral theories and constructs can be applied to various stages of the model where they may be most effective.

The TTM posits that individuals move through six stages of change: precontemplation, contemplation, preparation, action, maintenance, and termination. Termination was not part of the original model and is less often used in application of stages of change for health- related behaviors. For each stage of change, different intervention strategies are most effective at moving the person to the next stage of change and subsequently through the model to maintenance, the ideal stage of behavior.

Six Stages of Change:

- *Stage 1: Precontemplation*
  In this stage, people do not intend to take action in the foreseeable future (defined as within the next 6 months). People are often unaware that their behavior is problematic or produces negative consequences. People in this stage often underestimate the pros of changing behavior and place too much emphasis on the cons of changing behavior.



- *Stage 2: Contemplation*
  In this stage, people are intending to start the healthy behavior in the foreseeable future (defined as within the next 6 months). People recognize that their behavior may be problematic, and a more thoughtful and practical consideration of the pros and cons of changing the behavior takes place, with equal emphasis placed on both. Even with this recognition, people may still feel ambivalent toward changing their behavior.
- *Stage 3: Preparation (Determination)*
  In this stage, people are ready to take action within the next 30 days. People start to take small steps toward the behavior change, and they believe changing their behavior can lead to a healthier life.
- *Stage 4: Action*
  In this stage, people have recently changed their behavior (defined as within the last 6 months) and intend to keep moving

forward with that behavior change. People may exhibit this by modifying their problem behavior or acquiring new healthy behaviors.

- *Stage 5: Maintenance*
  In this stage, people have sustained their behavior change for a while (defined as more than 6 months) and intend to maintain the behavior change going forward. People in this stage work to prevent relapse to earlier stages.
- *Stage 6: Termination*
  In this stage, people have no desire to return to their unhealthy behaviors and are sure they will not relapse. Since this is rarely reached, and people tend to stay in the maintenance stage, this stage is often not considered in health promotion programs.

To progress through the stages of change, people apply cognitive, affective, and evaluative processes. Ten processes of change have been identified, with some processes being more relevant to a specific stage of change than other processes. These processes result in strategies that help people make and maintain change.

Ten Processes of Change:

1. *Consciousness Raising*Increasing awareness about the healthy behavior.
2. *Dramatic Relief*
   Emotional arousal about the health behavior, whether positive or negative arousal.
3. *Self-Reevaluation*
   Self-reappraisal to realize the healthy behavior is part of who they want to be.
4. *Environmental Reevaluation*
   Social reappraisal to realize how their unhealthy behavior affects others.
5. *Social Liberation*
   Environmental opportunities that exist to show society is supportive of the healthy behavior.
6. *Self-Liberation*
   Commitment to change behavior based on the belief that achievement of the healthy behavior is possible.
7. *Helping Relationships*
   Finding supportive relationships that encourage the desired change.
8. *Counter-Conditioning*
   Substituting healthy behaviors and thoughts for unhealthy behaviors and thoughts.
9. *Reinforcement Management*Rewarding the positive behavior and reducing the rewards that come from negative behavior.
10. *Stimulus Control*
    Re-engineering the environment to have reminders and cues that support and encourage the healthy behavior and remove those that encourage the unhealthy behavior.

Limitations of the Transtheoretical Model

Limitations of the model include the following:

- The theory ignores the social context in which change occurs, such as socioeconomic status and income.
- The lines between the stages can be arbitrary with no set criteria of how to determine a person's stage of change. The questionnaires that have been developed to assign a person to a stage of change are not always standardized or validated.
- No clear sense exists for how much time is needed for each stage, or how long a person can remain in a stage.
- The model assumes that individuals make coherent and logical plans in their decision-making process when this is not always true.

The Transtheoretical Model provides suggested strategies for public health interventions to address people at various stages of the decision-making process. Using strategies suggested by TTM can result in interventions that are more effective because they are tailored for a specific group of people. In other words, the interventions involve a message or program component that has been specifically created for a target population's level of knowledge and motivation. The TTM encourages an assessment of an individual's current stage of change and accounts for relapse in people's decision- making process.[2]

For more information about TTM, especially as it relates to exercise, watch the video

One of the most effective tools for changing behavior is goal setting. The links below provide information on how to set goals effectively to achieve greater success in goal attainment.

Goal Setting Info from Oregon State University's Academic Success Center

Two videos that may help

Making S.M.A.R.T. Goals Activity

2.6: Lifestyle Modification Barriers

Dr. James M. Olson, a psychology professor at the University of Western Ontario, London, has identified several psychological barriers that commonly prevent people from taking action, even when inaction poses a threat to their health. These barriers occur during 3 stages of behavior modification: admission of the problem, initial attempts to change, and long-term change as outlined below:

- *Barriers to Admission of the problem*
  The first step in lasting change is admitting a problem exists. People often fail to change behavior that poses a risk to their health because they deny a risk exists, trivialize their personal risk, feel invulnerable, make a faulty conceptualization, (i.e., they attribute early warning signs to a benign cause), or experience debilitating emotions when contemplating preventative measures.
- *Barriers to Initial Attempts to Change*
  At this stage, people acknowledge the need to change but struggle to accomplish their goals. This failure is a result of lack of knowledge, low self-efficacy (the belief in one's own ability to succeed at change), and dysfunctional attitudes.
- *Barriers to long-term change*
  Just because a person has experienced success in changing a behavior, that doesn't mean the change is permanent. Barriers to long-term change include cognitive and motivational drift (diminishing enthusiasm for the need to change), lack of perceived improvement, lack of social support, and lapses.

To read more about these barriers to change, including strategies for overcoming these barriers, read Dr. Olson's entire article linked below:

Psychological Barriers to Behavior Change

A presentation on overcoming barriers to change by the National Institute for Health and Clinical Excellence (NHS) is linked below:

Overcoming Barriers to Change

Fostering Wellness in Your Life

You are once again feeling motivated to eat better, exercise more, drink less caffeine or make any number of the positive lifestyle changes you have been telling yourself you want to make. You have tried before— probably declaring another attempt as a New Year's resolution—but without experiencing much success. Making a lifestyle change is challenging, especially when you want to transform many things at once. This time, think of those changes not as a resolution but as an evolution.

Lifestyle changes are a process that take time and require support. Once you are ready to make a change, the difficult part is committing and following through. So do your research and make a plan that will prepare you for success. Careful planning means setting small goals and taking things one step at a time.

Here are five tips from the American Psychological Association (APA) that will assist you in making lasting, positive lifestyle and behavior changes:

- *Make a plan that will stick.*
  Your plan is a map that will guide you on this journey of change. You can even think of it as an adventure. When making your plan, be specific. Want to exercise more? Detail the time of day when you can take walks and how long you will walk. Write everything down, and ask yourself if you are confident that these activities and goals are realistic for you. If not, start with smaller steps. Post your plan where you will most often see it as a reminder.
- *Start small*.
  After you've identified realistic short-term and long-term goals, break down your goals into small, manageable steps that are specifically defined and can be measured. Is your long-term goal to lose 20 pounds within the next five months? A good weekly goal would be to lose one pound a week. If you would like to eat healthier, consider as a goal for the week replacing dessert with a healthier option, like fruit or yogurt. At the end of the week, you will feel successful knowing you met your goal.
- *Change one behavior at a time*. Unhealthy behaviors develop over the course of time, so replacing unhealthy behaviors with healthy ones requires time. Many people run into problems when they try to change too much too fast. To improve your success, focus on one goal or change at a time. As new healthy behaviors become a habit, try to add another goal that works toward the overall change you are striving for.

- *Involve a buddy.*
  Whether it be a friend, co-worker or family member, someone else on your journey will keep you motivated and accountable. Perhaps it can be someone who will go to the gym with you or someone who is also trying to stop smoking. Talk about what you are doing. Consider joining a support group. Having someone with whom to share your struggles and successes makes the work easier and the mission less intimidating.
- *Ask for support.*
  Accepting help from those who care about you and will listen strengthens your resilience and commitment. If you feel overwhelmed or unable to meet your goals on your own, consider seeking help from a psychologist. Psychologists are uniquely trained to understand the connection between the mind and body, as well as the factors that promote behavior change. Asking for help does not mean a lifetime of therapy; even just a few sessions can help you examine and set attainable goals or address the emotional issues that may be getting in your way.

Start with "Why?"

Making changes in habitual behavior requires a deep and abiding belief that change is needed. Your desire to change may be motivated by personal goals, or it may be the result of the impact your improved wellness will have on those you love. Nietzsche said, "He who has a strong enough *why* can bear almost any *how*."

Once you have a compelling reason to change, develop a plan and commit to that plan. If you experience a moment of weakness, do not waste time on self- condemnation. Revisit your compelling reason and reaffirm your commitment to change. The health, peace, and sense of wellbeing inherent in the highest level of your own personal wellness is more than worth the effort required to change.

For more information about making permanent lifestyle changes, go to the APA website linked below:

LIfestyle Changes That Last

2.7: Assessing Your Personal Lifestyle Behaviors

Complete the following lab. Please print, complete, and submit the evaluation linked below to D2L.

Lifestyle Evaluation Lab

[1]Auburn University. Division of Student Affairs.

[2]Boston University School of Public Health.

CHAPTER OVERVIEW

3: Fitness Principles

By Scott Flynn

Learning Objectives

- Describe the origins of exercise
- Define physical activity and exercise
- Discuss principles of adaptation to stress
- Provide guidelines for creating a successful fitness program
- Identify safety concerns

3.1: Exercise- Not a Passing Fad
3.2: What are Physical Activity and Exercise?
3.3: Principles of Adaptation to Stress
3.4: Creating a Successful Fitness Plan
3.5: Additional Safety Concerns
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3.1: Exercise- Not a Passing Fad

The benefits of physical activity and exercise are universally recognized—and have been for far longer than one might think. Our Paleolithic ancestors regularly engaged in physical activity to survive. However, rather than chasing after a soccer ball to win a game or taking a leisurely stroll down a tree-lined path, they "worked out" by chasing after their next meal. For them, no exercise meant no food. How's that for a health benefit?

With the advent of sedentary agriculture some 10,000 years ago, that same level of peak performance was no longer necessary. As our ancestors continued to devise more advanced means of acquiring food, physical activity declined. It wasn't until the fourth century BCE, that the Greek physician Herodicus, recognized the importance of being physically active outside of a hunter-gatherer society. He practiced gymnastic medicine, a branch of Greek medicine that relied on vigorous exercise as a treatment. During that same time period, Hippocrates, who is often referred to as the Father of Modern Medicine, asserted, "If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health." In the 12 century CE, the Jewish philosopher Rabbi Moses ben Maimon, a physician to the Sultan of Egypt, stated, "Anyone who lives a sedentary life and does not exercise, even if he eats good foods and takes care of himself according to proper medical principles, all his days will be painful ones and his strength will wane." The 15th century theologian and scholar Robert Burton went so far as to declare that *not* exercising, or "idleness" as he referred to it in his widely read tome, *The Anatomy of Melancholy*, was the "bane of body and mind." Burton also warned that the lack of exercise was the sole cause of melancholy (the name given depression at that time) and "many other maladies." Burton claimed that idleness was one of the seven deadly, as well as "the nurse of naughtiness," and the "chief author of mischief." For Burton, exercise was not only essential for good health, but a means of avoiding eternal damnation.

By the 16th century, the benefits of exercise were widely accepted, at least among the wealthy and the educated, who had access to leisure. During this time period, H. Mercuralis defined exercise as "the deliberate and planned movement of the human frame, accompanied by breathlessness, and undertaken for the sake of health or fitness." This definition is still widely used today.

Beyond the physical health benefits, there are affective benefits associated with group games and activities. Ancient Mayans organized the first team game called the Ball Game. It consisted of two teams trying to get a ball through a hoop mounted approximately 23 feet on a wall. The rules were to get the ball through the hoop using certain parts of the body. In some cases the captain of the losing team gave himself as a human sacrifice to the winning team, an act that was believed by the Mayans to be a vital part of prosperity.

American Indians are thought to have founded the modern game of lacrosse, as well as other stick games. Lacrosse, which received its name from French settlers, was more than a form of recreation. It was a cultural event used to settle disputes between tribes.

Figure 3.1.1: *Lacrosse Players. George Catlin. Date unknown.*

The outcome of the game, as well as the choosing of teams, was thought to be controlled supernaturally. As such, game venues and equipment were prepared ritualistically.

From Ancient History to Modern Times

In retrospect, the perceived benefits of exercise have changed very little since Herodicus or the American Indians. Mounting research supports historical assertions that exercise is vital to sustaining health and quality of life. Culturally, sports play a huge role in growth and development of youth and adults. Physically, there is indisputable evidence that regular exercise promotes healthy functioning of the brain, heart, and the skeletal and muscular systems. Exercise also reduces risk for chronic diseases, such as cancer, diabetes, and obesity. Regular exercise can even improve emotional health and overall wellbeing.

3.2: What are Physical Activity and Exercise?

Physical activity is defined as any movement carried out by skeletal muscle that requires energy and is focused on building health. Health benefits include improved blood pressure, blood-lipid profile, and heart health. Acceptable physical activity includes yard work, house cleaning, walking the dog, or taking the stairs instead of the elevator. Physical activity does not have to be done all it once. It can be accumulated through various activities throughout the day. Although typing on a phone or laptop or playing video games does involve skeletal muscle and requires a minimal amount of energy, the amount required is not sufficient to improve health.

Despite the common knowledge that physical activity is tremendously beneficial to one's health, rates of activity among Americans continue to be below what is needed. According to the Center for Disease Control (CDC), only 1 in 5 (21%) of American adults meet the recommended physical activity guidelines from the Surgeon General. Less than 3 in 10 high school students get 60 minutes or more of physical activity per day. Non-Hispanic whites (26%) are more active than their Hispanic (16%) and Black counterparts (18%) as is the case for males (54%) and females (46%). Those with more education and those whose household income is higher than poverty level are more likely to be physically active.1

The word *exercise*, although often used interchangeably with the phrase *physical activity*, denotes a sub-category of physical activity. **Exercise** is a planned, structured, and repetitive movement pattern intended to improve fitness. As a positive side-effect, it significantly improves health as well. Fitness improvements include the heart's ability to pump blood, increased muscle size, and improved flexibility.

Components of Health-Related Fitness

In order to carry out daily activities without being physically overwhelmed, a minimal level of fitness is required. To perform daily activities without fatigue, it is necessary to maintain health in five areas: cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition. These five areas are called the components of health- related fitness. Development of these areas will improve your quality of life, reduce your risk of chronic disease, and optimize your health and well-being. Each of these 5 areas will be explored in depth at a later time. Below is a brief description of each.

- *Cardiorespiratory endurance*Cardiorespiratory endurance is the ability to carry out prolonged, large muscle, dynamic movements at a moderate to high level of intensity. This relates to your heart's ability to pump blood and your lungs' ability to take in oxygen.
- *Muscular strength*
  Muscular strength is the ability of the muscles to exert force over a single or maximal effort.
- *Muscular endurance*
  Muscular endurance is the ability to exert a force over a period of time or repetitions.
- *Flexibility*
  Flexibility is the ability to move your joints through a full range of motion.
- *Body Composition*
  Body composition is the relative amount of fat mass to fat-free mass.

As previously stated, these areas are significant in that they influence your quality of life and overall health and wellness.

Skill-Related Components of Fitness

In addition to the 5 health-related components, there are 6 skill-related components that assist in developing optimal fitness: speed, agility, coordination, balance, power, and reaction time. Although important, these areas do not directly affect a person's health. A person's ability to perform ladder drills (also known as agility drills) is not related to his/her heart health. However, coordination of muscle movements may be helpful in developing muscular strength through resistance training. As such, they may indirectly affect the 5 areas associated with health-related fitness. Skill- related components are more often associated with sports performance and skill development.

- **2.2: What are Physical Activity and Exercise?** by Scott Flynn, Jonathan Howard, Lisa Jellum, and Althea Moser is licensed CC BY-NC-ND 4.0. Original source: https://oer.galileo.usg.edu/cgi/viewcontent.cgi?article=1005&context=health-textbooks.

3.3: Principles of Adaptation to Stress

The human body adapts well when exposed to stress. The term *stress*, within the context of exercise, is defined as an exertion above the normal, everyday functioning. The specific activities that result in stress vary for each individual and depend on a person's level of fitness. For example, a secretary who sits at a desk all day may push his/her cardiorespiratory system to its limits simply by walking up several flights of stairs. For an avid runner, resistance training may expose the runner's muscles to muscular contractions the athlete is not accustomed to feeling. Although stress is relative to each individual, there are guiding principles in exercise that can help individuals manage how much stress they experience to avoid injury and optimize their body's capacity to adapt. Knowing a little about these principles provides valuable insights needed for organizing an effective fitness plan.

Overload Principle

Consider the old saying, "No pain, no gain." Does exercise really have to be painful, as this adage implies, to be beneficial? Absolutely not. If that were true, exercise would be a lot less enjoyable. Perhaps a better way to relay the same message would be to say that improvements are driven by stress. Physical stress, such as walking at a brisk pace or jogging, places increased stress on the regulatory systems that manage increased heart rate and blood pressure, increased energy production, increased breathing, and even increased sweating for temperature regulation. As these subsequent adaptations occur, the stress previously experienced during the same activity, feels less stressful in future sessions. As a result of the adaptation, more stress must be applied to the system in order to stimulate improvements, a principle known as the **overload principle**.

