COURSE CODE: KHE 108
COURSE TITLE: INTRODUCTION TO MOVEMENT ANALYSIS

COURSE DEVELOPER/WRITER
Dr ABDULSALAM ABDULLAH
DEPARTMENT OF PYSICAL AND HEALTH EDUCATION
FACULTY OF EDUCATION
UNIVERSITY OF MAIDUGURI, BORNO STATE

COURSE EDITOR
PROFESSOR FIDEL OKOPI
Department of Physical and Health

Education Faculty of Education

National Open University of Nigeria

14-16, Ahmadu Bello Way

Victoria Island, Lagos.

Kindly provide the Course Guide stating clearly the Course Competencies

Module 1: MEANING AND IMPORTANCES OF MOVEMENT PATTERNS

Unit 1 Defining Movement Analysis

CONTENTS

1.0 Introduction

In this unit, attempt would be made to define the meaning and importance of movement analysis in an attempt to give the meaning of movement patterns analysis. Also in this unit, physical education which is an important aspect of movement analysisis identified and treated.

2.0 Intended Learning Outcome(s)

By the end of this unit, you will be able to:

- define movement analysis
- identify various movement analyses
- explain the importance of movement analysis.

3.0 Main Content

3.1 Various Definitions of Movement Analysis

Movement analysis refers to the automatic analysis of sensor signals that determine the underlying motions and evaluate them with respect to a given target model.Any movement can be studied but the most commonly clinically analysed is of walking. Clinical analysis which involves obtaining a history and performing a standard physical examination of a stationary patient in an examination room is often sufficient to develop a working differential diagnosis for a particular musculoskeletal injury. However, such an assessment may fail to uncover important underlying causes that stem from abnormal gait mechanics. "Gait analysis" encompasses a broad spectrum of potential assessment strategies used to evaluate normal and abnormal gait, both walking and running. Such assessments range from simple observation to a sophisticated computer analysis of biomechanics.

Movement analysis is made possible by the acquisition of objective data that describes a subject's movement and a physical examination and relevant medical history.

3.2 Importance of Movement Analysis

Kurt & Thomas (2001),give five reasons why it is important to study movement analysis

1. Basic scientists are interested in the control of human movement. On the other hand, the motor control researcher measures coordinated movements in order to understand what the "neural program" is.
2. Human movements are studied to understand and treat pathologies. For example, gait analysis is often used to help guide the physician contemplating surgery for children with cerebral palsy. The best choice for a tendon transfer or muscle lengthening surgery can be predicted by using combinations of movement analysis and biomechanical modeling (Delp et al., 1996). Gait analysis can also be used to monitor the progression of the disease and the efficacy of the treatment.
3. The study of human athletic performance has been revolutionized by motion analysis equipment and software that make it possible to readily analyze complex three-dimensional movements. From cricket bowling to figure skating to swimming to pole vaulting, the kinematics and kinetics have been examined with an aim to improve human performance. Kinematics is a branch of mechanics that deals with the geometry of the motion of objects, including displacement, velocity, and acceleration, without taking into account the forces that produce the motion. While kinetics is the study of the relationships between the force system acting on a body and the changes it produces in body motion (Hall, 2019)
4. There is substantial interest in human movement from those studying ergonomics and human factors related to military applications. Both the development of human-machine interfaces for high-tech weapons and the minimization of industrial injuries require knowledge of human kinematics and kinetics.
5. The kinematics of human movement has been studied by animators interested in making computer-generated characters move in realistic ways. By recording actors while they perform choreographic dances and movements, it is possible to get complex kinematic data into a computer, which can then be used to animate a computer-generated image. Choreographic dance or ballet, but its specific meaning is the notation a choreographer makes on paper as she plans out the complex movements and steps made by dancers. Choreography is particularly important in musical theater, ballet, opera, and dance recitals.

4.0 Self-Assessment Exercise

1. One of the following is a reason why is important to study movement analysis (a) control of human body (b) to understand and treat pathologies (c) to study the performance of human athletic (d) All of the above ANS(D)
2. Which muscle is involved in the elevation of arm?
   (a) Deltoid (b) Biceps (c) Triceps (d) Quadriceps. ANS (a)
3. **Bending forward of the trunk is an example of movement in the**
(a) Frontal plane (b) Transverse plane (c) sagittal plane (d) Longitudinal axis. ANS (c)
4. A forward upward movement of the foot at the ankle joint is (a) Plantar flexion (b) dorsi flexion (c) inversion (d) eversion. ANS (a)
5. Bending of head towards right or left side of the shoulder is (a) Extension (b) flexion (c) Lateral flexion (d) Lateral extension. ANS (c)

5.0 Conclusion

You need to understand and be able to explain various definition of movement analysis and importance of studying human movement analysis.

