Learning Objectives

Upon completion of this unit, students should be able to:

1. Explain the muscular contractile system.
2. Explain the types of muscular work.
3. Discuss the types of muscle contractions.
4. Discuss the measurements of muscular strength.
5. Discuss the anthropometric design principles.
6. Define the terms used in anthropometric measurements.
7. Analyze the procedure for design using anthropometric data.

Unit Lesson

This unit focuses on muscular work, nervous control of movements, and anthropometry. The first chapter of the unit describes the functionality, relationship, and elements of the integrated roles of the musculoskeletal and nervous systems. Understanding the work of these systems is critical for safety professionals to help prevent musculoskeletal disorders in workplaces.

Actin and myosin play the most important role in muscular contraction, and the mechanism of contraction is explained and shown in Figure 4.1. In the muscle contraction process, the myosin heads protrude from the thick filaments and form a cross bridge with the actin. The chapter also explains the method to control the mechanism of contraction and the energy for contraction; glucose is the main energy supply, and oxygen plays an important role in energy production. Reflexes and energy transformation are also briefly explained.

Muscular work can be categorized as static muscle work or dynamic muscle work. While dynamic work allows the flow of nutrients and oxygen to the muscles during the task, static work does not allow the flow to refresh the muscular system, as discussed in the chapter. Examples of static work are carrying a box manually and painting a wall with the arms above the shoulders. Injuries caused by extended static work include arthritis, inflammation of the tendons, symptoms of arthrosis, muscle spasms, and intervertebral disc troubles. Thus, the duration of static work should be minimized and work breaks should be provided to reduce muscular fatigue. An isometric contraction is a static contraction. Another type of muscle contraction is an isotonic contraction, in which an equal amount of tension develops in the muscle throughout the exercise; some examples are push-ups and lifting weights.

The most commonly used methods to measure human muscular strengths are isometric, dynamic, and psychophysical tests. An Isometric strength test is widely used in research as it is comparatively easy to measure and to know the distribution of the static strengths of the subjects. However, a primary criticism of isometric strength tests is that these static tests are not compatible with most task performance. On the other hand, the psychophysical method is a dynamic test, which is one of the advantages of the method. In addition, the
The psychophysical method permits the realistic simulation of industrial work (Snook, 1985). In this method, a person finds his or her safe maximum lifting weight, that which he or she could lift without strain and discomfort.

For an example: in a lifting task at a frequency of three lifts per minute, a very light or very heavy load is initially given to the worker. The worker then adjusts the weight and finds the maximum weight he or she could lift without strain and discomfort for an 8 hour working duration. The adjustment period to find the weight while performing the lifting task is usually 50 minutes. The final weight at the end of the period is considered as the maximum lifting weight for the task that is safe to the worker.

Anthropometry and its design applications are discussed in Chapter 5. Anthropometry deals with sizes and shapes of the human body. There are three principles of anthropometric design: design for adjustable ranges, design for extremes, and design for average users. The design for adjustable ranges is the best among the three principles. However, it is also the most expensive. The next best method is the design for extremes principle. In this principle, the maximum value of design features or the minimum value of design features is used. The 5th and 95th percentiles are usually used for this design principle. On the other hand, the 50th percentile is used for the design for average users principle. Universal design focuses on designs of products and buildings for people. The seven principles of universal design are also well explained in this chapter. The most commonly used planes in anthropometric measurements are the sagittal, coronal, and transverse planes, as shown in Figure 5.3.

It is important to be familiar with the procedure for design using anthropometric data to properly design workplaces and equipment. The guideline for conducting anthropometric studies is well explained in the chapter. Confidence intervals (CIs) are used to accommodate 90% - 95% of the population. Confidence intervals are based on normal distribution, and the mean and standard deviation of a data set are used. Let’s briefly look at how to get confidence intervals.

In order to obtain 95% CI, equation 5.1 can be used.

\[
95\% \, CI = \mu \pm 1.96\sigma
\]

Where
- \( \mu \) represents population mean
- \( \sigma \) represents population standard deviation

If we want to obtain 95% CI for the mean stature of the female population, we can find the mean (\( \mu \)) and standard deviation (\( \sigma \)) of the female population.

The mean (\( \mu \)) is 162.1 cm and the standard deviation (\( \sigma \)) is 6.0 cm. Thus,

\[
95\% \, CI = \mu \pm 1.96\sigma
\]

\[= 162.1 \, \text{cm} \pm 1.96 \times 6.0 \, \text{cm}\]

\[= 162.1 \, \text{cm} \pm 11.76 \, \text{cm}\]

Hence, the 95% confidence interval for the mean stature of the female population is

\[162.1 \, \text{cm} - 11.76 \, \text{cm} < \mu < 162.1 \, \text{cm} + 11.76 \, \text{cm}\]

which reduces to

\[150.34 \, \text{cm} < \mu < 173.86 \, \text{cm}\]
References

**Supplemental Reading**

**Learning Activities (Non-Graded)**

*Apply What You Have Learned*

Complete exercises 4.7 and 4.10 on page 119 of your textbook.

1. (4.7) Explain why muscles fatigue more quickly in static loading. Identify an occupational task where static loading is required.
2. (4.10) Develop a process for collecting static strength.

Complete exercises 5.1, 5.3, and 5.10 on pages 156-157 of your textbook.

1. (5.1) Explain the purpose for universal design and how this might impact the economics, dimensions, and processes of design from an anthropometric perspective.
2. (5.3) In emergency situations, how should anthropometric data be used to guide design decisions?
3. (5.10) Identify three anthropometric data sources and explain how they should be used, the population they are most applicable to, and an industry that will benefit from this data. (Data sources, resources, and databases can be found on pages 158-161).

*Non-graded Learning Activities are provided to aid students in their course of study. You do not have to submit them. If you have questions, contact your instructor for further guidance and information.*