For example, a beginning weightlifter performs squats with 10 repetitions at 150 pounds. After 2 weeks of lifting this weight, the lifter notices the 150 pounds feels easier during the lift and afterwards causes less fatigue. The lifter adds 20 pounds and continues with the newly established stress of 170 pounds. The lifter will continue to get stronger until his/her maximum capacity has been reached, or the stress stays the same, at which point the lifter's strength will simply plateau. This same principle can be applied, not only to gain muscular strength, but also to gain flexibility, muscular endurance, and cardiorespiratory endurance.

FITT

In exercise, the amount of stress placed on the body can be controlled by four variables: **F**requency, **I**ntensity, **T**ime (duration), and **T**ype, better known as FITT. The FITT principle, as outlined by the American College of Sports Medicine (ACSM) falls under the larger principle of overload.

Frequency and Time

Each variable can be used independently or in combination with other variables to impose new stress and stimulate adaptation. Such is the case for frequency and time.

Frequency relates to how often exercises are performed over a period of time. In most cases, the number of walking or jogging sessions would be determined over the course of a week. A beginner may determine that 2–3 exercise sessions a week are sufficient enough to stimulate improvements. On the other hand, a seasoned veteran may find that 2–3 days is not enough to adequately stress the system. According to the overload principle, as fitness improves, so must the stress to ensure continued gains and to avoid plateauing.

The duration of exercise, or time, also contributes to the amount of stress experienced during a workout. Certainly, a 30-minute brisk walk is less stressful on the body than a 4-hour marathon.

Although independent of one another, frequency and time are often combined into the blanket term, **volume**. The idea is that volume more accurately reflects the amount of stress experienced. This can be connected to the **progression principle**. For example, when attempting to create a jogging plan, you may organize 2 weeks like this:

- Week 1: three days a week at 30 minutes per session
- Week 2: four days a week at 45 minutes per session

At first glance, this might appear to be a good progression of frequency and time. However, when calculated in terms of volume, the aggressive nature of the progression is revealed. In week 1, three days at 30 minutes per session equals 90 minutes of total exercise. In week two, this amount was doubled with four days at 45 minutes, equaling 180 minutes of total exercise. Doing too much, too soon, will almost certainly lead to burnout, severe fatigue, and injury. The progression principle relates to an optimal overload of the body by finding an amount that will drive adaptation without compromising safety.

Type of Exercise

Simply put, the type of exercise performed should reflect a person's goals. In cardiorespiratory fitness, the objective of the exercise is to stimulate the cardiorespiratory system. Other activities that accomplish the same objective include swimming, biking, dancing, cross country skiing, aerobic classes, and much more. As such, these activities can be used to build lung capacity and improve cellular and heart function.

However, the more specific the exercise, the better. While vigorous ballroom dancing will certainly help develop the cardiorespiratory system, it will unlikely improve a person's 10k time. To improve performance in a 10k, athletes spend the majority of their time training by running, as they will have to do in the actual 10k. Cyclists training for the Tour de France, spend up to six hours a day in the saddle, peddling feverishly. These athletes know the importance of training the way they want their body to adapt. This concept, called the **principle of specificity**, should be taken into consideration when creating a training plan.

In this discussion of type and the principle of specificity, a few additional items should be considered. Stress, as it relates to exercise, is very specific. There are multiple types of stress. The three main stressors are metabolic stress, force stress, and environmental stress. Keep in mind, the body will adapt based on the type of stress being placed on it.

Metabolic stress results from exercise sessions when the energy systems of the body are taxed. For example, sprinting short distances requires near maximum intensity and requires energy (ATP) to be produced primarily through anaerobic pathways, that is, pathways not requiring oxygen to produce ATP. Anaerobic energy production can only be supported for a very limited time (10 seconds to 2 minutes). However, distance running at steady paces requires aerobic energy production, which can last for hours. As a result, the training strategy for the distance runner must be different than the training plan of a sprinter, so the energy systems will adequately adapt.

Likewise, force stress accounts for the amount of force required during an activity. In weightlifting, significant force production is required to lift heavy loads. The type of muscles being developed, fast-twitch muscle fibers, must be recruited to support the activity. In walking and jogging, the forces being absorbed come from the body weight combined with forward momentum. Slow twitch fibers, which are unable to generate as much force as the fast twitch fibers, are the type of muscle fibers primarily recruited in this activity. Because the force requirements differ, the training strategies must also vary to develop the right kind of musculature.

Environmental stress, such as exercising in the heat, places a tremendous amount of stress on the thermoregulatory systems. As an adaptation to the heat, the amount of sweating increases as does plasma volume, making it much easier to keep the body at a normal temperature during exercise. The only way to adapt is through heat exposure, which can take days to weeks to properly adapt.

In summary, to improve performance, being specific in your training, or training the way you want to adapt, is paramount.

Intensity

Intensity, the degree of difficulty at which the exercise is carried out, is the most important variable of FITT. More than any of the other components, intensity drives adaptation. Because of its importance, it is imperative for those beginning a fitness program to quantify intensity, as opposed to estimating it as hard, easy, or somewhere in between. Not only will this numeric value provide a better understanding of the effort level during the exercise session, but it will also help in designing sessions that accommodate individual goals.

How then can intensity be measured? Heart rate is one of the best ways to measure a person's effort level for cardiorespiratory fitness. Using a percentage of maximum lifting capacity would be the measure used for resistance training.

Rest, Recovery, and Periodization

For hundreds of years, athletes have been challenged to balance their exercise efforts with performance improvements and adequate rest. The **principle of rest and recovery** (**or principle of recuperation**) suggests that rest and recovery from the stress of exercise must take place in proportionate amounts to avoid too much stress. One systematic approach to rest and recovery has led exercise scientists and athletes alike to divide the progressive fitness training phases into blocks, or periods. As a result, optimal rest and recovery can be achieved without overstressing the athlete. This training principle, called **periodization**, is especially important to serious athletes but can be applied to most exercise plans as well. The principle of periodization suggests that training plans incorporate phases of stress followed by phases of rest.

Training phases can be organized on a daily, weekly, monthly, and even multi-annual cycles, called micro-, meso-, and macrocycles, respectively. An example of this might be:

Week	Frequency	Intensity	Time	Type
1	3 days	40% HRR	25 min	walk
2	4 days	40% HRR	30 min	walk
3	4 days	50% HRR	35 min	walk
4	2 days	30% HRR	30 min	other

As this table shows, the volume and intensity changes from week 1 to week 3. But, in week 4, the volume and intensity drops significantly to accommodate a designated rest week. If the chart were continued, weeks 5-7 would be "stress" weeks and week 8 would be another rest week. This pattern could be followed for several months.

Without periodization, the stress from exercise would continue indefinitely eventually leading to fatigue, possible injury, and even a condition known as**overtraining syndrome**. Overtraining syndrome is not well understood. However, experts agree that a decline in performance resulting from psychological and physiological factors cannot be fixed by a few days' rest. Instead, weeks, months, and sometimes even years are required to overcome the symptoms of overtraining syndrome. Symptoms include the following:

- Weight loss
- Loss of motivation
- Inability to concentrate or focus
- Feelings of depression
- Lack of enjoyment in activities
- Normally considered enjoyable
- Sleep disturbances
- Change in appetite

Reversibility

Chronic adaptations are not permanent. As the saying goes, "Use it or lose it."
The **principle of reversibility** suggests that activity must continue at the same level to keep the same level of adaptation. As activity declines, called **detraining**, adaptations will recede.

In cardiorespiratory endurance, key areas, such as VO_{2max}, stroke volume, and cardiac output all declined with detraining while submaximal heat rate increased. In one study, trained subjects were given bed rest for 20 days. At the end of the bed rest phase, VO_{2max} had fallen by 27% and stroke volume and cardiac output had fallen by 25%. The most well-trained subjects in the study had to train for nearly 40 days following bed rest to get back into pre-rest condition. In a study of collegiate swimmers, lactic acid in the blood after a 2- minute swim more than doubled after 4 weeks of detraining, showing the ability to buffer lactic acid was dramatically affected.[2]

Not only is endurance training affected, but muscular strength, muscular endurance, and flexibility all show similar results after a period of detraining.

Individual Differences

While the principles of adaptation to stress can be applied to everyone, not everyone responds to stress in the same way. In the HERITAGE Family study, families of 5 (father, mother, and 3 children) participated in a training program for 20 weeks. They exercised 3 times per week, at 75% of their VO_{2max}, increasing their time to 50 minutes by the end of week 14. By the end of the study, a wide variation in responses to the same exercise regimen was seen by individuals and families. Those who saw the most improvements saw similar percentage improvements across the family and vice versa. Along with other studies, this has led researchers to believe individual differences in exercise response are genetic. Some experts estimate genes to contribute as much as 47% to the outcome of training.

In addition to genes, other factors can affect the degree of adaptation, such as a person's age, gender, and training status at the start of a program. As one might expect, rapid improvement is experienced by those with a background that includes less training, whereas those who are well trained improve at a slower rate.

Activity Guidelines

Below are links to the physical activity guidelines provided by the US Department of Health and Human Services and the American College of Sports Medicine (ACSM). As you review these recommendations, notice how closely they follow the FITT pattern described earlier in the chapter.

NIH Recommendations for Physical Activity

ACSM Physical Activity Guidelines

Fitness Guidelines

The recommendations linked above pertain to physical activity only. While they can be applied to fitness, more specific guidelines have been set to develop fitness. As stated previously, physical activity is aimed at improving health; exercise is aimed at improving health and fitness. These guidelines will be referenced often as each health-related component of fitness is discussed.

3.4: Creating a Successful Fitness Plan

Often, the hardest step in beginning a new routine is simply starting the new routine. Old habits, insufficient motivation, lack of support, and time constraints all represent common challenges when attempting to begin a new exercise program. Success, in this case, is measured by a person's ability to consistently participate in a fitness program and reap the fitness benefits associated with a long-term commitment.

Think Lifestyle

Beginning a fitness program is a daunting task. To illustrate the concept of lifestyle, consider attendance at fitness centers during the month of January. Attendance increases dramatically, driven by the number 1 New Year's resolution in America: losing weight. Unfortunately, as time marches on, most of these new converts do not. By some estimates, as many as 80% have stopped coming by the second week in February. As February and March approach, attendance continues to decline, eventually falling back to pre-January levels.

Why does this occur? Why aren't these new customers able to persist and achieve their goal of a healthier, leaner body? One possible explanation: patrons fail to view their fitness program as a lifestyle. The beginning of a new year inspires people to make resolutions, set goals, as they envision a new and improved version of themselves. Unfortunately, most of them expect this transformation to occur in a short period of time. When this does not happen, they become discouraged and give up.

Returning to teen level weight and/or fitness may be an alluring, well-intended goal, but one that is simply unrealistic for most adults. The physical demands and time constraints of adulthood must be taken into consideration for any fitness program to be successful. Otherwise, any new fitness program will soon be abandoned and dreams of physical perfection fade, at least until next January.

Like any other lifestyle habit, optimal health and fitness do not occur overnight. Time and, more importantly, consistency, drive successful health and fitness outcomes. The very term *lifestyle* refers to changes that are long term and become incorporated into a person's daily routine. Unlike many fad diets and quick fixes advertised on television, successful lifestyle changes are also balanced and reasonable. They do not leave you feeling depressed and deprived after a few days. Find a balance between what you want to achieve and what you are realistically able to do. Finally, you must do more than simply change your behaviors. You must also modify your mental perception to promote long-term health. Find a compelling reason for incorporating healthier behaviors into your daily routine.

The steps below will guide you through this process. Before beginning a fitness program, you should understand the safety concerns associated with exercise.

Safety First: Assessing Your Risk

The physical challenges of beginning a new exercise program increase the risk of injury, illness, or even death. Results from various studies suggest vigorous activity increases the risk of acute cardiac heart attacks and/or sudden cardiac death.3 While that cautionary information appears contradictory to the previously identified benefits of exercise, the long-term benefits of exercise unequivocally outweigh its risks. In active young adults (younger than 35), incidence of cardiac events are still rare, affecting 1 in 133,000 in men and 1 in 769,000 in women. In older individuals, 1 in 18,000 experience a cardiac event. 4

Of those rare cardiac incidents that do occur, the presence of preexisting heart disease is the common thread, specifically, atherosclerosis. **Atherosclerosis** causes arteries to harden and become clogged with plaque, which can break apart, move to other parts of the body, and clog smaller blood vessels. As such, it is important to screen individuals for risk factors associated with heart disease before they begin an exercise program.

The American College of Sports Medicine recommends a thorough pre-screening to identify any risk of heart disease. The 7 major risk factors associated with increased risk of heart disease are identified below.[5]

- *Family history*
  Having a father or first-degree male relative who has experienced a cardiac event before the age of 55, or a mother or first-degree female relative who has experienced a cardiac event before age 65, could indicate a genetic predisposition to heart disease.
- *Cigarette smoking*
  The risk of heart disease is increased for those who smoke or have quit in the past 6 months.

- *Hypertension*
  Having blood pressure at or above 140 mm/HG systolic, 90 mm/Hg diastolic is associated with increased risk of heart disease.
- *Dyslipidemia*
  Having cholesterol levels that exceed recommendations (130 mg/dL, HDL below 40 mg/dL), or total cholesterol of greater than 200 mg/dL increases risk.
- *Impaired fasting glucose (diabetes)*Blood sugar should be within the recommended ranges.
- *Obesity*
  Body mass index greater than 30, waist circumference of larger than 102 cm for men and larger than 88 cm for women, or waist to hip ratio of less than 0.95 men, or less than 0.86 women increases risk of heart disease.
- *Sedentary lifestyle*
  Persons not meeting physical activity guidelines set by US Surgeon General's Report have an increased risk of heart disease.

In addition to identifying your risk factors, you should also complete a Physical Activity Readiness Questionnaire (PAR-Q) before beginning an exercise program. The PAR-Q asks yes or no questions about symptoms associated with heart disease. Based on your responses on the PAR-Q, you will be placed into a risk category: low, moderate, high.

- Low risk persons include men younger than 45, and women younger than 55, who answer no to all of the PAR-Q questions and have one or no risk factors. Although further screening is a good idea, such as getting physician's approval, it isn't necessary.
- Moderate risk persons are men of or greater than 45, women 55 or those who have two or more risk factors. Because of the connection between cardiac disease, the seven risk factors, and risk during exercise, it is recommended you get a physician's approval before beginning an exercise program.
- High risk persons answer yes to one or more of the questions on the PAR-Q. Physician's approval is required before beginning a program.

Once you have determined your ability to safely exercise, you are ready to take the next steps in beginning your program. Additional safety concerns, such as where you walk and jog, how to be safe during your workout, and environmental conditions, will be addressed at a later time.

As you review the remaining steps, a simple analogy may help to better conceptualize the process.

Imagine you are looking at a map because you are traveling to a particular location and you would like to determine the best route for your journey. To get there, you must first determine your current location and then find the roads that will take you to your desired location. You must also consider roads that will present the least amount of resistance, provide a reasonably direct route, and do not contain any safety hazards along the way. Of course, planning the trip, while extremely important, is only the first step. To arrive at your destination, you must actually drive the route, monitoring your car for fuel and/or malfunction, and be prepared to reroute should obstacles arise.

Preparing yourself for an exercise program and ultimately, adopting a healthier lifestyle, requires similar preparation. You will need to complete the following steps:

- *Assess your current fitness*Where are you on the map?
- *Set goals*
  What is your destination's location?
- *Create a plan*
  What route will you choose?
- *Follow through*Start driving!

Assess Your Condition

To adequately prepare, you will need to take a hard look at your current level of

fitness. With multiple methods of assessing your fitness, you should select the one that most closely applies to you. Obtaining a good estimate will provide you a one-time glance at your baseline fitness and health and provide a baseline measurement for gauging the efficacy of your fitness program in subsequent reassessments.

Assessments are specific to each health- related component of fitness. You will have the opportunity to assess each one in the near future.

Set Goals

Using the map analogy, now that you know your current location, you must determine your destination and the best route for getting there. You can start by setting goals. In his bestselling book, *The 7 Habits of Highly Effective People*, author Stephen Covey suggests you should "Begin with the end in mind."7 While Covey's words may not be directly aimed at those seeking to complete a fitness program, his advice is useful to anyone making a significant lifestyle change. To be successful, you must develop a clear vision of your destination. Setting specific goals about how you want to feel and look, increases your chances of success. Without specific goals to measure the success of your efforts, you could possibly exceed your target and believe you failed.

The art of setting goals includes stating them in a clearly defined and measurable way. Consider exactly what you would like to accomplish, make certain your goals can be measured, and establish a reasonable timeframe in which to achieve your goals.

Goals that meet these guidelines are referred to as S.M.A.R.T. goals.

- **S**pecific
  Be as specific and detailed as possible in creating your goal.
- **M**easurable: If your goal cannot be measured, you will not know when you have successfully completed the goal.
- **A**ttainable
  Consider whether you have the resources—such as time, family support, and financial means—to obtain your goal.
- **R**ealistic
  While your goal should be challenging, it should not exceed reasonable expectations.
- **T**imeframe
  Set a deadline to accomplish your goal.

A well-stated goal contains all of the SMART components listed above. Take a look at the well-stated example below:

Example 3.4.1:

I will improve my 12-minute distance by 10% within 2 months of the first assessment.

