Module 3
Muscle Physiology

Introduction

In this module you will learn about the different types of muscle tissue and the role they play in your body. You will also learn which exercises and training methods will help you to develop the muscles you want to work on. In addition, you will learn about specific muscle fibre types that can help you perform certain physical activities more effectively.

In Module 1 the **health-related fitness components** and the **skill-related fitness components** were identified. In this module you will determine your own capacity to perform some of the skill-related fitness components that help you to perform different movement and/or sport skills.

One of the first things you need to do is start Assignment 3.1, which is found in the Assignments section at the end of this module. In the Module 3 Physical Activity Log, you will describe the physical activities in which you will participate during the four weeks you will spend completing Modules 3 and 4. So, start filling in the Log now on a daily basis because it will take you at least four weeks to complete.

Assessment

You will be assessed on your completion of the Module 3 assignments found at the end of this module. The Checklist for Module 3 Assignments appears below. You will mail your completed assignments to your tutor/marker for assessment when you have completed Module 4.

Checklist for Module 3 Assignments

Lesson 1	Assignment 3.1: Module 3 Physical Activity Log
	Assignment 3.2: The Way I Move
Lesson 2	Assignment 3.3: Skill-Related Fitness
	Assignment 3.4: Quiz—Components of Physical Fitness
Lesson 3	Assignment 3.5: How Fit Am I?
	Assignment 3.6: Module 3 Physical Activity Plan

Lesson 1

Muscle Physiology

Lesson Focus

You will show an understanding of

- the structure of a skeletal muscle
- how muscles have different concentrations of various fibre types
- how fibre concentrations contribute to specific types of muscle actions
- how muscles change in response to various types of exercise

You will be able to

- distinguish between the different roles that muscles play
- differentiate between skeletal muscle fibre types

Introduction

This lesson will give you an opportunity to develop your understanding of the different types of muscles. You will learn about the structure of skeletal muscle and the skeletal muscle fibre types and how they relate to muscular development.

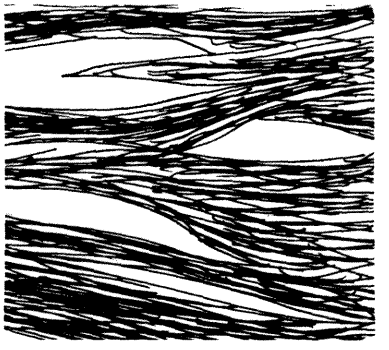
Assignment 3.1: Module 3 Physical Activity Log

Remember that, in your Physical Activity Log, you need to describe the physical activities you will be taking part in over the next four weeks, so it will take you at least that long to finish it. Better get started now! Assignment 3.1 is found in the Assignments section at the end of this module. You will mail the completed assignment to your tutor/marker when you have finished Module 4.

Types of Muscles

We use muscles to move. What is being moved is determined by the muscle that is working. Humans have three different kinds of muscles:

1. **Heart muscle,** also called **cardiac muscle,** makes up the wall of the heart. The heart beats, on average, about 70 times per minute, pumping (moving) about five litres of blood to the body in that same time. The contraction of cardiac muscle is **not** under voluntary control. In other words, it is **not** under your control. You don't make your heart beat; it beats automatically.
2. **Smooth muscle** is found in the walls of all the hollow organs of the body (except the heart). Its contraction reduces the size of these structures. The contraction of smooth muscle is **not** under voluntary control. Smooth muscle
   - regulates the flow (movement) of blood in the arteries
   - moves food along through the gastrointestinal tract
   - expels (moves) urine from the urinary bladder
   - sends (moves) babies out into the world from the uterus
   - regulates the flow (movement) of air through the lungs
3. **Skeletal muscle**, as its name implies, is the muscle attached to the skeleton. It is also called **striated** (or striped) **muscle** because it looks striped under a microscope (look at the graphic). When skeletal muscles are working they move body parts by pulling on the bones to which they are attached. The contraction of skeletal muscle **is** under voluntary control.



Anatomy of Skeletal Muscles

A muscle is actually made up of a number of units, each unit consisting of smaller units. Each unit of a muscle is encased in connective tissue, which holds that unit together much like the plastic covering of an electrical cord holds the wires together.

The structure of a muscle has the following components:

- A muscle is made up of numerous **bundles** (fascicle).
- Each bundle contains many **fibres.**
- Each fibre contains lots of **myofibrils**.