6.0 Summary

This unit gives you various definition of movement analysis and importance of studying human movement analysis,

7.0 References/Further Reading

Hall, S. J. (2019). What is biomechanics? In: Hall SJ. eds. *Basic biomechanics.*(8th ed.). New York, NY: McGraw-Hill;. http://accessphysiotherapy.mhmedical.com/content.aspx?bookid=2433&sectionid=191508967. (last accessed June 03, 2019).

Kurt T. ManalThomas S. Buchana. (2001). Biomechanics of human movement. In: *Standard handbook of biomedical engineering and design*. University of delaware, Newark. https://cmasuki.org/introduction-to-movement-analysis/

Rosenhahn, B., Klette, R. & Metaxas, D.(2007). *Human motion - Understanding, modeling, capture and animation.* Volume 36 in 'Computational Imaging and Vision', Springer, Dordrecht, 2007

Unit 2 Some Fundamental Movements (Walking, Running)

Contents

1.0 Introduction

We shall consider the approach to studying human movements, and go on to look at examples of walking, running, including the subdivision of these fundamental movements into phases.

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you will be able to

- analysis stages in walking and running
- explain stages in walking and running

3.0 Main Content

3.1 Analysis and Stages of Walking

The analysis and stages are as follows: Heel strike, Early flatfoot, Late flatfoot, Heel rise, and Toe off.

3.1.1 Heel Strike

The heel strike phase starts the moment when the heel first touches the ground, and lasts until the whole foot is on the ground (early flatfoot stage) (Sasaki & Neptune, 2005).

3.1.2 Early flatfoot

The beginning of the "early flatfoot" stage is defined as the moment that the whole foot is on the ground. The end of the "early flatfoot" stage occurs when the body's center of gravity passes over top of the foot. The body's center of gravity is located approximately in the pelvic area in front of the lower spine, when we stand and walk. The main purpose of the "early flatfoot" stage is to allow the foot to serve as a shock absorber, helping to cushion the force of the body weight landing on the foot.

3.1.3 Late flatfoot

Once the body's center of gravity has passed in front of the neutral position, a person is said to be in the late flatfoot stage. The "late flatfoot" stage of gait ends when the heel lifts off the ground. During the "late flatfoot" phase of gait, the foot needs to go from being a flexible shock absorber to being a rigid lever that can serve to propel the body forward. As the body's center of gravity passes over the foot, the posterior compartment muscles begin to contract. This contraction of the calf muscle serves to control the body movement as it goes forward so that the body does not fall forward. During this phase of gait (late flatfoot), the calf muscle is strongly contracting and lengthening. This is called an "eccentric" muscle contraction, and it serves to generate an extraordinary amount of internal force within the calf muscle and Achilles tendon. This is why most Achilles tendon ruptures and calf tears occur during this stage gait. During the late flatfoot phase, the posterior tibial muscle also contracts helping to "lock" the foot and create a rigid lever. Therefore in patients with posterior tibia dysfunction often have flatfooted gait with a limited or absent heel rise.

3.1.4 Heel rise

As the name suggests, the heel rise phase begins when the heel begins to leave the ground. During this phase, the foot functions as a rigid lever to move the body forward. During this phase of walking, the forces that go through the foot are quite significant: often 2-3x a person's body weight. This is because the foot creates a lever arm (centered on the ankle), which serves to magnify body weight forces. Given these high forces and considering that the average human takes 3000-5000 steps per day (an active person commonly takes 10,000 steps/day), it is not surprising that the foot can easily develop chronic repetitive stress-related problems, such as metatarsalgia, bunions, posterior tibia tendon dysfunction, peroneal tendonitis, and sesamoiditis.

3.1.5 Toe off

The toe off stage of gait begins as the toes leave the ground. This represents the start of the swing phase. During the heel rise phase, the calf muscle continues to contract, but is now shortening rather than lengthening (performing a concentric contracture). This lasts until the toe off phase.