Note, all the ingredients of a well-stated goal are present. It is specific (improve 12- minute distance by 10%), measurable (10% improvement), attainable and realistic (the degree of improvement is reasonable in that time frame), and includes a time frame (a clear deadline of 2 months).

Less effective goals would be stated like this:

- I will run farther next time I assess my fitness.
- I want to jog faster.
- I will lose weight

And a common one:

- I will exercise 3 days a week at 60% max heart rate for 45 minutes per session for 2 months.

At a closer glance, none of these examples contain all of the ingredients of a well- stated goal. How can "faster" be measured? "Farther" is not specific enough, nor is "lose weight." In the last example, this is not a goal at all. It is a plan to achieve a goal that has not been stated.

In the end, setting up well-stated goals will give you the best chance to convert good intentions into a healthier lifestyle.

To complete this step, write down 2-3 personal goals, stated in the SMART format, and put them in a place you will see them frequently.

Create a Plan

Once you know exactly what you want to achieve, generate a strategy that will help you reach your goals. As you strategize, your goal is to determine the frequency, the intensity, and the duration of your exercise sessions. While doing this, it is imperative to keep in mind a few key principles.

First, use your goals as the foundation for your program. If your goal is related to weight loss, this should drive the frequency, duration, and intensity of your daily workouts as these variables will influence your body's use of fat for fuel and the number of

calories burned. If you feel more interested in improving your speed, you will need to dedicate more workout time to achieving those results.

Another key principle is the importance of safety. The importance of designing a program that is safe and effective cannot be overstated. You can minimize any risks by relying on the expert recommendations of the US Department of Health and Human Services and the American College of Sports Medicine previously outlined and linked here. These highly reputable organizations have conducted extensive research to discover the optimal frequency, intensity, and duration for exercise.

Follow Through

Once you have assessed your current fitness levels, set goals using the SMART guidelines, and created your personalized fitness plan, you should feel very proud of yourself! You have made significant progress toward achieving a healthier lifestyle. Now is when the "rubber hits the road." (Literally so, if your plan includes walking or jogging.) Now that you have invested time and energy to develop a thoughtful, well-designed fitness program, it is time to reap the returns of good execution. The assessment, planning and preparation are really the hardest parts. Once you know what to do and how to do it, success is simply a matter of doing it.

Unfortunately, the ability to stick with a program proves difficult for most. To prevent getting derailed from your program, identify barriers that may prevent you from consistently following through. One of the most common challenges cited is a shortage of time. Work schedules, school, child care, and the activities of daily living can leave you with little time to pursue your goals. Make a list of the items that prevent you from regularly exercising and then analyze your schedule and find a time for squeezing in your exercise routine. Regardless of when you schedule your exercise, be certain to exercise consistently. Below are a few additional tips for achieving consistency in your daily fitness program:

- *Think long term; think lifestyle.*
  The goal is to make exercise an activity you enjoy every day throughout your life. Cultivating a love for exercise will not occur overnight and developing your ideal routine will take time. Begin with this knowledge in mind and be patient as you work through the challenges of making exercise a consistent part of your life.
- *Start out slowly.*
  Again, you are in this for the long haul. No need to overdo it in the first week. Plan for low intensity activity, for 2–3 days per week, and for realistic periods of time (20–30 minutes per session).
- *Begin with low Intensity/low volume.*
  As fitness improves, you will want to gradually increase your efforts in terms of quantity and quality. You can do this with more time and frequency (called volume) or you can increase your intensity. In beginning a program, do not change both at the same time.
- *Keep track.*
  Results from a program often occur slowly, subtly, and in a very anti- climactic way. As a result, participants become discouraged when immediate improvements are not visible. Keeping track of your consistent efforts, body composition, and fitness test results and seeing those subtle improvements will encourage and motivate you to continue.
- *Seek support.*
  Look for friends, family members, clubs, or even virtual support using apps and other online forums. Support is imperative as it provides motivation, accountability, encouragement, and people who share a common interest, all of which are factors in your ability to persist in your fitness program.
- *Vary your activities from time to time.*
  Your overall goals are to be consistent, build your fitness, and reap the health benefits associated with your fitness program. Varying your activities occasionally will prevent boredom. Instead of walking, play basketball or ride a bike. Vary the location of your workout by discovering new hiking trails, parks or walking paths.
- *Have fun.*
  If you enjoy your activities, you are far more likely to achieve a lasting lifestyle change. While you cannot expect to be exhilarated about exercising every day, you should not dread your daily exercise regimen. If you do, consider varying your activities more, or finding a new routine you find more enjoyable.
- *Eat healthier.*
  Nothing can be more frustrating than being consistent in your efforts without seeing the results on the scale. Eating a balanced diet will accelerate your results and allow you to feel more successful throughout your activities.

3.5: Additional Safety Concerns

As activity rates among Americans increase, specifically outdoor activities, safety concerns also rise. Unfortunately, the physical infrastructure of many American cities does not accommodate active lifestyles. Limited financial resources and de-emphasis on public health means local and state governments are unlikely to allocate funds for building roads with sidewalks, creating walking trails that surround parks, or adding bike lanes. In addition, time constraints and inconvenience make it challenging for participants to travel to areas where these amenities are available. As a result, exercise participants share roads and use isolated trails/pathways, inherently increasing the safety risks of being active.

A key principle in outdoor safety is to recognize and avoid the extremes. For example, avoid roads that experience heavy traffic or are extremely isolated. Avoid heavy populated areas as well as places where no one is around. Do not exercise in the early morning or late at night, during extreme cold or extreme heat. To minimize safety risks during these types of environmental conditions, do not use headphones that could prevent you from hearing well and remaining alert, do not exercise alone, prepare for adequate hydration in the heat, and use warm clothing in extreme cold to avoid frostbite. Extreme conditions require extra vigilance on your part.

A second key principle, whether outdoor or indoor, is to simply use common sense. While this caveat seems obvious, it gets ignored far too often. Always remember the purpose of your exercise is for enjoyment and improved health. If these objectives could be compromised by going for a run at noon in 95-degree heat, or lifting large amounts of weight without a spotter, you should reconsider your plan. Before exercising in what could be risky conditions, ask yourself, “Is there a safer option available?”

Lastly, be aware of the terrain and weather conditions. Walking or jogging on trails is a wonderful way to enjoy nature, but exposed roots and rocks present a hazard for staying upright. Wet, muddy, or icy conditions are additional variables to avoid in order to complete your exercise session without an accident.

The document linked below from the University of Texas at San Antonio Police Department outlines specific safety tips that will help you stay safe in your activities.

Safety Tips for Runners, Walkers, and Joggers

Environmental Conditions

When exercising outdoors, you must consider the elements and other factors that could place you at increased risk of injury or illness.

Heat-Related Illness

Heat-related illnesses, such as heat cramps, heat exhaustion, and heat stroke, contributed to 7,233 deaths in the United States between 1999 and 2009. A 2013 report released by the Center for Disease Control stated that about 658 deaths from heat-related illnesses occurred every year which account for more deaths than tornadoes, hurricanes, and lightning combined. Of those deaths, most were male, older adults.[8]

The number one risk factor associated with heat-related illness is hydration, the starting point of all heat-related illness. Unfortunately, sweat loss can occur at a faster rate than a person can replace with fluids during exercise, especially at high intensities. Even when trying to hydrate, ingestion of large amounts of fluids during exercise can lead to stomach discomfort. What does this mean? Hydration must begin before exercise and must become part of your daily routine.

Several practical methods of monitoring hydration levels can assist in preventing illness. One simple method, while not full proof, is to simply monitor the color of your urine. In a hydrated state, urination will occur frequently (every 2–3 hours) and urine will have very little color. In a dehydrated state, urination occurs infrequently in low volume and will become more yellow in color.

Another simple method involves weighing yourself before and after a workout (see lab). This is a great way to see firsthand how much water weight is lost during an exercise session primarily as a result of sweat. Your goal is to maintain your pre- and post-body weight by drinking fluids during and after the workout to restore what was lost. This method, when combined with urine-monitoring, can provide a fairly accurate assessment of hydration levels.

The best preventative measure for maintaining a hydrated state is simply drinking plenty of water throughout the day. In previous years, recommendations for the amount of water to drink were a one size fits all of about 48–64 oz. per day, per person. In an effort to individualize hydration, experts now recommend basing fluid intake on individual size, gender, activity levels, and climate.

Generally, half an ounce (fluid ounces) to 1 ounce per pound of body weight is recommended.[9] For a 150-pound individual, this would mean 75–150 ounces of water per day! While there is still considerable debate over the exact amounts, no one disputes the importance of continually monitoring your hydration using one of the techniques described previously. Insufficient hydration leads to poor performance, poor health, and potentially serious illness.

It should be noted that electrolyte "sport" drinks, such as Gatorade and PowerAde, are often used to maintain hydration. While they can be effective, these types of drinks were designed to replace electrolytes (potassium, sodium, chloride) that are lost through sweating during physical activity. In addition, they contain carbohydrates to assist in maintaining energy during activities of long duration. If the activity planned is shorter than 60 minutes in duration, water is still the recommended fluid. For activities beyond 60 minutes, a sports drink should be used.

Cold-Related Illnesses

Much like extremely hot environmental conditions, cold weather can create conditions equally as dangerous if you fail to take proper precautions. To minimize the risk of cold-related illness, you must prevent the loss of too much body heat. The three major concerns related to cold- related illnesses are hypothermia, frost-nip, and frost bite.

As with heat-related illness, the objective of preventing cold-related illness is to maintain the proper body temperature of between 98.6 and 99.9 degrees Fahrenheit. If body temperature falls below 98.6 F, multiple symptoms may appear, indicating the need to take action. Some of those symptoms include:

- Shivering
- Numbness and stiffness of joints and appendages
- Loss of dexterity and/or poor coordination
- Peeling or blistering of skin, especially to exposed areas
- Discoloration of the skin in the extremities

When walking or jogging in the cold, it is important to take the necessary steps to avoid problems that can arise from the environmental conditions.

- *Hydration is key*.
  Cold air is usually drier air, which leads to moisture loss through breathing and evaporation. Staying hydrated is key in maintaining blood flow and regulating temperature.
- *Stay dry.*
  Heat loss occurs 25x faster in water than on dry land. As such, keeping shoes and socks dry and clothing from accumulating too much sweat will allow for more effective body temperature regulation.
- *Dress appropriately.*
  Because of the movement involved, the body will produce heat during the exercise session. Therefore, the key point is to direct moisture (sweat) away from the skin. This is controlled most effectively by layering your clothing. A base layer of moisture-wicking fabric should be used against the skin while additional layers should be breathable. This will channel moisture away from the skin, and any additional layers of clothing, without it becoming saturated in sweat. If exercising on a windy day, use clothing that protects from the wind and is adjustable so you can breathe.
- *Cover the extremities*.
  Those parts of the body farthest away from the heart (toes, fingers, and ears) tend to get coldest first. Take the appropriate steps to cover those areas by using gloves, moisture-wicking socks, and a winter cap to cover your head.

3.6: References-

1. Center for Disease Control and Prevention, Retrieved April 2017, CDC: Physical Activity, Data and Statistics, https://www.cdc.gov/physicalactivity/data/facts.htm
2. Saltin, B., Blomqvist, G., Mitchell, J.H., Johnson, R.L., Jr., Wildenthal, K., Chapman, C.B. Response to submaximal and maximal exercise after bed rest and training. 1968 Nov, Vol. 38 (Suppl. 5)
3. Noakes, Timothy D.; Sudden Death and Exercise, Sportscience, 1998, retrieved Dec. 2017, http://www.sportsci.org/jour/9804/tdn.html
4. Van Camp SP, Boor CM, Mueller FO, et al. Non-traumatic Sports Death in High School and college Athletes, Medicine and Science of Sports and Exercise 1995; 27:641-647
5. American College of Sports Medicine, 7th Edition, ACSM's Guidelines for Exercise Testing and Prescription, Philadelphia, PA, Lippincott, Williams and Wilkins, p. 10
6. American College of Sports Medicine, 7th Edition, ACSM's Guidelines for Exercise Testing and Prescription, Philadelphia, PA, Lippincott, Williams and Wilkins, p. 27
7. 7 Habits of Highly Effective People,2003, Covey, Stephen R. Habit 2, New York, Franklin Covey Co. p. 40-61
8. Center for Disease Control and Prevention, Retrieved April 2017, CDC: Quick Stats: Number of Heat-related Deaths, by Sex-National Vital Statistics System-United States, 1999-2010, https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6136a6.htm
9. Mayo Clinic, retrieved April 2017, Water: How Much Should You Drink Each Day? www.mayoclinic.org/healthy-li...thy-eating/in- depth/water/art-20044256

CHAPTER OVERVIEW

4: Cardiorespiratory Fitness

By Scott Flynn

Learning Objectives

- Define the cardiovascular and respiratory system
- Describe how the cardiorespiratory system works
- Identify the benefits of cardiorespiratory fitness
- What is the importance of this system?
- Identify methods for assessing and improving the CR system

4.1: What is the cardiovascular and respiratory system?
4.2: The Benefits of Good Cardiorespiratory Health
4.3: How the CR System Works
4.4: The CR System and Energy Production
4.5: Oxidative Energy System (Aerobic)
4.6: Immediate/Explosive Energy System
4.7: Immediate/Explosive Energy System
4.8: Non-Oxidative or Anaerobic Energy System
4.9: Energy Systems Combine
4.10: Changes in the CR System
4.11: Assessing CR Fitness
4.12: Creating a Plan to Develop CR Fitness
4.13: Measuring Heart Rate
4.14: Measuring Intensity
4.15: Cardiorespiratory Fitness Assessment

4.1: What is the cardiovascular and respiratory system?

Imagine for a moment climbing to the top of Mt. Everest, a challenging feat very few have accomplished. In the process, you gradually ascend from base camp, which sits at about 17,500 feet above sea level, to the peak at over 29,000 feet. At this elevation, the pressure of oxygen is so low, you struggle to take in a satisfying breath. Although you strive to breathe deeply, you are unable to get enough air. Your heart rate increases and you might even develop nausea and a headache. Unless your body has a chance to acclimate itself to higher elevations or you gain access to supplemental oxygen, your symptoms will persist or worsen.

These are the sensations many people with cardiovascular or respiratory illnesses, such as asthma, chronic bronchitis, or mild cardiovascular disease, experience on a daily basis. Climbing up a flight of steps may leave them gasping for air, as would walking briskly or even breathing in cold air. Regardless of the cause, being unable to take in sufficient air can create a sense of panic and cause serious physical discomfort. The goal of this short narrative is to engender an appreciation for the simple act of breathing and the ensuing satisfaction that comes with each life-sustaining breath. For most people, unless they engage in strenuous physical activity, such as jogging or climbing a flight of stairs, their **cardiovascular and respiratory system** (heart, blood vessels, and lungs) operates efficiently enough to go unnoticed. However, does that mean their cardiorespiratory (CR) system is functioning at optimal capacity, or could it be operating at a minimum level and experiencing problems that go undetected? This chapter defines cardiorespiratory fitness, examines the benefits of a healthy CR system, and explores how to effectively assess and improve the CR system.

4.2: The Benefits of Good Cardiorespiratory Health

The link below provides a list of specific benefits:

• List of Benefits

The article linked below describes how exercise protects against Cardiovascular Disease (CVD):

• Preventing CVD

4.3: How the CR System Works

The cardiorespiratory system operates to obtain and circulate vital compounds throughout the body—specifically, oxygen and nutrients, such as food energy, vitamins, and minerals. Both oxygen and nutrients, which are imperative for cellular energy production, must be taken in from the lungs and digestive system. Because the heart and lungs are so interlocked in this process, the two systems are often labeled together as the cardiorespiratory system. Without a healthy respiratory system, the body would struggle to bring in enough oxygen, release **carbon dioxide** (the chemical waste product of cellular metabolism) and eliminate unwanted particles that enter the respiratory tract when inhaling. Without a healthy heart, transporting oxygen from the lungs and nutrients from the digestive system to the body's cells would be impossible. If the health of the CR system were compromised enough, survival would be impossible. Additionally, both must be healthy or the function of one or the other will be compromised.

Below are several videos explaining how the cardiovascular and respiratory systems operate and function together:

The CR System and Exercise

How the Cardiovascular System Works

Respiratory System Explained in Detail

4.4: The CR System and Energy Production

Clearly the cardiovascular and respiratory systems function as one, but why is the CR system so important? What makes the distribution of oxygen throughout the body so vital to existence? The answer is simple: ENERGY. While oxygen in and of itself does not contain any energy (**calories**), it does combine with fuel extracted from food once it has been introduced into the cell to help produce **adenosine triphosphate** (ATP). ATP is the basic form of cellular energy found in the body. Because the body stores very little ATP, it must constantly be regenerated. For this reason, people must continue eating and breathing to live.

Within the context of fitness, the purpose of the cardiorespiratory system is not only to produce energy but to also adapt in a way so that energy production can be optimized. For example, a high school cross country runner wants to be fit enough to compete in the state cross country meet. Unfortunately, this athlete's current mile times are 6 minutes per mile. In other words, that is the maximum work rate possible for this athlete. However, the goal is to improve to 5 minutes per mile, or improve the maximum work rate. To do so, more energy must be produced. According to the principles of adaptation, it is possible for this athlete to become more efficient at producing energy, enabling him to run a mile in less time. An example of this adaptation comes from the world record mile time of 3 minutes and 43 seconds. The world record marathon time (26.2 miles) is 2 hours, 2 minutes, and 52 seconds. That equates to 4 minutes and 41 seconds per mile over the 26-mile course. That is some serious ATP production!