A **myofibril** is a single muscle cell and represents the smallest unit of a muscle. Physically, myofibrils range in size from microscopic to a few centimetres. The muscle cell is densely packed with proteins, energy stores, and signalling mechanisms that cause the muscle to contract. The myofibril requires systems for using energy (glucose and fat), which allow it to do its work (contract).

A single skeletal muscle is attached to a large area of bone by a **tendon**. This area of attachment is referred to as the **origin**. At its other end it tapers into a glistening white **tendon** and attaches to a different bone, thereby crossing a joint. This end is called the **insertion**.

The area of insertion is pulled toward the area of origin when the muscle contracts or gets shorter, thereby decreasing the angle of the joint. The decreasing angle results in movement. Since skeletal muscle only exerts force when it contracts, a second muscle is usually needed to return the joint to its original position unless gravity is used as the force to do so. These muscles are called **antagonistic pairs**.

Example: The **biceps** muscle bends the elbow and the **triceps** straightens it.

Together, the biceps and triceps make up an **antagonistic pair** of muscles. Similar pairs working antagonistically across other joints provide for almost all the movement of the skeleton.

Learning Activity 3.1: Skeletal Muscle Model

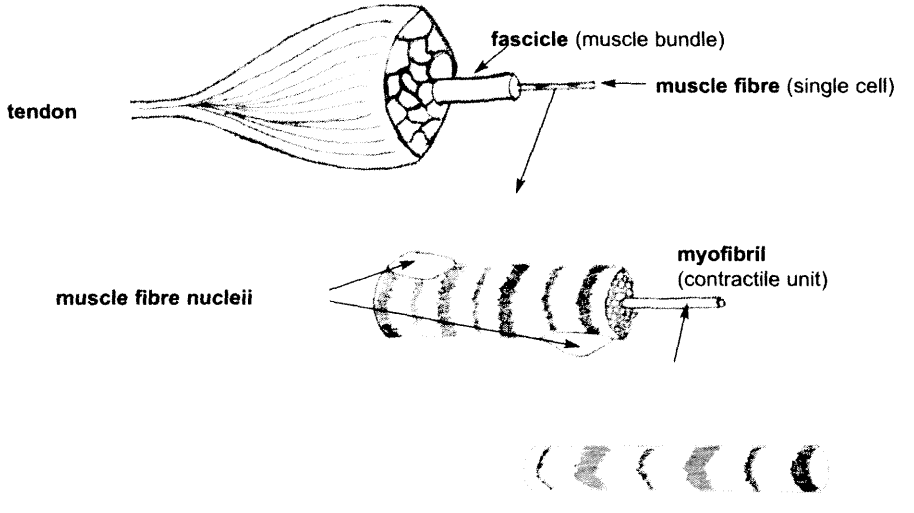
This learning activity will give you the chance to create a model of a skeletal muscle and label each of its individual units. You may use any materials that will illustrate the units of a muscle. Label the model clearly and include a brief explanation of the different parts.

Labelling should include

- muscle
- tendon
- muscle bundle or fascicle
- muscle fibre
- myofibril

You could start by bundling together materials such as string or wire (elastic works well) and wrapping them in plastic cling wrap. If you are unable to create a model, you could draw a colour picture of a skeletal muscle. First, find a colour picture on the Internet or in a textbook and use it as a model for your picture.

Skeletal Muscle (e.g., biceps)



Please note that no Learning Activity Answer Key is provided for Module 3.

Skeletal Muscle Fibre Types

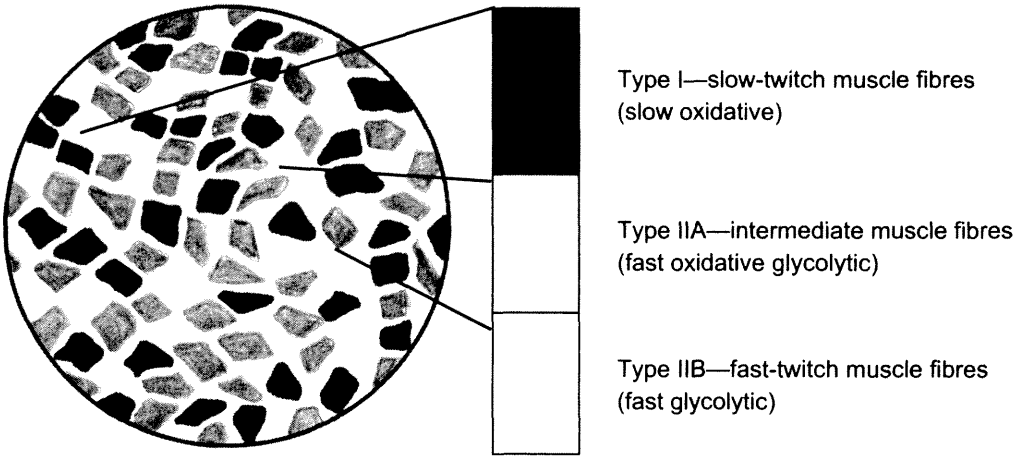
All skeletal muscles are composed of a blend of three different types of muscle fibres:

1. **Type I** or **slow-twitch muscle fibres** (also known as **slow oxidative**): These are smaller, have more blood flow (therefore more oxygen), have less immediately available fuel sources, and contract less quickly and with less force than fast-twitch muscle fibres. Their nerves conduct more slowly. They are important for endurance activities.
2. **Type IIA** or **intermediate muscle fibres** (also known as **fast oxidative glycolytic**): These are classified as fast-twitch muscle fibres but are able to take on the characteristics of slow-twitch fibres through specific training. They are more like fast-twitch fibres but, like slow-twitch fibres, have more blood flow.
3. **Type IIB** or **fast-twitch muscle fibres** (also known as **fast glycolytic**): These are larger, faster conducting, have less blood flow, have more immediately available fuel sources, have larger nerves activating them, and can contract more rapidly and with more force than slow-twitch muscle fibres. These are important for strength and speed activities.

Everyone's skeletal muscles include a blend of these three different types of muscle fibres. For most people this blend is made up of equal amounts of fast-twitch and slow-twitch muscle fibres (remember that intermediate fibres are classified as fast-twitch). However, there is a great difference when it comes to elite athletes. Olympic marathon runners have as much as 80 per cent slow-twitch fibres in their leg muscles, while Olympic sprinters have as much as 70 per cent fast-twitch fibres in their leg muscles.

The illustration below shows the cross-section of a skeletal muscle. The fibres have been shaded to show the distribution of slow-twitch, intermediate, and fast-twitch fibres.

Cross-Section of Skeletal Muscle



An athlete can become more successful in a sport when his or her most abundant muscle type is matched with the type of performance required. People with more fast-twitch muscle fibres are likely to be better at sports that require sprinting and jumping, which are movements that are brief, yet powerful. On the other hand, people with more slow-twitch muscle fibres are better suited to endurance activities such as long-distance running.

Which fibre types would you think are dominant in the arms of rowers and in the legs of football receivers, cross-country skiers, and hockey players?

Below is a comparison chart showing the characteristics of the three muscle fibre types.

Muscle Fibre Types			
Type / Characteristics	**Slow-Twitch Muscle Fibre Type I (SO—slow oxidative)**	**Intermediate Muscle Fibre Type IIA (FOG—fast oxidative glycolytic)**	**Fast-Twitch Muscle Fibre Type IIB (FG—fast glycolytic)**
Colour	red	pale red to white	white
Resistance to fatigue	high	moderate	low
Speed of contraction	slow	fast	very fast
Aerobic capacity	high	moderate	low
Anaerobic capacity	low	high	high
Strength and power	low power output	high power output	highest power output
Most active during	long-distance running/swimming/ cycling	weight lifting, constant activity that includes starts and stops	short sprints, explosive jumping

References:

Temertzoglou, Ted, and Paul Challen. *Exercise Science: An Introduction to Health and Physical Education*. Toronto, ON: Thompson Educational Publishing, 2003.

Wilmore, Jack H., and David L. Costill. *Physiology of Sport and Exercise*. 3rd ed. Windsor, ON: Human Kinetics, 2004.

Lesson 2

Skill-Related Fitness Components

Lesson Focus

You will show an understanding of

- the nature of the skill-related fitness components
- the importance of a high level of ability in each component as it relates to specific sport performance

You will be able to

- identify the skill-related fitness components of specific activities
- differentiate between skill-related and health-related fitness components

Introduction

In previous years you learned about the health-related fitness components: cardiovascular endurance, muscular strength, muscular endurance, flexibility, and body composition. You will now learn about the skill-related fitness components. Did you know that every activity requires at least one skill component and usually more than one? Some people are born with abilities in these areas and are often referred to as **natural athletes**.

The skill-related fitness components are agility, balance, coordination, power, speed, and reaction time. They enable you to perform the skills needed in certain sports and to perform everyday tasks. For example, tennis requires agility, coordination, speed, and reaction time. Running up a flight of stairs requires agility, balance, and power.