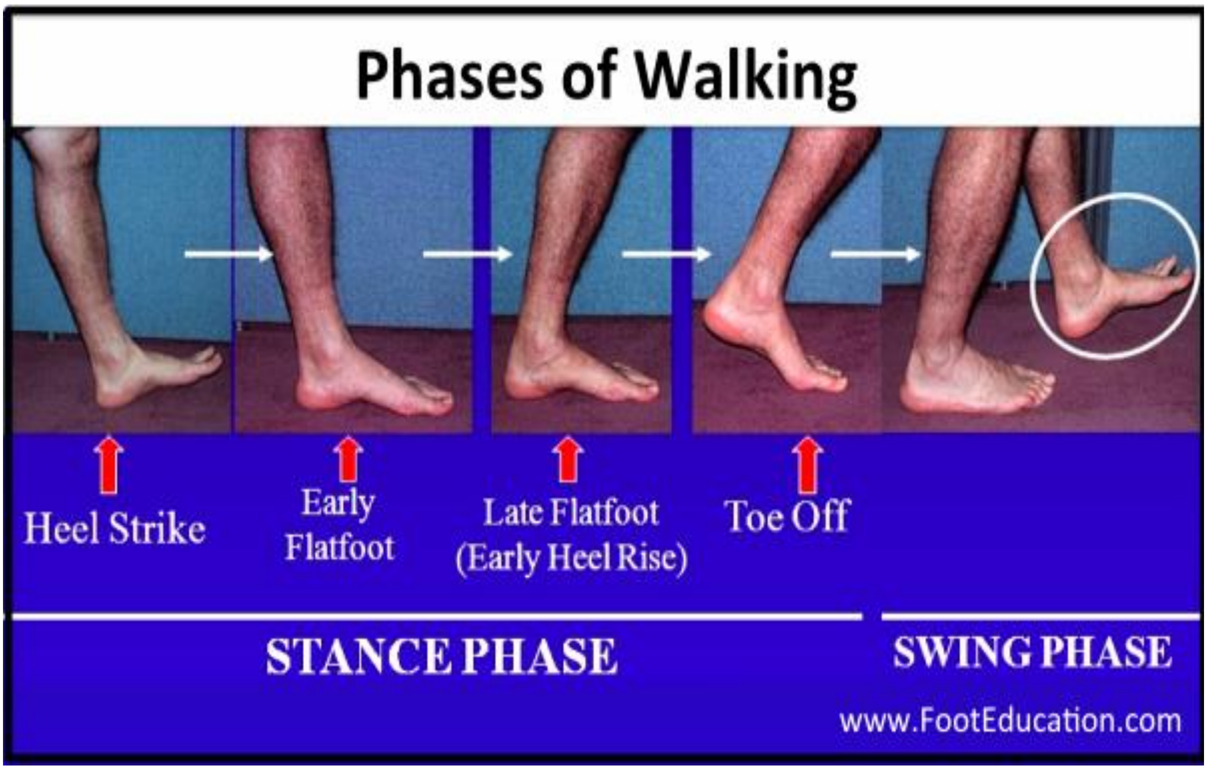


Fig. 1: Phases of Gait/Walking

3.2 Analysis and Stages of Running

It can be divided up into two "phases" – the stance phase (during which the foot is in contact with the ground) and the swing phase (during which the foot is not in contact with the ground). The stance phase is traditionally paid more attention in the study of performance & injury as it is in this phase where the foot and leg bear the body weight. The swing phase is presented as a passive movement, i.e. the product of the stance phase and not consciously controlled.

3.2.1 The Stance Phase

This can be divided into four stages: initial contact, braking (absorption), mid-stance, and propulsion.

Initial Contact

Let us imagine you are at that moment in your stride when both feet are off the floor (sometimes referred to as float phase). Your left leg is out in front of you and about to touch the ground. This moment (whether you land on heel, mid-foot, or forefoot) is called initial contact and marks the beginning of the stance phase. Your right foot behind you is off the floor and in swing phase.

Braking (absorption)

As soon as your left foot makes contact with the ground in front of you, your body is in effect performing a controlled landing, managed via deceleration and braking. Your left knee and ankle flex (the opposite of straighten) and the left foot rolls in (pronates) to absorb impact forces. During this process of absorption, the tendons and connective tissue within the muscles store elastic energy for use later in the propulsion phase.

Mid-stance

The braking phase above continues until the left leg is directly under the hips taking maximum load (maximum risk of injury) as the body weight passes over it. The left ankle and knee are at maximum flexion angle. This moment is called mid-stance (you may also hear it referred to as single support phase).

Propulsion
Now that your left leg has made a controlled landing and absorbed as much energy as it's going to get, it starts to propel you forwards. This is achieved by your left ankle, knee and hip all extending (straightening) to push the body up and forwards, using the elastic energy stored during the braking phase above. The more elastic energy available at this stage, the less your body has to use the muscles.

3.2.2 The Swing Phase

At the moment of toe off, your left leg has travelled as far back as its going to and the heel starts to lift towards your backside. The height the heel reaches and the returning drive of the knee is dependent on the power of hip extension achieved, and will hence be greater at higher speeds. Letting go results in the leg firing forwards rapidly, leading with the knee. Steve argues that any conscious attempt to move the leg through the swing phase (which he refers to as the "recovery phase") results in wasted energy and a less powerful firing of the slingshot. Once the knee has passed under the hips, the lower leg unfolds in preparation once again for initial contact, marking the end of the swing phase.

3.3 Upper Body and Arm Mechanics

The interaction between the upper and lower body plays a vital role in running, the upper body and arm action providing balance and promoting efficient movement. This balance is achieved by the arms and upper body effectively working in direct opposition to the legs. Bringing the left arm forward opposes the forward drive of the right leg, and vice versa. During the braking (absorption) stage described above (initial contact to mid-stance), the arms and upper body produce a propulsive force. During the propulsion stage (mid-stance to toe off), the arms and upper body produce a braking force.