4.5: Oxidative Energy System (Aerobic)

As oxygen and nutrients are delivered to the cells, they are utilized to produce ATP. The workhorses of the cell for oxidative metabolism are the **mitochondria**. This form of energy production is contingent on the ability of the CR system to deliver oxygen and nutrients and the cell's ability to process that oxygen. Because of the importance of oxygen in this particular energy-producing pathway, it is called the oxidative energy system, or **aerobic system**.

Oxidative energy production is the primary means of ATP production during rest and for activities that last for 2 minutes or longer. Although other forms of energy production assist in ATP production at any given time, long duration exercise sessions rely on this aerobic pathway. Also, in contrast to other forms of ATP production, the oxidative energy system uses both carbohydrates and fats for fuel sources.

To consider: What activities would emphasize development of this energy pathway?

4.6: Immediate/Explosive Energy System

While the oxidative system is the primary source of ATP production, it does require a few minutes for the system to begin operating at full capacity during exercise. How then could the body immediately produce enough energy to perform a strenuous activity, such as sprinting 50 meters? Clearly, another energy system must drive ATP production. The immediate or explosive energy system utilizes the storage of **creatine phosphate** (CP) and the storage of **adenosine diphosphate**, which is stored in very small amounts, to generate ATP. When needed, this energy system provides enough ATP to sustain a short- duration, explosive activity, approximately 10–20 seconds or less. Once CP is depleted, other energy systems must assist in the ATP generating process.

4.7: Immediate/Explosive Energy System

4.8: Non-Oxidative or Anaerobic Energy System

As the name implies, the **non-oxidative energy system** does not require oxygen to generate ATP. Instead, the cells where the ATP is produced require **glucose**(carbohydrates that have been broken down) as the fuel source. Like the immediate energy system, this system is associated with high intensity and short duration movements. While it is possible for some elite athletes to maintain exercise at “anaerobic” levels for several minutes, even they will eventually fatigue as a result of the non-oxidative system’s ability to sustain ATP production for events lasting longer than approximately 2 minutes.

As glucose is processed to produce ATP, the natural byproduct of this process, lactic acid, also begins to accumulate. The result of excessive lactic acid accumulation contributes to muscle fatigue, making it impossible to continue exercise at a high intensity.

4.9: Energy Systems Combine

It is important to understand that energy systems do not operate in a compartmental fashion, but rather operate simultaneously, each carrying some of the burden of ATP production. For example, a professional soccer player would spend most of the match “cruising” at a light/moderate intensity level, thus primarily utilizing the oxidative energy system. However, during the match, he or she may sprint for several hundred meters, utilizing the explosive and non-oxidative system, or he or she may jump, requiring use of the explosive system. Thus, both energy systems are utilized simultaneously throughout the match. To improve performance, this player would need to develop the energy system which is utilized the most during the match.

4.10: Changes in the CR System

An improvement in CR functioning, or fitness level, requires adaptation of the system. Remember, the point is to more effectively generate ATP so more work can be accomplished. In order to process more oxygen and deliver more oxygenated blood to the cells, the overall system must undergo changes to make this possible. Here is a list of adaptations that occur to the CR system as a result of consistent aerobic exercise:

- Resting heart rate may decrease. The average resting heart rate hovers around 70–75 beats per minute. Elite athletes may have resting heart rates in the high 30s. Generally, resting heart rate may decrease by approximately 10 beats per minute with chronic exercise.
- Pulmonary adaptations, such as increased **tidal volume** (the amount of oxygen entering the lungs with each breath) and increased **diffusion capacity** (the amount of oxygen that enters the blood stream from the lungs). This allows for more oxygen to enter the pulmonary circulation en route to the left side of the heart.
- The heart muscles, specifically the left side of the heart, increase in size making it possible to contract more forcefully. As a result, more blood can be pumped with each beat meaning more oxygen can be routed to the systemic circulation.
- More oxygen is delivered and transported into the cells where ATP production can occur. This is called the **arterial-vein difference** (a-VO_{2diff})

These changes in the system are not permanent because of a process known as the **principle of reversibility**. Following a period of inactivity, the benefits from chronic aerobic exercise will be reversed.

4.11: Assessing CR Fitness

To adequately prepare for starting a personal fitness program, it is important to first assess your current level of fitness. There are multiple methods for assessing a person's level of fitness. Each of the walking/jogging assessments discussed here attempts to estimate a key physiological marker of the heart's and lungs' functioning capacity and maximal oxygen consumption. **Maximal oxygen consumption**, or $VO_{2\ max}$, measures the body's maximum ability to take in and utilize oxygen, which directly correlates to overall health and fitness. A good estimate of $VO_{2\ max}$ provides a one- time glance at a person's health and fitness level and a baseline measurement for reassessment at future dates to gauge improvements.

Some of the most common walking/jogging assessments used to estimate $VO_{2\ max}$ include the 12-Minute Walk, 1.5-Mile Run/Walk Test, 3-Minute Step Test, and 1- Mile Walk Test. Unfortunately, these field assessments, although practical and inexpensive, only provide estimations. More accurate assessments require a lab- based VO_{2max} test using equipment that measures the volume of oxygen and carbon dioxide being moved in and out of the air passages during exercise. Although this test is more accurate, the expense and availability make it impractical for most. Unlike the lab test, the field assessments are relatively cost free, user-friendly and require very little expertise to conduct or perform. In addition, the key point of the assessment is measuring differences rather than absolute values, and the field tests accurately meet that objective.

Information on how to safely perform these assessments will be provided at the end of this chapter.

4.12: Creating a Plan to Develop CR Fitness

Once the assessments have been completed, the next step is to develop a plan for maintaining or improving your current level of fitness. This fitness plan should include activities that are safe and adapted to meet your personal goals. Once these fitness goals have been identified, the principles of adaptation to change can be utilized to achieve those goals. These principles include **specificity**, targeting specific areas in a workout, and **overload,**the practice of increasing exertion as the body adapts to ensure continued gains in fitness levels. Specifically, you need to apply the FITT principle (**F**itness, **I**ntensity, **T**ime, and **T**ype) described in detail in the previous chapter, “Fitness Principles”:

- **Frequency**: 3–5 days per week for healthy adults.
- **Intensity**: moderate to vigorous intensity, which equals 40–85% of heart rate reserve, or 55–90% of percentage of max heart rate. (More information about intensity will be provided later.)
- **Time/duration**: 20–60 minutes per session or accumulation of 150 minutes per week. Sessions must be continuous for 10 minutes or more.
- **Type/mode**: Use large muscle groups and exercises specific to cardiorespiratory exercise.

Click on the link below for ACSM’s latest recommendations on the quantity and quality of exercise for adults:

ACSM's Official News Release

4.13: Measuring Heart Rate

Those starting the VO2max assessments must first measure their heart rate, an important component used in the calculations.

Here is a video describing how to determine heart rate:

4.14: Measuring Intensity

Intensity may be the most important aspect of the FITT principle. Engaging in a “cardio” program that does not stress the CR system to the recommended levels will be ineffective. Engaging in a program that overstresses the system can lead to injury and pose unnecessary risks. So how do you know if you are in the right range?

Heart rate is one of the best ways to measure effort level. Walking and jogging increase a person’s heart rate. Based on the function of the heart, this is no surprise. The heart rate directly correlates with the amount of oxygen being taken in by the lungs. As activity increases in intensity, oxygen demands increase and so does heart rate.

Because of this relationship, heart rate can be used in the design of an effective walking and jogging program by creating target heart rate zones. Heart rate zones represent an intensity range—a low end heart rate and a high end rate—within which a person’s heart rate would fall during a walking or jogging session.

The first step in determining your **target heart rate (THR)**, is to determine your **maximum heart rate (MHR),** both measured in beats per minute (bpm). Generally, MHR is estimated to be your age subtracted from 220 beats per minute. In other words, your heart rate should theoretically stop increasing once it reaches the calculated maximum. While helpful, it is not uncommon to see variances in the laboratory tested maximum heart rate versus the calculated method.

The next step in calculating THR is to calculate a specific percentage of your MHR. This is done using two different methods. Keep in mind, finding the THR is the objective in both methods, even though slightly different numbers are used.

The first method, called Max Heart Rate Method, is more commonly used.

Max Heart Rate Method

1. Calculate MHR;
   MHR = 220 – age.
2. Calculate high and low THR by plugging in a percentage range. In this example, 60 and 80% are being used.
   MHR x .60 = THR_{Low}
   MHR x .80 =THR_{High}
3. The resulting low and high THR numbers represent the range, or target intensity.

The target intensity signifies an optimal training zone for that particular walking or jogging session. By keeping the heart rate within that range, you will drive adaptation specific to that intensity. By using real, but random numbers, and plugging them into the above equation this becomes apparent.

Female, aged 20:

1. MHR = 220 -20
   MHR = 200 bpm;
2. THR_{low} = 200 x .60
   THR_{low} = 120 bpm
   THR_{high} =200 x .80
   THR_{high} = 160 bpm
3. THR=120-160bpm

To achieve her self-established goals, the female in the example above will need to stay within the range of 120 and 160 bpm. If her efforts are intense enough that she begins to exceed 160 bpm during her session, or easy enough that her heart rate falls below 120 bpm, she would need to change her intensity mid-session to get the optimal results.

The Karvonen Formula or Heart Rate Reserve Method

1. Calculate MHR; MHR = 220 – age.
2. Determine your **resting heart rate (RHR)**.
3. Find the **heart rate reserve (HRR)**;

   HRR = MHR – RHR

4. Calculate high and low THR by plugging in a percentage range and then adding in the RHR. In this example, 60 and 80% are being used.

THR_{low} = HRR x .60 + RHR

THR_{high} = HRR x .80 + RHR

5. The resulting low and high THR numbers represent the range, or target intensity.

Clearly, the Karvonen formula requires a few more steps, specifically, the incorporation of the resting heart rate. Using the same female in the example above, along with a randomly selected RHR, the THR looks like this:

1. MHR=220–20
   MHR = 200
2. RHR = 72 bpm (randomly selected)
3. HRR=MHR–RHR
   HRR=200–72
   HRR = 128
4. THR_{low}=HRRx.60+RHR
   THR_{low}=128x.60+72
   THR_{low} = 149 bpm
   THR_{high} = HRR x .80 + RHR
   THR_{high}=128x.80+72
   THR_{high} = 174 bpm
5. THR=149–174bpm

A comparison of the two methods, reveals that the low and high end of the Karvonen formula is much higher than the Max Heart Rate method, even though the exact same percentages have been used. If the female in this example used the Karvonen Formula, she would find herself at a much higher intensity, especially at the low end of the range (120 vs. 149 bpm). How can this be? Aren't these formulas supposed to have the same objective?

While it is true that both equations are used to estimate a target heart rate range, only the Karvonen Formula takes into account the RHR, the lowest possible heart rate that can be measured for that individual. The Max Heart Rate method assumes the lowest heart rate possible is "0," a number to be avoided if at all possible! Because of the difference between 0 and the maximum heart rate, the calculated percentages result in a much lower number. In terms of accuracy, the Karvonen method is superior. It simply is a better representation of true target ranges.

Other Ways to Determine Intensity

Since not everyone owns a heart rate monitor, other methods of determining exercise intensity have been developed. One particular method, called the **rating of perceived exertion (RPE)**, uses subjective measurement to determine intensity. The method is as simple as asking the question, Overall, how hard do I feel I am working? The answer is given based on a scale of 6 to 20 with 6 being almost no effort and 20 being maximum effort. Studies have indicated that when subjects are asked to exercise at a moderate or heavy intensity level, subjects can accurately do so, even without seeing their heart rate. As a result, using the RPE scale can be an effective way of managing intensity.

The original RPE scale or **Borg Scale**, designed by Dr. Gunnar Borg, was developed to mimic generalized heart rate patterns. The starting and ending point of the scale are less intuitive than a typical scale of 1-10. By design, the 6 represents a resting heart rate of 60 bpm and the 20 an exercise heart rate of 200 bpm, a beat count someone might experience at maximum effort. Over time, a modified Borg Scale was developed using a simple 1– 10 scale, with 1 being resting effort and 10 being maximum effort. Even though the modified scale is more intuitive, the traditional scale is still used more frequently.

Walking and jogging not only benefit physical health, but many enjoy the social benefits realized by exercising with friends. When walking or jogging with friends, intensity can easily be measured by monitoring your ability to carry on a conversation. With the **Talk Test**, if you are only able to say short phrases or give one word responses when attempting to converse during an exercise session, this would suggest you are working at a high enough intensity that your breathing rate makes conversation difficult. Certainly, if you can speak in full sentences without getting winded, the intensity would be very light. Just like RPE, the Talk Test is yet another way to subjectively measure intensity, which can then be correlated with heart rates.

4.15: Cardiorespiratory Fitness Assessment

Follow the link below to the course lab in which you will be assessing your current level of cardiorespiratory fitness. You will be using the lab labeled:

Assessing Your Cardiorespiratory Fitness Level

CHAPTER OVERVIEW

5: Muscular Strength and Endurance

By Jonathan Howard

Learning Objectives

- Describe muscular structure and function
- Identify types of muscles
- Describe an effective resistance exercise program
- Assess your muscular strength and endurance
- Understand the dangers of supplements

Muscles are used for movement in the body. The largest portion of energy expenditure in the body happens in muscles while helping us perform daily activities with ease and improving our wellness. Muscular strength is the amount of force that a muscle can produce one time at a maximal effort, and muscular endurance is the ability to repeat a movement over an extended period of time. Resistance training is the method of developing muscular strength and muscular endurance, which in turns improves wellness. This chapter explores many ways to resistance train. However, achieving the best muscular performance requires the assistance of a trained professional.

5.1: Muscular Physiology

5.2: Resistance Exercise Programing

5.3: Supplements

5.4: Assessing your Muscular Strength and Endurance

5.1: Muscular Physiology

Muscles are highly specialized to contract forcefully. Muscles are powered by muscle cells, which contract individually within a muscle to generate force. This force is needed to create movement. There are over 600 muscles in the human body; they are responsible for every movement we make, from pumping blood through the heart and moving food through the digestive system, to blinking and chewing. Without muscle cells, we would be unable to stand, walk, talk, or perform everyday tasks.

Types of Muscle

There are three types of muscle:

- *Skeletal Muscle* - Responsible for body movement.
- *Cardiac Muscle* - Responsible for the contraction of the heart.
- *Smooth Muscle* - Responsible for many tasks, including movement of food along intestines, enlargement and contraction of blood vessels, size of pupils, and many other contractions.

Skeletal Muscle Structure and Function

Skeletal muscles are attached to the skeleton and are responsible for the movement of our limbs, torso, and head. They are under conscious control, which means that we can consciously choose to contract a muscle and can regulate how strong the contraction actually is. Skeletal muscles are made up of a number of **muscle fibers**. Each muscle fiber is an individual muscle cell and may be anywhere from 1 mm to 4 cm in length. When we choose to contract a muscle fiber—for instance we contract our bicep to bend our arm upwards—a signal is sent from our brain via the spinal cord to the muscle. This signals the muscle fibers to contract. Each nerve will control a certain number of muscle fibers. The nerve and the fibers it controls are called a **motor unit**. Only a small number of muscle fibers will contract to bend one of our limbs, but if we wish to lift a heavy weight then many more muscles fibers will be recruited to perform the action. This is called muscle **fiber recruitment**.

Each muscle fiber is surrounded by connective tissue called an **external lamina**. A group of muscle fibers are encased within more connective tissue called the **endomysium**. The group of muscle fibers and the endomysium are surrounded by more connective tissue called the **perimysium.** A group of muscle fibers surrounded by the perimysium is called a muscle **fasciculus**. A muscle is made up of many muscle fasciculi, which are surrounded by a thick collagenous layer of connective tissue called the **epimysium**. The epimysium covers the whole surface of the muscle.

Muscle fibers also contain many mitochondria, which are energy powerhouses that are responsible for the aerobic production of energy molecules, or**ATP molecules**. Muscle fibers also contain glycogen granules as a stored energy source, and **myofibrils**, which are threadlike structures running the length of the muscle fiber. Myofibrils are made up of two types of protein: 1) **Actin myofilaments**, and 2) **myosin myofilaments**. The actin and myosin filaments form the contractile part of the muscle, which is called
the **sarcomere**. Myosin filaments are thick and dark when compared with actin filaments, which are much thinner and lighter in appearance. The actin and myosin filaments lie on top of one another; it is this arrangement of the filaments that gives muscle its striated or striped appearance. When groups of actin and myosin filaments are bound together by connective tissue they make the myofibrils. When groups of myofibrils are bound together by connective tissue, they make up muscle fibers.

The ends of the muscle connect to bone through a tendon. The muscle is connected to two bones in order to allow movement to occur through a joint. When a muscle contracts, only one of these bones will move. The point where the muscle is attached to a bone that moves is called the **insertion**. The point where the muscle is attached to a bone that remains in a fixed position is called the **origin**.

How Muscles Contract

Muscles are believed to contract through a process called the **Sliding Filament Theory**. In this theory, the muscles contract when actin filaments slide over myosin filaments resulting in a shortening of the length of the sarcomeres, and hence, a shortening of the muscle fibers. During this process the actin and myosin filaments do not change length when muscles contract, but instead they slide past each other.