Improving any of the skill-related fitness components requires regular training that is specific to a given component. Fitness training also enhances the health-related fitness components that are needed to perform skills at an even higher level. As with the health-related fitness components, you need to work on the skill-related fitness components to stay at a high level of ability.

How the skills or abilities are combined usually determines the level of performance in a particular sport. Note also that a high level of fitness in the health-related components may make skill acquisition easier. One cannot improve skill well if one is fatigued or lacking in strength or flexibility.

How Do the Skill-Related Fitness Components Work?

Let's take a brief look at each skill-related fitness component to see how it works:

- **Agility:** Agility is the ability to change position and direction quickly, with accuracy, and without loss of balance. Agility is dependent upon strength, speed, balance, and coordination.
- **Balance:** Balance refers to the ability to control or stabilize one's equilibrium while moving (dynamic balance) or while stationary (static balance). Balance depends on the integration of visual input, information from structures found in the inner ear, and sensors in the muscles that indicate how hard and in what direction one is moving.
- **Coordination:** Coordination is the ability to combine the movements of various body parts (e.g., arms, legs, hands, feet, head, torso) into smooth, fluid motion. Coordination is achieved through the repetition of a skill that eventually makes the movement automatic. Movements done in the wrong sequence appear awkward and uncoordinated. Practising and repeating a skill with the wrong movement will lead to the formation of a habit that will be hard to change.

Practice does not make perfect, practice makes permanent... perfect practice makes perfect.

The ABCs (agility, balance, and coordination) of skill-related fitness are commonly referred to as the ability to change direction quickly and to move as efficiently as possible with minimal energy expenditure. These three components can be improved or developed through developmental training programs, specific exercises or drills, and regular sports participation.

Some experts contend that strength is the most important factor in agility since a stronger body moves with more ease and efficiency. Flexibility is most important to balance and coordination in that it increases one's range of motion. Agility-type drills should involve a number of direction changes, place the performer in a variety of body positions, and be of short duration so fatigue does not become a factor.

- **Power:** Power is the application of strength and speed during a muscular movement. ***Power = force x velocity*** and has to do with the speed of the contraction of a muscle against less than maximal resistance. Power is related to movement time. If you decrease the time it takes to do a particular movement, you will increase power.

  Power is displayed in many activities in different ways.

  Examples:

  — a golfer driving a ball

  — a batter hitting a baseball

  — a football player tackling a receiver

  — a gymnast performing a giant swing on the high bar

  Some individuals generate more power by improving their strength, while others rely more on improving speed.

- **Speed:** Speed is the ability to move one's body and/or body parts as quickly as possible in the shortest amount of time. Speed is the rate of movement, or the amount of time it takes for a body or an object to travel between two points. Speed usually refers to running speed (e.g., sprints in track or football). However, speed can be performed as leg speed (in soccer kicking), arm speed (in throwing a baseball), and body speed or acceleration (in gymnastics).

  Total speed includes reaction time and movement time (the interval from the beginning to the end of the movement). Speed may be improved with appropriate strength training. Speed requires the expenditure of a large amount of energy in a short time period. Age is a factor in attaining speed. Without practice, speed diminishes quickly by our late 20s.

- **Reaction time:** Reaction time is the time it takes to react or respond to stimuli that one hears, sees, or feels; the time from stimulation to the start of the movement (e.g., a 100-metre sprinter reacting to the starter's gun to push off out of the blocks). Reaction time enables the performer to move faster, which can affect other skill components, such as speed and power. Reaction time can be improved through the use of many developmental programs, such as strength and speed improvement. Many drills involving sight, sound, and touch will also help improve reaction time.

Assignment 3.3: Skill-Related Fitness

Have you ever considered what skill-related fitness components are necessary for successfully performing the skills in your favourite sports or activities? You will do so as you complete Assignment 3.3, which is found in the Assignments section at the end of this module.

After you have finished Assignment 3.3, continue with the next assignment.

Assignment 3.4: Quiz—Components of Physical Fitness

You will find Assignment 3.4 in the Assignments section at the end of this module. Completing this short quiz will help you review what you have learned about health-related and skill-related fitness components.

Summary

In this lesson you learned about how skill-related fitness components (agility, balance, coordination, power, speed, and reaction time) relate to physical activity performance.