During this process the muscle fiber becomes shorter and fatter in appearance. As a number of muscle fibers shorten at the same time, the whole muscle contracts and causes the tendon to pull on the bone it attaches to. This creates movement that occurs at the point of insertion.

For the muscle to return to normal (i.e., to lengthen), a force must be applied to the muscle to cause the muscle fibers to lengthen. This force can be due to gravity or due to the contraction of an opposing muscle group.

Skeletal muscles contract in response to an electric signal called an **action potential**. Action potentials are conducted along nerve cells before reaching the muscle fibers. The nerve cells regulate the function of skeletal muscles by controlling the number of action potentials that are produced. The action potentials trigger a series of chemical reactions that result in the contraction of a muscle.

When a nerve impulse stimulates a motor unit within a muscle, all of the muscle fibers controlled by that motor unit will contract. When stimulated, these muscle fibers contract on an all-or-nothing basis. The all- or-nothing principle means that muscle fibers either contract maximally along their length or not at all. Therefore, when stimulated, muscle fibers contract to their maximum level and when not stimulated there is no contraction. In this way, the force generated by a muscle is not regulated by the level of contraction by individual fibers, but rather it is due to the number of muscle fibers that are recruited to contract. This is called **muscle fiber recruitment**. When lifting a light object, such as a book, only a small number of muscle fibers will be recruited. However, those that are recruited will contract to their maximum level. When lifting a heavier weight, many more muscle fibers will be recruited to contract maximally.

When one muscle contracts, another opposing muscle will relax. In this way, muscles are arranged in pairs. An example is when you bend your arm at the elbow: you contract your bicep muscle and relax your tricep muscle. This is the same for every movement in the body. There will always be one contracting muscle and one relaxing muscle. If you take a moment to think about these simple movements, it will soon become obvious that unless the opposing muscle is relaxed, it will have a negative effect on the force generated by the contracting muscle.

A muscle that contracts, and is the main muscle group responsible for the movement, is called the **agonist** or **prime mover**. The muscle that relaxes is called the **antagonist**. One of the effects that regular strength training has is an improvement in the level of relaxation that occurs in the opposing muscle group. Although the agonist/antagonist relationship changes, depending on which muscle is responsible for the movement, every muscle group has an opposing muscle group.

Below are examples of agonist and antagonist muscle group pairings:

AGONIST (Prime Mover)	Antagonist
Latimus Dorsi (upper back)	**Deltoids** (shoulder)
Rectus Abdominus (stomach)	**Erector Spinae** (back muscles)
Quadricepts (top of thigh)	**Hamstrings** (back of thigh)
Gastrocnemius (calf)	**Tibialis Anterior** (front of lower leg)
Soleus (below calf)	**Tibialis Anterior** (front of lower leg)

Smaller muscles may also assist the agonist during a particular movement. The smaller muscle is called the **synergist**. An example of a synergist would be the deltoid (shoulder) muscle during a press-up. The front of the deltoid provides additional force during the press-up; however, most of the force is applied by the pectoralis major (chest). Other muscle groups may also assist the movement by helping to maintain a fixed posture and prevent unwanted movement. These muscle groups are called **fixators**. An example of a fixator is the shoulder muscle during a bicep curl or tricep extension.

Types of Muscular Contraction

- *Isometric* - This is a static contraction where the length of the muscle, or the joint angle, does not change. An example is pushing against a stationary object such as a wall. This type of contraction is known to lead to rapid rises in blood pressure.
- *Isotonic* - This is a moving contraction, also known as **dynamic contraction**. During this contraction the muscle fattens, and there is movement at the joint.

Types of Isotonic Contraction

- *Concentric*
  This is when the muscle contracts and shortens against a resistance. This may be referred to as the lifting or positive phase. An example would be the lifting phase of the bicep curl.
- *Eccentric*
  This occurs when the muscle is still contracting and lengthening at the same time. This may be referred to as the lowering or negative phase.

Muscle Fiber Types

Not all muscle fibers are the same. In fact, there are two main types of muscle fiber:

- *Type I* - Often called slow-twitch or highly- oxidative muscle fibers
- *Type II* - Often called fast-twitch or low- oxidative muscle fibers

Additionally, Type II muscle fibers can be further split into **Type IIa** and **Type IIb**. Type IIb fibers are the truly fast twitch fibers, whereas Type IIa are in between slow and fast twitch. Surprisingly, the characteristics of Type IIa fibers can be strongly influenced by the type of training undertaken. Following a period of endurance training, they will start to strongly resemble Type I fibers, but following a period of strength training they will start to strongly resemble Type IIb fibers. In fact, following several years of endurance training they may end up being almost identical to slow-twitch muscle fibers.

Type I (Slow-Twitch Muscle Fibers)

Slow-twitch muscle fibers contain more**mitochondria**, the organelles that produce aerobic energy. They are also smaller, have better blood supply, contract more slowly, and are more fatigue resistant than their fast-twitch brothers. Slow-twitch muscle fibers produce energy, primarily, through aerobic metabolism of fats and carbohydrates. The accelerated rate of aerobic metabolism is enhanced by the large numbers of mitochondria and the enhanced blood supply. They also contain large amounts of **myoglobin**, a pigment similar to hemoglobin that also stores oxygen. The myoglobin provides an additional store of oxygen for when oxygen supply is limited. This extra oxygen, along with the slow-twitch muscle fibers' slow rate of contraction, increases their endurance capacity and enhances their fatigue resistance. Slow-twitch muscle fibers are recruited during continuous exercise at low to moderate levels.

Type IIb (Fast-Twitch Low-oxidative Muscle Fibers)

These fibers are larger in size, have a decreased blood supply, have smaller mitochondria and less of them, contract more rapidly, and are more adapted to produce energy **anaerobically** (without the need for oxygen) than slow-twitch muscle fibers. Their reduced rate of blood supply, together with their larger size and fewer mitochondria, makes them less able to produce energy aerobically, and are therefore, not well suited to prolonged exercise. However, their faster rate of contraction, greater levels of glycogen, and ability to produce much greater amounts of energy anaerobically make them much more suited to short bursts of energy. Because of their greater speed of contraction and reduced blood supply, they are far less fatigue resistant than slow- twitch fibers, and they tire quickly during exercise.

Numbers of Slow and Fast-Twitch Fibers

The number of slow and fast-twitch fibers contained in the body varies greatly between individuals and is determined by a person's genetics. People who do well at endurance sports tend to have a higher number of slow-twitch fibers, whereas people who are better at sprint events tend to have higher numbers of fast-twitch muscle fibers. Both the slow twitch and fast-twitch fibers can be influenced by training. It is possible through sprint training to improve the power generated by slow twitch fibers, and through endurance training, it is possible to increase the endurance level of fast-twitch fibers. The level of improvement varies, depending on the individual, and training can never make slow-twitch fibers as powerful as fast- twitch, nor can training make fast-twitch fibers as fatigue resistant as slow-twitch fibers.

Cardiac Muscle Structure and Function

Cardiac muscle cells are only found in the heart. They are elongated and contain actin and myosin filaments, which form**sarcomeres**; these join end to end to form**myofibrils**. The actin and myosin filaments give cardiac muscle a striated appearance. The striations are less numerous than in skeletal muscle. Cardiac muscles contain high numbers of mitochondria, which produce energy through aerobic metabolism. An extensive capillary network of tiny blood vessels supply oxygen to the cardiac muscle cells. Unlike the skeletal muscle cells, the cardiac cells all work as one unit, all contracting at the same time. In

short, the sinoatrial node at the top of the heart sends an impulse to the atrioventricular node, which sends a wave of polarization that travels from one heart cell to another causing them all to contract at the same time.

Smooth Muscle Structure and Function

Smooth muscle cells are variable in function and perform numerous roles within the body. They are spindle shaped and smaller than skeletal muscle and contain fewer actin and myosin filaments. The actin and myosin filaments are not organized into sarcomeres, so smooth muscles do not have a striated appearance. Unlike other muscle types, smooth muscle can apply a constant tension. This is called **smooth muscle tone**. Smooth muscle cells have a similar metabolism to skeletal muscle, producing most of their energy aerobically. As such, they are not well adapted to producing energy anaerobically.[1]

For more information on muscle physiology, click on the links below:

Skeletal Muscle Physiology

Fast Twitch versus Slow Twitch Video

Actin and Myosin: the Romeo and Juliet of Muscle Cells

Skeletal Muscles

5.2: Resistance Exercise Programing

Designing a resistance exercise program can seem like a daunting task. However, the basics are very simple. The table below provides instructions for designing an effective resistance exercise program.

Resistance Exercise Program

F	Frequency of Exercise	How Often	Beginner	2–3 days per week Full-body workout of all 6 body areas 48–72 hours of rest in-between workouts	
			Intermediate to High	4–5 days per week; often perform split workouts (example: Monday and Thursday, work chest, shoulders, triceps, abdominals; Tuesday and Friday, work back, legs, biceps) 48–72 hours of rest in-between workouts	
I	Intensity of Exercise	How Hard	Beginner	60%–70% of maximum strength	
			Intermediate to High	70%–90% of maximum strength	
T	Time of Exercise	–How many reps –How many sets –How much time between sets	Beginner	1–3 Sets 8–12 repetitions	30 sec to 1 minute
			Intermediate to High	Endurance – 12–20+ Reps 2–3 Sets	30 sec to 1 minute
				Strength – 2–6 Reps 3–5 Sets	2 to 5 minutes
T	Type of Exercise	Which Exercises	Weight machines, free weights, resistance tubing, medicine ball, own body weight		

Note

Specificity Principle - you must work each muscle group to have strength gains in that particular part of the body

Recommendations for Resistance Training Exercise

- *Perform a minimum of 8 to 10 exercises that train the major muscle groups.*
  - Workouts should not be too long. Programs longer than one hour are associated with higher dropout rates.
  - Choose more compound, or multi-joint exercises, which involve more muscles with fewer exercises.
- *Perform one set of 8 to 12 repetitions to the point of volitional fatigue.*
  - More sets may elicit slightly greater strength gains, but additional improvement is relatively small.
- *Perform exercises at least 2 days per week.*
  - More frequent training may elicit slightly greater strength gains, but additional improvement is relatively small since progress is made during the recuperation between workouts.
- *Adhere as closely as possible to the specific exercise techniques.*
- *Perform exercises through a full range of motion.*
  - Elderly trainees should perform the exercises in the maximum range of motion that does not elicit pain or discomfort.
- *Perform exercises in a controlled manner.*

- *Maintain a normal breathing pattern.*
- *If possible, exercise with a training partner.*
  - Partners can provide feedback, assistance, and motivation.

Position Stand on Progression Models in Resistance Training for Healthy Adults[2]

- *Both concentric and eccentric muscle actions*
- *Both single and multiple joint exercises*
- *Exercise sequence*
  - Large before small muscle group exercises
  - Multiple-joint exercises before single-joint exercises
  - Higher intensity before lower intensity exercises
- *When training at a specific RM load*
  - 2-10% increase in load if one to two repetitions over the desired number
- *Training frequency*
  - 2-3 days per week for novice and intermediate training
  - 4-5 days per week for advanced training
- *Novice training*
  - 8-12 repetition maximum (RM)
- *Intermediate to advanced training*
  - 1-12 RM using periodization* (strategic implementation of specific training phases alternating between phases of stress and phases of rest)
  - Eventual emphasis on heavy loading (1-6 RM)
  - At least 3-min rest periods between sets
  - Moderate contraction velocity
  - 1-2 s concentric, 1-2 s eccentric

* For more information on using periodization for weight training, click on the link below:

Periodization for Weight Training

Details

- *Hypertrophy training*
  - 1-12 RM in periodized fashion, with emphasis on the 6-12 RM zone
  - 1- to 2-min rest periods between sets
  - Moderate contraction velocity
  - Higher volume, multiple-set programs
- *Power training* (two general loading strategies):
  - **Strength training**
    - Use of light loads
    - 30-60% of 1 RM
    - Fast contraction velocity
    - 2-3 min of rest between sets for multiple sets per exercise
    - Emphasize multiple-joint exercises especially those involving the total body
  - **Local muscular endurance training**
    - Light to moderate loads
    - 40-60% of 1 RM
    - High repetitions (> 15)
    - Short rest periods (< 90 seconds)

Recommendations should be viewed within the context of an individual's target goals, physical capacity, and training status.

Six Types of Resistance Training

Each type of resistance training benefits muscles in a different way. While these types of resistance training are not new, they could be unique sources of resistance that you have not considered in your quest to add muscle to your frame. Using these forms of resistance alone, in combination with one another, or in combination with the more traditional resistance apparatus, can enable you to diversify your efforts to produce valuable and improved results.

In each type of training, you may use an apparatus to create an environment for resistance. The uniqueness of these sources is found in the way they are implemented. You might use a dumbbell for a particular exercise in some of these alternative resistance methods, but the way you use the resistance through a range of motion may be altogether different.

In isokinetic training, resistance is steady while velocity remains constant. For example, isokinetics are at work with any machine that is hydraulically operated. The opposing forces mirror each other throughout the range of motion. A good example would be pressing down for triceps on a hydraulic machine and having to immediately pull up (the resistance is constant in both directions) into a biceps curl while maintaining the same speed. IKT often involves opposing body parts. Trainers can use a variety of apparatus with their clients to achieve isokinetic stasis between muscle groups.

- *Dynamic Constant Training*
  As the name suggests, the most distinctive feature of dynamic constant training (DCT) is that the resistance is constant. A good example of DCT occurs when you use free weights or machines that do not alter resistance, but redirect it instead. The emphasis shifts to different planes along the muscle group being worked. When you work on a shoulder-press machine, for example, the resistance remains constant over the entire range of motion. It is identical from the bottom of the movement to the top and back down again. Only the direction of the resistance varies. The resistance redirects itself through the arc and then redirects itself again when the shoulders let the weight come back down to the starting position.
- *Dynamic Progressive Training*
  In dynamic progressive training (DPT), resistance increases progressively as you continue to exercise. DPT is often used as a rehabilitative measure and offers the sort of resistance that builds gradually while remaining completely within the control of the person using it. Equipment includes rubber bands and tubing, springs, and an apparatus controlled by spring-loaded parts. They are low- cost items that are easily accessible and can be used anywhere. Though commonly employed for rehabilitation of torn ligaments, joints, muscles, and broken bones, it is also convenient for travelers on either vacation or business trips. When combined with traditional forms of resistance, this training creates a better-balanced program and provides the muscles with a welcome alternative from time to time.
- *Dynamic Variable Training*
  This form of resistance exercise takes up where dynamic constant training leaves off. Whereas DCT employs constant resistance, never varying to accommodate the body's mechanics, DVT can be adapted to the varying degrees of strength of a muscle group throughout a range of motion. Though very few machines succeed in this goal, a few have come close.

  Hammer Strength equipment emphasizes common fixed areas of resistance. However, the Strive line of equipment has been able to give the user much more choice in resistance levels during an exercise. Strive equipment uses the DVT principle most effectively because it allows the user to increase resistance at the beginning, middle or end of the range of motion. If your joints are stronger at the end of a movement (the top) or the beginning (the bottom), you can set the resistance accordingly. The Strive line is the most flexible yet of all gym equipment designed to adhere to the DVT principle. It lets you tailor-make your workouts based on your body's mechanics.

- *Isokinetic Training*
  In isokinetic training (IKT), the muscle is contracted at a constant tempo. Speed determines the nature of this resistance training, not the resistance itself; however, the training is based on movement carried out during a condition of resistance. IKT can be performed with the body's own weight.

  In isokinetic training, resistance is steady while velocity remains constant. For example, isokinetics are at work with any machine that is hydraulically operated. The opposing forces mirror each other throughout the range of motion. A good example would be pressing down for triceps on a hydraulic machine and having to immediately pull up (the resistance is constant in both directions) into a biceps curl while maintaining the same speed. IKT often involves opposing body parts. Trainers can use a variety of apparatus with their clients to achieve isokinetic stasis between muscle groups.

- *Isometric Training*
  Familiar to most people, isometric training (IMT) is an excellent way to build strength with little adverse effect on joints and

tendons commonly associated with strength training and lifting heavy weights. Though it appears simple in comparison to traditional resistance training, IMT should not be underrated in its effectiveness. IMT is a method in which the force of contraction is equal to the force of resistance. The muscle neither lengthens nor shortens. You may be wondering how any training occurs without lengthening and shortening the muscles. In IMT, the muscles act against each other or against an immovable object.

Isometric training is what you see swimmers do when they press their hands against a solid wall, forcing all their bodyweight into the wall. Another common IMT exercise is pressing the hands together to strengthen the pectorals and biceps. Pressing against the wall can involve muscles in the front deltoid, chest and biceps. Isometric training has been proven very effective for gaining strength, but this method usually strengthens only the muscles at the point of the isometric contraction. If the greatest resistance and force are acting upon the mid-portion of the biceps, that is where most of the benefit will occur. A comprehensive isometric routine can serve to increase strength in certain body parts.

- *Isotonic Training*
  This method demands constant tension, typically with free weights. Though this approach may sound a lot like dynamic constant training, it differs because it does not necessarily redirect the resistance through a range of motion, but rather, keeps tension constant as in the negative portion of an exercise. Complete immobility of the muscle being worked is required. For example, in the preacher curl, the biceps are fixed against the bench. They lift (positive), then release the weight slowly downward (negative), keeping the same tension on the muscles in both directions. This is one reason that free-weight exercise is considered the best form of isotonic training. Merely lifting a dumbbell or barbell, however, is not necessarily enough to qualify as isotonic. The true essence of isotonic training is keeping resistance constant in both the positive and negative portions of each repetition.

Exercise Order for Resistance Training

The general guidelines for exercise order when training all major muscle groups in a workout is as follows:

- Large muscle group exercises (i.e., squat) should be performed before smaller muscle group exercises (i.e., shoulder press).
- Multiple-joint exercises should be performed before single-joint exercises.
- For power training, total body exercises (from most to least complex) should be performed before basic strength exercises. For example, the most complex exercises are the snatch (because the bar must be moved the greatest distance) and related lifts, followed by cleans and presses. These take precedence over exercises such as the bench press and squat.
- Alternating between upper and lower body exercises or opposing (agonist–antagonist relationship) exercises can allow some muscles to rest while the opposite muscle groups are trained. This sequencing strategy is beneficial for maintaining high training intensities and targeting repetition numbers.
- Some exercises that target different muscle groups can be staggered between sets of other exercises to increase workout efficiency. For example, a trunk exercise can be performed between sets of the bench press. Because different muscle groups are stressed, no additional fatigue would be induced prior to performing the bench press. This is especially effective when long rest intervals are used.[3]

Resistance Training Conclusion

The most effective type of resistance- training routine employs a variety of techniques to create a workout program that is complete and runs the gamut, from basic to specialized. Learning different methods of training, different types of resistance, and the recommended order can help you acquire a balanced, complete physique. That does not mean that these training methods will help everybody to win competitions, but they will help you learn how to tune in to your body and understand its functions through resistance and movement. This knowledge and understanding develops a valuable skill, allowing you to become more adept at finding what works best for you on any given day.

For additional information on resistance exercises, click on the links below:

Exercise and Muscle Directory

Muscular Strength and Endurance Activity

5.3: Supplements

Many active people use nutritional supplements and drugs in the quest for improved performance and appearance. Most of these substances are ineffective and expensive, and many are dangerous. A balanced diet should be your primary nutritional strategy.

Below are links that provide additional information about the use of supplements during exercise:

Benefits and Side Effects of Steroid Use

Claims versus actual effects of performance aids

References

1. Information pulled from www.strengthandfitnessuk.com

2. (ACSM 2002)

3. Information is from the National Strength and Conditioning Association and LiveStrong.org

Bringing Together Top Strength and Fitness Professionals. (n.d.). Retrieved April 25, 2017, from https://www.nsca.com/

Home. (n.d.). Retrieved April 25, 2017, from https://www.livestrong.org/

Kraemer, W. J., Adams, K., Cafarelli, E., Dudley, G. A., Dooly, C., Feigenbaum, M. S., . . . American, M. E. (2002, February). American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. Retrieved April 25, 2017, https://www.ncbi.nlm.nih.gov/pubmed/11828249

N. (n.d.). Strength And Fitness UK. Retrieved April 25, 2017, from http://www.strengthandfitnessuk.com/

5.4: Assessing your Muscular Strength and Endurance

Functional Leg Strength Tests

The following tests assess functional leg strength using squats. Most people do squats improperly, increasing their risk of knee and back pain. Before you add weight- bearing squats to your weight-training program, you should determine your functional leg strength, check your ability to squat properly, and give yourself a chance to master squatting movements. The following leg strength tests will help you in each of these areas.

These tests are progressively more difficult, so do not move on to the next test until you have scored at least a 3 on the current test. On each test, give yourself a rating of 0, 1, 3, or 5, as described in the instructions that follow the last test.

Chair Squat

Instructions

1. Sit up straight in a chair with your back resting against the backrest and your arms at your sides. Your feet should be placed more that shoulder-width apart so that you can get them under your body.
2. Begin the motion of rising out of the chair by flexing (bending) at the hips-not the back. Then squat up using a hip hinge movement (no spine movement). Stand without rocking forward, bending your back, or using external support, and keep your head in a neutral position.
3. Return to the sitting position while maintaining a straight back and keeping your weight centered over your feet. Your thighs should abduct (spread) as you sit back in the chair. Use your rear hip and thigh muscles as much as possible as you sit.

   Do five repetitions.
   Your rating _____

Un-weighted Squat

Instructions

1. Stand with your feet placed slightly more than shoulder-width apart, toes pointed out slightly, hands on hips or across your chest, head neutral, and back straight. Center your weight over your arches or slightly behind.
2. Squat down, keeping your weight centered over your arches and actively flexing (bending) your hips until your legs break parallel. During the movement, keep your back straight, shoulders back, and chest out, and let your thighs part to the side so that you are squatting between your legs.
3. Push back up to the starting position, hinging at the hips and not with the spine, maximizing a straight back and neutral head position.

   Do five repetitions.
   Your rating _____

Single-Leg Lunge-Squat with Rear-Foot Support

Instructions

1. Stand about 3 feet in front of a bench (with your back to the bench).
2. Place the instep of your left foot on the bench, and put most of your weight on your right let (your left leg should be bent), with your hands at your sides.
3. Squat on your right leg until your thigh is parallel with the floor. Keep your back straight, chest up, shoulders back, and head neutral.
4. Return to the starting position. Do three repetitions for each leg. Your rating: _____

Rating Your Functional Leg Strength Test Results

- *5 POINTS*
  Performed the exercise properly with good back and thigh position, weight centered over the middle or rear of the foot, chest out, and shoulders back; good use of hip muscles on the way down and on the way up, with head in a neutral position throughout the movement; maintained good form during all repetitions; abducted)spread) the thighs on the way down during chair squats and double-leg squats; for single-let exercises, showed good strength on both sides; for single-leg lunge-squat with rear-foot support, maintained straight back, and knees stayed behind toes.

- *3 POINTS:*
  Weight was forward on the toes, with some rounding of the back; used thigh muscles excessively, with little use of hip muscles; head and chest were too far forward; showed little abduction of the thighs during double-leg squats; when going down for single-leg exercises, one side was stronger than the other; form deteriorated with repetitions; for single-leg lunge-squat with rear-foot support and single-leg squat from a bench, could not reach parallel (thigh parallel with floor).
- *1 POINT*
  Had difficulty performing the movement, rocking forward and rounding back badly; used thigh muscles excessively, with little use of hip muscles on the way up or on the way down; chest and head were forward; on un-weighted squats, had difficulty reaching parallel; and showed little abduction of the thighs on single-leg exercises, one leg was markedly stronger than the other; could not perform multiple repetitions.
- *0 POINTS*
  Could not perform exercise.

Using Your Results

Are you at all surprised by your rating for muscular strength?

What factors , if any, influenced your ability to perform these assessments?

Are you satisfied with your current level of muscular strength as evidenced in your daily life? For example, are you happy with your ability to lift objects, climb stairs, and engage in sports and recreational activities?

Muscle Endurance Assessment

For best results, do not do any strenuous weight training within 48 hours of any test.

The 60-Second Sit-Up Test

- *Equipment*
  1. Stopwatch, clock, or watch with a second hand
  2. Partner

> Warning
>
> **DO NOT TAKE THIS TEST IF YOU SUFFER FROM LOW-BACK PAIN.**

To prepare, try a few sit-ups to get used to the proper technique and warm up your abdominal muscles.

1. Lie flat on your back on the floor with knees bent, feet flat on the floor, and your fingers interlocked behind your neck and your elbows wide. Your partner should hold your ankles firmly so that your feet stay on the floor as you do the sit-ups.
2. When your partner signals you to begin, raise your head and chest off the floor until your chest touches your knees or thighs, keeping your elbows wide, then return to the starting position. Keep your neck neutral. Do not force your neck forward, and stop if you feel any pain.
3. Perform as many sit-ups as you can in 60 seconds.

   Number of sit-ups: _____

To rank your results, please see the chart on page 16.

Ratings for 60-second Sit-up Test:

Number of Sit-Ups						
Men	*Very Poor*	*Poor*	*Fair*	*Good*	*Excellent*	*Superior*
Age: Under 20	Below 36	36 - 40	41 -46	47 - 50	51 - 61	Above 61
20 - 29	Below 33	33 -37	38 - 41	42 - 46	47 - 54	Above 54
30 - 39	Below 30	30 - 34	35 - 38	39 - 42	43 - 50	Above 50
40 - 49	Below 24	24 - 28	29 - 33	34 - 38	39 - 46	Above 46
50 - 59	Below 19	19 - 23	24 - 27	28 - 34	35 - 42	Above 42
60 and over	Below 15	15 - 18	19 - 21	22 - 29	30 - 38	Above 38

Number of Sit-Ups						
Women	*Very Poor*	*Poor*	*Fair*	*Good*	*Excellent*	*Superior*
Age: Under 20	Below 28	28 - 31	32 - 35	36 - 45	46 - 54	Above 54
20 - 29	Below 24	24 - 31	32 - 37	38 - 43	44 - 50	Above 50
30 - 39	Below 20	20 - 24	25 - 28	29 - 34	35 - 41	Above 41
40 - 49	Below 14	14 - 19	20 - 23	24 - 28	29 - 37	Above 37
50 - 59	Below 10	10 - 13	14 - 19	20 - 23	24 - 29	Above 29
60 and over	Below 3	3 - 5	6 - 10	11 - 16	17 - 27	Above 27

The Push-Up Test

- *Equipment*:
  Mat or towel (optional)

In this test, you will perform either standard push-ups, or modified push-ups, in which you support yourself with your knees. The Cooper Institute developed the ratings for this test with men performing push-ups and women performing modified push-ups. Biologically, males tend to be stronger than females; the modified technique reduces

the need for upper-body strength in a test of muscular endurance. Therefore, for an accurate assessment of upper-body endurance, men should perform standard push-ups and women should perform modified push-ups. (However, in using push-ups as part of a strength-training program, individuals should choose the technique most appropriate for increasing their level of strength and endurance, regardless of gender.)

Instructions

1. For push-ups: Start in the push-up position with your body supported by your hands and feet. For the modified push-ups: Start in the modified push-up position with your body supported by your hand and knees. For both positions, your arms and your back should be straight and your fingers pointed forward.
2. Lower your chest to the floor with your back straight, and then return to the starting position.
3. Perform as many push-ups as you can without stopping.

   Number of push-ups: _____

   Number of modified push-ups: _____

Rating Your Push-Up Test Result

Your score is the number of completed push-ups or modified push-ups. Refer to the appropriate portion of the table on page 19 for a rating of your upper-body endurance.

Record your rating below and in the chart at the end of this lab.

Rating: _____

Ratings for the Push-Up and Modified Push-Up Test:

Men	Number of Modified Push-Ups					
	Very Poor	*Poor*	*Fair*	*Good*	*Excellent*	*Superior*
Age: 18 - 29	Below 22	22 - 28	29 - 36	37 - 46	47 - 61	Above 61
30 - 39	Below 17	17 - 23	24 - 29	30 - 38	39 - 51	Above 51
40 - 49	Below 11	11 - 17	18 - 23	24 - 29	30 - 39	Above 39
50 - 59	Below 9	9 - 12	13 - 18	19 - 24	25 - 38	Above 38
60 and over	Below 6	6 - 9	10 - 17	18 - 22	23 - 27	Above 27
Women	**Number of Modified Push-Ups**					
	Very Poor	*Poor*	*Fair*	*Good*	*Excellent*	*Superior*
Age: 18 - 29	Below 17	17 - 22	23 - 29	30 - 35	36 - 44	Above 44
30 - 39	Below 11	11 - 18	19 - 23	24 - 30	31 - 38	Above 38
40 - 49	Below 6	6 - 12	13 - 17	18 - 23	24 - 32	Above 32
50 - 59	Below 6	6 - 11	12 - 16	17 - 20	21 - 27	Above 27
60 and over	Below 2	2 - 4	5 - 11	12 - 14	15 - 19	Above 19

SOURCE: Based on norms from the Cooper Institute for Aerobic Research, Dallas, Texas; from the Physical Fitness Specialist Manual, Revised 2002.
Used with permission.

The Squat Endurance Test

Instructions

1. Stand with your feet placed slightly more than shoulder width apart, toes pointed out slightly, hands on hips or across your chest, head neutral, and back straight. Center your weight over your arches or slightly behind.
2. Squat down, keeping your weight centered over your arches, until your thighs are parallel with the floor. Push back up to the starting position, maintaining a straight back and neutral head position.
3. Perform as many squats as you can without stopping.

Number of squats: _____

Rating your Squat Endurance Test Result

Your score is the number of completed squats. Refer to the appropriate portion of the table for a rating of your leg muscular endurance. Record your rating below and in the summary at the end of this lab.

Rating: _____

Ratings for the Squat-Endurance Test:

Number of Squats Performed

Men	Very Poor	Poor	Below Average	Average	Above Average	Good	Excellent
Age: 18-25	<25	25-30	31-34	35-38	39-43	44-49	>49
26-35	<22	22-28	29-30	31-34	35-39	40-45	>45
36-45	<17	178-22	23-26	27-29	30-34	35-41	>41
46-55	<9	13-17	18-21	22-24	25-38	29-35	>35
56-65	<9	9-12	13-16	187-20	21-24	25-31	>31
65 +	<7	7-10	11-14	15-18	19-21	22-28	>28
Women	*Very Poor*	*Poor*	*Below Average*	*Average*	*Above Average*	*Good*	*Excellent*
Age: 18-25	*<18*	*18-24*	*25-28*	*29-32*	*33-36*	*37-43*	*>43*
26-35	*<20*	*13-20*	*21-24*	*25-28*	*29-32*	*33-39*	*>39*
36-45	*<7*	*7-14*	*15-18*	*19-22*	*23-26*	*27-33*	*>33*
46-55	*<5*	*5-9*	*10-13*	*14-17*	*18-21*	*22-27*	*>27*
56-65	*<3*	*3-6*	*7-9*	*10-12*	*13-17*	*18-24*	*>24*
65 +	*<2*	*2-4*	*5-10*	*11-13*	*14-16*	*17-23*	*>23*

SOURCE: Top End Sports. www.topendsports.com/testing/tests/home-squat.htm

Summary of Results

Test	Number Performed	Rating
Sit-up Test		
Push-up Test		
Squat Endurance Test		

Using Your Results

1. Are you at all surprised by your ratings for muscular endurance?
2. What factors, if any, influenced your scores?
3. Are you satisfied with your current level of muscular endurance as evidenced in your daily life, for example, your ability to carry groceries or your books, hike, and do yard work?

CHAPTER OVERVIEW

6: Flexibility

One of the five health related components of fitness is flexibility. Flexibility relates to the ability to move a joint through it's full range of motion (ROM). To develop a complete fitness program, you should take time to emphasize this component in your routine by stretching. Unfortunately, "...most people neglect flexibility training, limiting freedom of movement, physical and mental relaxation, release of muscle tension and soreness, and injury prevention." (American Council on Exercise)

Flexibility is classified into two types: static and dynamic. **Static flexibility** is a measure of the limits of a joints overall range of motion. It's measured by stretching and holding a joint in the position of it's maximum range while using a measuring instrument to quantify that range. To achieve the maximum range, passive forces are required (force generated from an external source). **Dynamic flexibility** is a measure of overall joint stiffness during movement. Unlike static flexibility, dynamic flexibility requires active force production (your own muscles contracting). Because it's difficult to quantify "stiffness," dynamic flexibility is measured more subjectively. For example, how easy is it to swing a tennis racket, climb steps, or get in and out of a car? The target of any good stretching program is to improve static and dynamic flexibility so that normal ROM can be achieved. The term "normal" relates to population studies that have measured various areas of the body and established an average degree of movement for a particular joint.

6.1: THE BENEFITS OF FLEXIBILITY AND STRETCHING
6.2: IMPROVING RANGE OF MOTION
6.3: WAYS TO IMPROVE FLEXIBILITY
6.4: CREATING AN EFFECTIVE STRETCHING PROGRAM
6.5: ASSESSING YOUR FLEXIBILITY, LABORATORY EXERCISES

6.1: THE BENEFITS OF FLEXIBILITY AND STRETCHING

There are many benefits to regular stretching with the most important of those being simple: being flexible will help you move freely and complete activities with greater ease.

Healthy Joints and Pain Management

As many as 28 percent of all adults report pain and stiffness in joints. That number increases dramatically with age and women are more likely to develop joint symptoms. For adults, arthritis is one of the most common conditions with 54% of people 75 years and older having been diagnosed with arthritis. Regular exercise, including regular stretching, is essential for people with arthritis to maintain function and manage joint pain. Even for those not affected by joint conditions, stretching increases joint mobility and function, and decreases joint stiffness and pain.

Pain can also be related to imbalances in the muscles. For example, if the front of your thighs and hips get too tight from a lack of flexibility, the tension will pull on the hips (where the muscles are attached). The result is the pelvis may be pulled forward and cause greater sway in your lower back. This affects your posture and can eventually lead to pain and stiffness in the neck, shoulders and lower back. Stretching regularly, for all major muscle groups/joint areas, promotes good alignment and balance.

Muscle Relaxation and Stress Relief

Staying in one position for long periods of time, repetitive movements, and other everyday stressors can result in stiff muscles and knots (also called trigger points). Regular stretching decreases anxiety, blood pressure, and breathing rate which help to relax muscles and aches and pains related to neuromuscular tension (stress). Flexibility has also been prescribed successfully to treat dysmenorrhea (painful menstruation) and to relieve muscle cramps during participation of exercise/sports.