Assignment 3.2: The Way I Move

1 hour (17 marks)

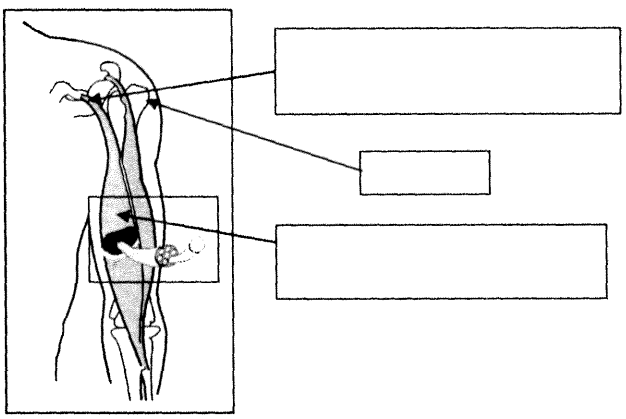
1. Read the list of activities/sports in the chart below. Identify what type of muscle fibres would play the largest role in the body part used by placing a check mark (✓) in the applicable column. Give **five** reasons for your selections. (10 marks—5 marks for checking the correct fibres, 5 marks for the reasons)

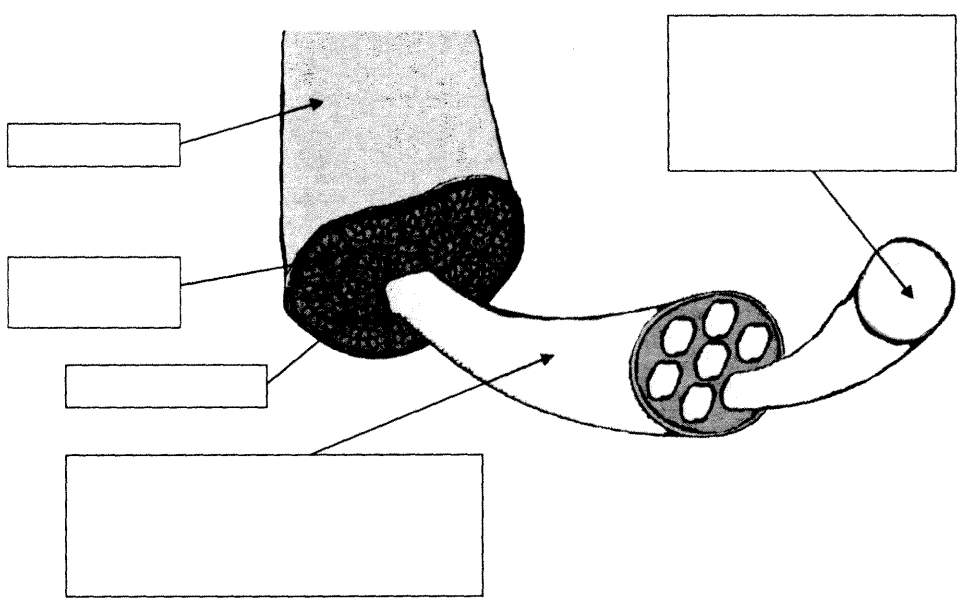
The Way I Move: Muscle Chart			
Activity/Sport	**Slow-Twitch Muscle Fibres**	**Fast-Twitch Muscle Fibres**	**Reasons**
Running a marathon			
Lifting weights			
Canoeing			
Throwing a discus			
Playing soccer			
Sprinting			
Cross-country skiing			
Backpacking			
Shovelling snow			
Pushing a car out of a rut			

2. In your own words, write two clear, distinct points about each of the three skeletal muscle fibre types. (3 marks—1 mark for each fibre type)
   - Type I: _____
     _____
   - Type IIA: _____
     _____
   - Type IIB: _____
     _____

(continued)

3. Identify the structure of skeletal muscle, using the unlabelled illustration provided below. (4 marks)





Assignment 3.3: Skill-Related Fitness

30 minutes (15 marks)

Directions

For this assignment, you will complete the Skill-Related Fitness chart on the following page.

- In the first column of the chart, list **three** of your favourite sports or activities.
- In the second column, list the skill-related fitness components required to perform the skills for each sport or activity successfully.
- In the last column, indicate how the components contribute to performance in each sport or activity.

Each of the three sports or activities is worth a total of 5 marks. For each sport or activity, you can earn up to

- 2 marks for identifying the skill-related fitness components associated with the sport or activity
- 3 marks for offering a reasonable explanation for how the components contribute to the performance of the sport or activity

An example is provided.

Skill-Related Fitness		
Sport or Activity	**Skill-Related Fitness Components**	**Contribution to Sport Performance**
Example: Golf	• coordination • balance • power	A golfer needs to maintain good balance throughout the swing in order to achieve maximum power and accuracy. Coordination is needed to make precise contact with the ball.
1.		
2.		
3.		