Other Benefits

In addition to the benefits listed above, several other benefits have been researched and characterized as good reasons maintain a regular routine of stretching:

- Increased blood flow- Blood carries vital nutrients and oxygen to muscles and tissues. Stretching increases blood flow to the muscles being stretched which may help them recover from exercise faster.
- Reduction of Future Lower Back Pain-Most experts agree (while research is still inconclusive) that counteracting the natural loss in muscle and connective tissue elasticity that occurs with aging with muscle fitness and stretching exercises can reduce your risk of developing lower- back pain.

Flexibility and Aging

For many young adults, the thought of long term flexibility can be taken for granted. For example, how hard is it to bend over and tie your shoes? How difficult is it to walk around campus with a backpack? As young adults, most of those activities are likely encountered with little pain or resistance. However, ROM declines with age. Simple things like rotating the head and neck to glance over the shoulders, getting in and out of a vehicle, or carrying groceries can be painful. Therefore, flexibility is critical to maintaining a high quality of life in older years.

The Inactivity-Mobility Cycle

If you have ever been injured to the point that required immobilization of a joint, you realize how important mobility is in relation to your overall health. Unfortunately, as joints ROM is restricted from arthritis or other injuries, activity declines. As activity declines, the ROM likely continues to suffer as a result of inactivity and the vicious cycle ensues. A simple stretching program can help alleviate this problem and help break out of the cycle.

6.2: IMPROVING RANGE OF MOTION

Joint ROM results from a combination of factors which could be classified as internal or external. Internal structures relate to the physical structures of body materials and tissue. External factors are non-structural and include environmental temperature, gender, age, excess fat mass, muscle mass, and restrictions in clothing or equipment.

Internal factors include joint structure/joint mechanics and the connective and soft tissue surrounding the joint. Because muscular actions such as muscular contractions and stretching are controlled by the nervous system, another internal factor can be attributed to the neuromuscular system and how the stretching and tension is managed.

Joint Structure

A joint is a location on the body in which two or more bones intersect and interact. For example, the humerus (upper arm) intersects with the radius and ulna (lower arm) at the point of the elbow. The bony formation of each joint structurally limits the ROM. For example, the shoulder joint which is structurally a ball-in-socket joint, can rotate in multiple directions. In other words, it has a wide range of motion. However, the knee joint is a modified hinge joint which is limited to essentially a forward-backward direction of movement. Additionally, excessive fat mass surrounding a joint or even large muscle mass may limit the ROM for a particular joint. Although weight loss could affect amounts of fat mass surrounding a joint, or loss of muscle, joint structure cannot be altered. As a result, little can be done in this area to improve flexibility.

Not only is range of motion related to the joint structure, but flexibility exercises are joint-specific. In other words, you can't stretch your hamstring and expect your shoulders to improve. Likewise, you can be flexible in your shoulder but very "stiff" in your fingers or ankles. So, a complete stretching program must include multiple stretches for various joints.

Connective and Muscle Tissue

Joints are surrounded and connected by muscles, tendons, ligaments, and skin. For example, the head of the humerus fits into a small cavity to create the shoulder joint. However, those bones can only remain in place as a result of the muscles, tendons, and ligaments that keep the joint tight an in place. In addition, muscle tissue is surrounded with connective tissue, primarily collagen and elastin. As a joint moves through it's normal range of motion, all of this soft tissue must stretch to accommodate the movement. Therefore, static and dynamic flexibility is probably most limited by the flexibility of the surrounding soft tissue, specifically the connective tissue.

While the exact biomechanics of how flexibility is changed isn't well understood, it does appear to be related to the elastic and plastic properties of the connective tissue. Elasticity is defined as the ability to return to resting length after **passive stretching** (i.e. elastic recoil). Like a spring, soft tissues stretch and then recoil to their resting position. Plasticity is the tendency to assume a greater length after passive stretching (i.e. plastic deformation). In other words, taking that stretchy spring and changing the resting position to a new longer length. The goal of a flexibility program, is to repeatedly overload the elastic properties of the muscle to elicit plastic deformation over time. Several studies have suggested that a slow, sustained stretch of 30-90 seconds is necessary to produce chronic plastic deformation.

Neuromuscular System

Modern cars come equipped with a central computer and sensors throughout to troubleshoot problems with the vehicle. Sensors in the engine determine temperature. Sensors on the wheels determine tire pressure while sensors in the gas tank tell you when the gas tank is low in fuel. Much like car, our bodies are equipped with sensors, called proprioceptors, that help us manage movement and prevent injury.

Muscles have two specific types of proprioceptors that determine the length and tension of the muscle. These proprioceptors are called muscle spindles and Golgi tendon organs (GTO's).

Muscles spindles, lie parallel to the regular muscle and help determine the length of muscles when they are being stretched. When a muscle is stretched, they send signals to the central nervous system causing the stretched muscle to contract. In other words, there is some resistance to the stretch generated by the nervous system's reflexive stimulus sent to the stretching muscle. This is called the myotatic or stretch reflex. Additionally, that same signal also causes the antagonist (the opposing) muscle to relax, called reciprocal inhibition. So, when you stretch your upper thigh (quadriceps) your hamstrings (antagonist to the quadriceps) are relaxed.

The GTOs are located near the musculotendon junction, the end points of the muscle, and relay messages to the central nervous system regarding muscle lengthening and tension of the muscle. When activated, these signals will override the stretch reflex causing a sudden relaxation of the stretching muscle. This is called autogenic inhibition or the inverse myotatic reflex. This inhibitory reflex can only occur after the muscle has been stretched for 5 seconds or longer. This is why, to effectively stretch, movements must be sustained for long, slow increments of time. Otherwise, the resistance encountered from the stretch reflex will not be overridden and lengthening cannot occur. Whether signaling the muscles to contract or relax, the neuromuscular system manipulates the stretched muscle, presumably as a protective mechanism to prevent injury.

6.3: WAYS TO IMPROVE FLEXIBILITY

Stretching Techniques

Multiple stretching techniques have been researched with results showing they can be beneficial in improving ROM. Regardless of the specific technique or specific mode used, each technique can be performed using two basic modes: active or passive. **Active stretching**, also called unassisted stretching, suggests that the actual stretch is done individually without an external stimulus.**Passive stretching**, or assisted stretching is when a partner or trainer is used as the stimulus in the stretching exercise. Both modes are effective and can be applied to each of the techniques mentioned below.

Static Stretching

The most commonly prescribed and most commonly used technique for improving flexibility is the static stretch. A static stretch involves slow, gradual and controlled movements. The muscle group is stretched toward the end of the joint ROM until the point of mild discomfort is reached. Once that point is reached, the stretch is held in a “static” position for 30 to 90 seconds. After the prescribed time, the stretch can be repeated. Common ways in which static stretching is applied would be in Yoga routines or stretching after a workout or athletic event.

Some of the major advantages for static stretching is that it is generally considered safe (see Stretches to Avoid), it is simple to perform and effective at increasing ROM. The only major disadvantage comes from when it is done too much which can reduce strength and may make joints unstable. Of course this could apply to any of the techniques.

Ballistic Stretching

Ballistic stretching involves forceful bouncing or ball-like movements that quickly exaggerate the joint ROM without holding the position for any particular duration. This type of stretching involves dynamic movements like those done by athletes during sports events. In that regard, ballistic stretching is seen as being very specific to and beneficial for athletes. However, one criticism of ballistic stretching is that because of the short duration of the stretch, and ballistic movements that can be forceful, the muscular contraction from the stretch reflex may cause muscle soreness or even injury. For that reason, many athletic coaches feel ballistic stretching is unsafe. Also, many researchers feel it is less effective at improving ROM. Nonetheless, the ACSM still recommends ballistic as one method to effectively increase flexibility.

Synamic Stretching

Ballistic stretching is a form of dynamic stretching. However, when referring to dynamic stretching routines, most fitness professionals are referring to dynamic movements that don’t involve forceful bouncing motions. Instead, dynamic stretching, in this context, suggests performing exaggerated sports movements in a slower, more controlled manner. For example, a sprinter may use several exaggerated stride lengths before a race to improve hip ROM.

An advantage of dynamic stretching is that it will target and improve dynamic flexibility which in turn may improve performance. A disadvantage comes from the type of movements which often require good balance and coordination. So, learning correct form and being able to perform dynamic stretches may take a little time to learn or may not be applicable to certain populations.

Proprioceptive Neuromuscular Facilitation (PNF) Stretching

This type of exercise usually involves a partner. The partner will passively stretch the muscle, immediately followed by an isometric muscle contraction against resistance. This contraction is then followed by another passive stretch. This type of stretch is also named contract-relax stretch because of the sequence of movements involved. Other types of PNF stretching involve contract-relax-antagonist contrac- tion, also describing the sequence of movements involved but adding an additional step.

As the name of the technique implies, PNF stretching emphasizes the natural interaction of the proprioceptors with the muscles to increase the ROM during the stretch. Remember that during the stretch, the muscle spindles cause two things to happen, the stretch reflex and reciprocal inhibition (the antagonist muscle to relax). After 5 seconds, the GTO’s then override the muscle spindle’s signals causing autogenic inhibition. Because the muscle is relaxed, it can more easily be stretched. In other words, the stretch either uses the activity of the antagonist muscle to get the target muscle to relax or the target muscle itself to relax as a result of the contraction.

While many experts feel that PNF stretching is the most effective technique, studies that compare static and PNF stretching are inconclusive. Regardless, it does appear to be very effective at increasing static flexibility. Some disadvantages to PNF is that it

generally requires a knowledgeable partner, it’s somewhat complicated, and can cause some soreness from the contractions.

6.4: CREATING AN EFFECTIVE STRETCHING PROGRAM

The ACSM has made recommendations on how to design a flexibility program. However, before getting into the design, you should know your current flexibility status by assessing various joint's ROM. Specifically, performing the sit- and-reach test will assess your hamstring and lower back flexibility while using a goniometer can be used to assess your ankles, knees, hips, neck and shoulders. Instructions on how to perform these assessments will follow later.

Set Goals

Once you learn where you are most and least flexible, you should make some realistic goals to improve or maintain your ROM. Be specific when you set goals. Instead of just saying, "I want to increase my flexibility," you will want to state the specific area of the body you intend to improve. You will also want to make sure your goal can be measured. A better way to state your goal may be, "I will improve my sit-and-reach score by 4 cm by the end of the semester." Notice this goal, as stated, includes a specific area, is measurable, and includes a deadline. By stating your goal properly, you will increase the likelihood of actually achieving it.

Apply the FITT Principle

As mentioned previously, the ACSM has made recommendations for carrying out a flexibility program based on the FITT Principle (Frequency, Intensity, Time and Type). As you select the areas you want to stretch, keep in mind it is recommended that multiple stretching exercises should be performed to target all major joints including the neck, shoulders, elbows, wrists, trunk, hips, knees, and ankles. (insert link to specific exercise here). After selecting your exercises, follow the below recommendations when performing your routine.

- ***Frequency***-Stretch a minimum of 2-3 days per week, ideally 5-7 days per week.
- ***Intensity***-Stretch to the point of tightness or mild discomfort.
- ***Time (or duration of each stretch)***-a minimum of 10 seconds for very tight muscles with an emphasis to progress to 30-90 seconds. Two to four repetitions of each stretch should be done.
- ***Type (mode)***-Select from either of the above techniques mentions that best suit your circumstances (Static, Dynamic, Ballistic, or Proprioceptive Neuromuscular Facilitation).

When to Stretch

Although stretching can be done at any time of the day, the ACSM has traditionally recommended that flexibility training be incorporated into the warm up or cool down phase of an exercise session. Recent studies have provided evidence against stretching before exercise session suggesting that stretching will compromise the force- producing capabilities of muscles. Therefore, it is recommended that stretching take place only after the body temperature and of the muscles has increased, i.e. after the warm up or after the workout. Additional confirming evidence of this concept has shown that applying heat packs for 20 minutes to increase muscle temperature can increase hamstring flexibility more so than 30 seconds of static stretching. As you can see, temperature also plays a significant role in muscle ROM.

http://www.acsm.org/public-information/articles/2016/10/07/improving-your-flexibility-and-balance

Stretching Safely

In addition to warming the muscle before performing stretching exercises, there are other things that can be done to make your flexibility routine safe. When muscles are stretched quickly and forcefully, the stretch reflex can be activated. This creates significant tension because the muscle fibers will not only be stretching but also attempting to contract. As mentioned, this is one of the reasons ballistic stretching may not be suitable for everyone. To avoid this, stretch slowly and in a controlled fashion while holding the stretch for 10 seconds or more.

In addition, some stretches are not recommended, or contraindicated. Researchers have determined that some stretching exercises may not be beneficial at all or may cause injury. A list of contraindicated stretches and alternative stretches can be found by clicking on the link below. However, this is not a comprehensive list of potentially risky stretches. It is important to understand personal limitations before or during a stretch exercise to avoid injury.

Contraindicated Stretches

https://www.unm.edu/~lkravitz/Teaching%20Aerobics/YoungExercise3.pdf

6.5: ASSESSING YOUR FLEXIBILITY, LABORATORY EXERCISES

The first step in creating a successful flexibility program is to assess your own flexibility. Follow the link below to understand how you can perform these assessements. Those that may be most helpful include sections 5.1, 5.2, and 5.3.

https://wpscms.pearsoncmg.com/bc_hopson_health_2/214/54825/14035385.cw/index.html

References

Sources

1. Gummelt, D, The Impact of Flexibility Training on Performance, 2015, ACE Fitness; https://www.acefitness.org/education...on-performance

2. Neogi, T. (2013). The Epidemiology and Impact of Pain in Osteoarthritis. Osteoarthritis and Cartilage / OARS, Osteoarthritis Research Society, 21(9), 1145–1153. http://doi.org/10.1016/j.joca.2013.03.018

3. Arthritis Foundation; arthritis.org, retrieved April 2018; https://www.arthritis.org/aboutarthr...tics-facts.php

4. Kruse, NT, Sillete, CR, Scheuermann, BW; American Journal of Physiology; Heart and Circulatory Physiology, 2016, May 1; 310 (9): H1210-21.

5. Hindle, K. B., Whitcomb, T. J., Briggs, W. O., & Hong, J. (2012). Proprioceptive Neuromuscular Facilitation (PNF): Its Mechanisms and Effects on Range of Motion and Muscular Function. Journal of Human Kinetics, 31, 105–113. http://doi.org/10.2478/v10078-012-0011-y

Biomechanics of Stretching

medind.nic.in/jau/t06/jaut06p3.pdf

CHAPTER OVERVIEW

7: Body Composition

By Scott Flynn

Learning Objectives

- What is body composition?
- How does body composition affect a person's health?
- What are the health risks and costs associated with overweight and obesity?
- What is the significance of body fat distribution?
- What is Body Mass Index (BMI) and why is it important?

7.1: Body Weight versus Body Composition
7.2: Diseases Associated with Excessive Body Fat
7.3: How Much Fat is Needed?
7.4: Body Fat Distribution
7.5: Body Mass Index
7.6: How to Measure Body Composition
7.7: Weighing in on the U.S.
7.8: What Can Be Done?

7.1: Body Weight versus Body Composition

According to surveys, the top reason American females exercise is for weight control. For males, the top reason is to improve muscle tone while weight control ranks as the fourth most important reason.[1] Levels of attractiveness based on weight and visible musculature are significant points of emphasis in American culture. As such, individuals with well-toned muscles and low body weight are marketed as*superior* within the context of attractiveness, financial success, and multiple other traits. Unfortunately, this emphasis, as seen in mainstream media, can result in unrealistic ideals and potentially harmful behaviors, such as eating disorders.

Unlike the mainstream outlets, which focus on the association between fat levels and physical attractiveness, this chapter focuses on the health-related consequences related to good and bad body composition. **Body composition** is defined as the body's relative amount of fat-free mass (FFM) and fat mass (FM) and is generally expressed as a percentage of total body weight. FFM includes bones, muscles, ligaments, body fluids and other organs, while FM is limited to fat tissue.

The Importance of Measuring Body Composition Rather Than Just Tracking Body Weight

Tracking weight can be helpful, but body composition measurements help separate a person's actual weight from the weight that could be unhealthy.

For example, an individual who weighs 200 pounds and has 8% body fat, such as an athlete, only carries around 16 pounds of FM. However, a 200-pound person who has a sedentary lifestyle and a body composition of 20%, carries 40 pounds of FM. Weight alone, in this case, does not distinguish between FFM and FM and would suggest both individuals have similar health. As body fat percentage increases, the potential for various diseases also increases significantly.

7.2: Diseases Associated with Excessive Body Fat

According to the National Institute of Health (NIH), a wide array of diseases can be linked to excessive body fat.[2] Some of them are:

- Type II Diabetes Mellitus
- Hypertension
- Cancer
- Cerebrovascular Disease (Stroke)
- Cardiovascular Disease
- Metabolic Syndrome
- Lung Disorders
  - Sleep Apnea
  - Asthma
- Musculoskeletal Diseases
  - Osteoarthritis
  - Gout
- Gallbladder Disease
- Pancreatitis
- Non-Alcohol Fatty Liver Disease
- Dementia
- Psychological Problems and Quality of Life
- Kidney Disease
- Pregnancy Problems

An explanation of how being overweight relates to each disease (those highlighted) can be viewed by clicking on the following link.

NIH-Explanation of Disease Risk Associated with Overweight

7.3: How Much Fat is Needed?

Fat is a necessary component of daily nutrition. It is needed for healthy cellular function, energy, cushioning for vital organs, insulation, and for food flavor.

Fat storage in the body consists of two types of fat: essential and nonessential fat.**Essential fat** is the minimal amount of fat necessary for normal physiological function. For males and females, essential fat values are typically considered to be 3% and 12%, respectively. Fat above the minimal amount is referred to as **nonessential fat**. It is generally accepted that an overall range of 10-22 percent for men and 20-32 percent for women is considered satisfactory for good health. A body composition within the recommended range suggests a person has less risk of developing obesity-related diseases, such as diabetes, high blood pressure, and even some cancers.

A woman's essential fat range is naturally greater than a man's because of fat deposits in breasts, uterus and sex-specific sites. In both males and females, non- essential fat reserves can be healthy, especially in providing substantial amounts of energy.

Excessive body fat is categorized by the terms overweight and obesity. These terms do not implicate social status or physical attractiveness, but rather indicate health risks. **Overweight** is defined as the accumulation of non-essential body fat to the point that it adversely affects health. According to the American College of Sports Medicine (ACSM), the threshold for being characterized as overweight is having a body composition of FM greater than 32% and 19% for females and males, aged 20-39, respectively.[3]

Obesity is characterized by excessive accumulation of body fat and can be defined as a more serious degree of being overweight. Classifications of obesity begin at body composition of FM greater than 39% and 25% in females and males ages 20- 39, respectively. [4]

Other Health Risks

Diseases are not the only concern with an unhealthy body fat percentage. Several others are listed below.

- *Performance of physical activity*
  An important component of a healthy lifestyle and weight management is regular physical activity and exercise. To the contrary, those who live a sedentary lifestyle will find it more difficult to maintain a healthy body weight or develop adequate musculature, endurance, and flexibility. Unfortunately, additional body weight makes it more difficult to be active because it requires more energy and places a higher demand on weak muscles and the cardiovascular system. The result is a self-perpetuating cycle of inactivity leading to more body weight, which leads to more inactivity.
- *Emotional wellness*
  Studies indicate obesity is associated with a 25% increase in anxiety and mood disorders, regardless of age or gender. Other studies suggest increases in BMI significantly increase the incidence of personality disorders and anxiety and mood disorders. Additional studies have been able to associate a higher incidence of psychological disorders and suicidal tendencies in obese females compared with obese males.[5]
- *Pre-mature death*
  The association between obesity and diseases, such as cancer, CVD, and diabetes, suggests that people with more body fat generally have shorter lifespans. The Center for Disease Control (CDC) estimates up to 365,000 deaths each year can be linked with obesity, representing nearly 15% of all deaths. Other studies have tied the Years of Life Lost to body mass index measurements, estimating anywhere from 2 to 20 years can be lost, depending on ethnicity, age at time of obese classification, and gender.[6]
- *Economic impact*
  The physical harm caused by obesity and overweight is mirrored by its economic impact on the health care system. The CDC has estimated the medical costs to be about $147 billion in 2008, which includes preventative, diagnostic, and treatments. Overweight and obesity also contribute to loss of productivity at work through absenteeism and *presenteeism*, defined as being less productive while working. The annual nationwide productive costs fall within the range of from $3.38 to $6.38 billion.[7]

7.4: Body Fat Distribution

Body composition measurements can help determine health risks and assist in creating an exercise and nutrition plan to maintain a healthy weight. However, the presence of unwanted body fat is not the only concern associated with an unhealthy weight. Where the fat is stored, or fat distribution, also affects overall health risks.

Non-essential fat is primarily stored in**adipose tissue**, or fat cells, located on the surface of the body and surrounding the body's organs. Surface fat, located just below the skin, is called **subcutaneous fat**. Fat that lies deeper in the body surrounding the body's organs is called **visceral fat**. Unlike subcutaneous fat, visceral fat is more often associated with abdominal fat. Researchers have found that excessive belly fat decreases insulin sensitivity, making it easier to develop type II diabetes. It may also negatively impact blood lipid metabolism, contributing to more cases of cardiovascular disease and stroke in patients with excessive belly fat.[8]

Body fat distribution can easily be determined by simply looking in the mirror. The outline of the body, or body shape, would indicate the location of where body fat is stored. Abdominal fat storage patterns are generally compared to the shape of an apple, called the **android shape**. This shape is more commonly found in males and post- menopausal females. In terms of disease risk, this implies males and post- menopausal females are at greater risk of developing health issues associated with excessive visceral fat. Individuals who experience chronic stress tend to store fat in the abdominal region.

A pear-shaped body fat distribution pattern, or **gynoid shape**, is more commonly found in pre-menopausal females. Gynoid shape is characterized by fat storage in the lower body such as the hips and buttocks. This shape may be connected to females' child-bearing abilities as enzymes associated with fat-storage and mobilization are activated during certain times of pregnancy and post-partum.

Besides looking in the mirror to determine body shape, people can use an inexpensive tape measure to measure the diameter of their hips and waist. Many leading organizations and experts currently believe a waist circumference of 40 or greater for males and 35 or greater for females significantly increases risk of disease.[9]

In addition to measuring waist circumference, measuring the waist and the hips and using a waist-to-hip ratio (waist circumference divided by the hip circumference) is equally effective at predicting body fat-related health outcomes. According to the National Heart, Lung, and Blood Institute, a ratio of greater than 0.82 for females and 0.94 for males is associated with a higher risk of developing heart disease, diabetes, and hypertension.[10]

7.5: Body Mass Index

In addition to body composition and waist/hip circumferences, measuring body mass has also been used as an effective method to assess health risks. **Body mass index (BMI)** is a measurement of height (m2) and weight (kg) suggesting that a person's body's weight should be proportional to his or her height. For example, based on the BMI scale, a female with a height of 5'6" should not weigh more than 155 lbs. If her weight exceeded 155 lbs., she would be categorized as "overweight."

$$BMI = \frac{Weight(kg)}{Height(m^2)} \tag{7.5.1}$$

Among several criticisms, the BMI method has been faulted for not distinguishing between FM and FFM, since only the overall weight is taken into account. For athletes, who may be more massive as a result of larger muscles, this criticism holds true. For example, a professional football player who weighs 215 pounds and stands at 6'3" would have the exact same BMI as a relatively sedentary arm-chair quarterback who also weighs 215 pounds with the same height. This discrepancy also exists when applying BMI to the senior population. As age increases, muscle mass declines. Seniors who have experienced years of muscle mass decline but increased body fat may maintain a constant weight despite having a very different body composition.

Other criticisms of using BMI as a health risk assessment tool include its failure to take age or gender into account. As discussed previously, females naturally have more body fat yet are classified in the same context as males. Because this measurement is so widely used by physicians, patients continue to express concerns about the validity of BMI as an indication of fatness.

Regardless of the criticisms, BMI as used for the general population, has been shown to be a reasonable predictor of health outcomes. At its core, it is not intended to be an estimate of body composition, i.e., measure FM and FFM. Instead, it is intended to be used as an estimate of healthy/unhealthy levels of body fat. When used as a means of tracking weight changes over time it can be a valuable tool in predicting health and for recommending lifestyle modifications.[11]

7.6: How to Measure Body Composition

Multiple methods exist to estimate body composition. Remember, body composition is the ration of FM and FFM used to help determine health risks. Of the other methods already mentioned (waist, waist- to-hip ratio, and BMI), none provide estimates of body composition but do provide measurements of other weight- related health markers, such as abdominal fat. Experts have designed several methods to estimate body composition. While they are not flawless, they do provide a fairly accurate representation of body composition. The most common are:

- *Hydrostatic Weighing (Underwater Weighing)*
  At one time, hydrostatic weighing (also and maybe more accurately called **hydrodensitometry**) was considered the criterion for measuring body composition. Many other methods are founded on this model, in one form or another. This method attempts to measure the density of the body by applying Archimedes' principle: density = mass/volume. The mass and volume components are measured by using dry weight and then weight while being submerged in a water tank. Since fat is less dense than muscle tissue, a person with more body fat will weigh less in the water than a similar person with more lean mass. Using the measurements, the density can be determined and converted into body fat percentage. With a small margin of error (around 1-2%) this method is very accurate. Unfortunately, the expense and practicality of building and maintaining a water tank limits access for most. Also, for those with a fear of water, this would obviously not be the preferred method.
- *Dual Energy X-Ray Absorptiometry (DEXA)*
  Replacing underwater weighing as the new "gold standard," is DEXA. While underwater weighing accurately compartmentalizes FM and FFM, DEXA adds a third compartment by using low-radiation X-rays to distinguish bone mineral. This addition slightly increases the accuracy of DEXA by eliminating some of the guess work associated with individual differences, such as total body water and bone mineral density.

  Originally, DEXA scanners were designed to determine and help diagnose bone density diseases. As a result, they can be found in many physicians' offices. However, a full body scan, which takes only a few minutes, is all that is needed to also determine body fat percentage. Major disadvantages to this method are its high cost and the need for a well-trained professional to operate the equipment and analyze the results.

- *Air Displacement (Plethysmography)*
  A good alternative to more expensive methods, air displacement determines body density using the same principle as underwater weighing, by measuring mass and volume. Clearly, the main difference is that mass and volume are being determined by air displacement rather than water displacement. Using a commercial device (the Bod Pod is most commonly referenced), a person sits in a chamber that varies the air pressure allowing for body volume to be assessed. Air displacement provides a viable alternative for those with a fear of water.

  Like many other methods, the expense, availability, and training of personnel Air Displacement requires limit accessibility. Additionally, its accuracy is slightly less than underwater weighing.

- *Bio-electrical Impedance Analysis (BIA)*
  BIA takes a slightly different approach to measuring FFM. The premise behind BIA is that FFM will be proportional to the electrical conductivity of the body. Fat-tissue contains little water, making it a poor conductor of electricity; whereas, lean tissue contains mostly water and electrolytes, making it an excellent conductor. BIA devices emit a low-level electrical current through the body and measure the amount of resistance the current encounters. Based on the level of impedance, a pre-programed equation is used to estimate body fat percentage.

  The most accurate BIA devices use electrodes on the feet and hands to administer the point-to-point electrical current. The margin of error for these devices falls in the range of 3–5%. Portable or handheld BIA devices that only measure lower or upper body conductivity have a higher margin of error (4–8%).

  Because BIA devices primarily measure hydration, circumstances that may influence hydration status at the time of measurement must be taken into account. Recent exercise, bladder content, hydration habits, and meal timing can cause wide measurement variations and influence accuracy. However, this method is generally inexpensive, often portable, and requires limited training to use, making it a very practical option.

- *Skinfold Analysis*
  Skinfold analysis is a widely used method of assessing body composition because of its simplicity, portability, and affordability. It is also fairly accurate when administered properly. Margins of error are about 4–7%, depending on the quality of the skinfold

calipers and skill of the administrator/technician. The assumption of skinfold measurement is that the amount of subcutaneous fat is proportionate to overall body fat. As such, a technician pinches the skin at various sites and uses calipers to measure and record the diameter of the skin folds. These numbers can then be plugged into an equation to generate an estimate of body fat percentage.

The proportionality of subcutaneous fat and overall body fat depends on age, gender, ethnicity, and activity rates. As such, technicians should use the skinfold technique specific to the equation that accounts for those variables to improve accuracy.

7.7: Weighing in on the U.S.

Despite the well-known health concerns implicated in overweight and obesity and the availability of multiple methods for assessment and tools to improve body composition, current trends in the United States and around the world are moving in the wrong direction. The unprecedented number of obese Americans has led experts to label it an epidemic, much like they would a disease in a developing country. According to the CDC, the number of American adults (>20 years) that fall into the overweight classification based on BMI are 70.7%. Of those, 37.9% fall within the obese classification. In 1962, the overweight and obesity rates for adults in the U.S. were 32% and 13%, respectively. In other words, overweight trends have more than doubled and obesity rates have almost tripled over the past 50+ years.[12]

Of more concern are the increasing number of obese children ages 6-11 and adolescents ages 12-19, amounting to 17.4% and 20.6%, respectively.[13] While those numbers have stabilized over the past decade, this has led to a dramatic increase in insulin resistance, a form of diabetes formerly known as adult onset diabetes.

With such a diverse population in the U.S. and with an understanding of how BMI is calculated, it is only natural to question the high number of overweight and obese citizens based on BMI alone. However, it is generally believed this is an accurate portrayal of weight status. In a study attempting to compare BMI measurements to actual body fat percentage, it was determined that the total number of obese citizens may be underestimated, and its current prevalence may be worse than is currently being reported.

7.8: What Can Be Done?

With the available tools to identify health risks associated with body fat, anyone concerned about their health should gather as much data about body composition and body fat distribution as possible. Compiling multiple measurements and analyzing them provides a better idea of a person's current health status and will help determine the next course of action. For example, BMI alone can be beneficial. But when combined with waist circumference, a greater understanding of risk can be achieved. Likewise, when combining BMI and waist circumference with body fat percentage, an ideal conclusion of health status can be made.

In the lab accompanying this chapter, you will be guided through the process of assessing your BMI, waist circumference, waist-to-hip ratio, and body fat percentage.

The next course of action is to set goals and formulate a plan to get to a healthy range of weight and body fat percentage. Where weight loss is needed, the plan should include a balance of calorie restriction and physical activity/exercise. This might also include tracking your current eating and activity habits. More specific information on weight management strategies will be discussed in a later chapter.

Low Body Composition

Because more people experience excess body fat, the focus up to this point has been on health concerns related to overweight and obesity. However, fat is an essential component to a healthy body, and in rare cases, individuals have insufficient fat reserves, which can also be a health concern. The range of essential body fat for males is 3-5% and 8-12% for females. Attempting to, or intentionally staying in those ranges, through excessive exercise or calorie restriction is not recommended. Unfortunately, low body fat is often associated with individuals struggling with eating disorders, the majority of whom are females.

The main concern of low body fat relates to the number and quality of calories being consumed. Foods not only provide energy but also provide the necessary nutrients to facilitate vital body functions. For example, low amounts of iron from a poor diet can result in anemia. Potassium deficiencies can cause hypokalemia leading to cardiovascular irregularities. If adequate calcium is not being obtained from foods, bone deficiencies will result. Clearly, having low body fat, depending on the cause, can be equally as detrimental to health as having too much.

The health concerns most often linked to low body fat are:

- Reproductive disorders
  - Infrequent or missing menstrual cycles
- Respiratory disorders
- Immune System disorders
- Circulatory disorders
- Premature death

In some cases, despite attempts to gain weight, individuals are unable to gain the pounds needed to maintain a healthy weight. In these cases, as in the case of excess fat, a holistic approach should be taken to determine if the low levels of body fat are adversely affecting health. These individuals should monitor their eating habits to assure they are getting adequate nutrition for their daily activity needs. Additionally, other lifestyle habits should be monitored or avoided, such as smoking, which may suppress hunger.

Additional reading on low body fat and its impact can be found on the Livestrong.com website, on this page: At what body fat percent do you start losing your period?.

Sources:

1. Fitness Products Council/IHRSA/American Sports Data, Inc.,2005, Reprinted in SGMA's "Tracking the fitness movement" reports.

2. NIH-Disease Risk and Overweight https://www.niddk.nih.gov/health-information/weight-management/adult-overweight-obesity/health-risks

3. Body Composition http://www.acsm.org/public-information/articles/2016/10/07/measuring-and-evaluating-body-composition

4. Kravitz, L., Heward, V. Getting a Grip on Body Composition, Retrieved April 2017, https://www.unm.edu/~lkravitz/Article%20folder/underbodycomp.html

5. Knight, J.; Diseases and Disorders Associated with Excess Body Weight; Annals of Clinical Laboratory Science Spring 2011 vol. 41 no.2 107-121 http://www.annclinlabsci.org/content/41/2/107.full

6. Chang, S.-H., Pollack, L. M., & Colditz, G. A. (2013). Life Years Lost Associated with Obesity-Related Diseases for U.S. Non-Smoking Adults. PLoS ONE, 8(6), e66550. http://doi.org/10.1371/journal.pone.0066550

7. Centers for Disease Control and Prevention, Retrieved Jan 2018, CDC: Adult Obesity Causes and Consequences https://www.cdc.gov/obesity/adult/causes.html

8. Doheny, K. The Truth About Fat, WebMD, July 2009, http://www.webmd.com/diet/features/the-truth-about-fat#4

9. Harvard T.H. Chan School of Public Heatlh, Retrieved March 2018, HSPH: Waist Size Matters https://www.hsph.harvard.edu/obesity...minal-obesity/

10. National Heart, Lung, and Blood Institute, Retrieved Jan 2018, NIH: Classification of Overweight and Obesity by BMI, Waist Circumference, and Associated Disease Risks https://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmi_dis.htm

11. Jitnarin, N., Poston, W. S. C., Haddock, C. K., Jahnke, S. A., & Day, R. S. (2014). Accuracy of Body Mass Index-defined Obesity Status in US Firefighters. Safety and Health at Work, 5(3), 161–164. http://doi.org/10.1016/j.shaw.2014.06.003

12. National Institute of Diabetes and Digestive and Kidney Diseases, Retrieved March 2018, NIH: Overweight and Obesity Statistics https://www.niddk.nih.gov/health-information/health-statistics/overweight-obesity

13. Center for Disease Control and Prevention, Retrieved Feb 2018, CDC: Obesity and Overweight, https://www.cdc.gov/nchs/fastats/obesity-overweight.htm

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