By working as opposites, forward momentum is maintained. The arms and upper body also counterbalance rotation in the midsection. For example, as the right knee is fired through in front of the body (right swing phase) an anticlockwise momentum is created. To counterbalance this, the left arm and shoulder move forwards to create a clockwise momentum to reduce rotational forces. To help the above occur as efficiently as possible, arm swing should be initiated at and through the shoulders. Driving the elbows down as well as back can help avoid elevation of the shoulders, which in itself causes tightness and limits range of motion.
Just as bringing the knee through in swing phase needs to be a passive movement, so does the forward movement of the arm. Driving your arms up and forwards wastes energy and reduces the efficiency of the stretch reflex mechanism in the shoulders. Your hands crossing the midline of the body is a sign that you may be driving the arms forwards instead of backwards, or that you have tightness in the chest.

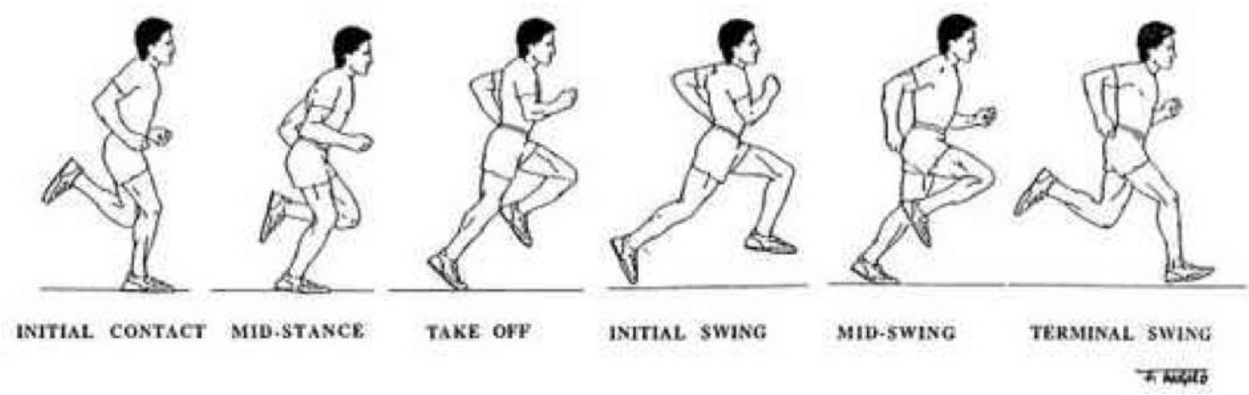


Fig. 2: Phases of running and arm swinging

4.0 Self-Assessment Exercise

6. When the heel first touches the ground, and lasts until the whole foot is on the ground. (A)Heel strike (b) Early flatfoot (c) Late flatfoot (d) Heel rise and Toe off. ANS (A).
7. ----------- is defined as the moment that the whole foot is on the ground (A)Heel strike (b) Early flatfoot (c) Late flatfoot (d) Heel rise and Toe off. ANS (B).
8. The ---------- stage of gait ends when the heel lifts off the ground. (A)Heel strike (b) Early flatfoot (c) Late flatfoot (d) Heel rise and Toe off. ANS (C).
9. The --------- phase begins when the heel begins to leave the ground. (A)Heel strike (b) Early flatfoot (c) Late flatfoot (d) Heel rise and Toe off. ANS (D).
10. The ----------- of gait begins as the toes leave the ground. (A)Heel strike (b) Early flatfoot (c) Late flatfoot (d) Toe off. ANS (D).

Answers

5.0 Conclusion

In this unit, it describes and analysis stages that is involved in some fundamental movement patterns. The major fundamental movement patterns analysis and describes are running and running are describe and analysis in this unit.

6.0 Summary

In this unit, you have learnt the various definitions of movement analysis and importance in studying human movement analysis. The physical educator and human movement expect need to have good knowledge of major fundamental movement patterns for analysis and improvement of performance in general. Therefore, walking and running.

7.0 References/Further Reading

Rosenhahn, B., Klette, R. & Metaxas, D.(2007). *Human motion - Understanding, modelling, capture and animation.* Volume 36 In 'Computational Imaging and Vision', Springer, Dordrecht, 2007

Sasaki, K & Neptune, R. (2005).*Muscle mechanical work and elastic energy utilization during walkingand running near the preferred gait transition speed*http://www.me.utexas.edu/~neptune/Papers/gait&posture23(3).pdf

Magness, S. (n.d).*Running with proper biomechanics*http://www.scienceofrunning.com/2010/08/how-to-run-running-with-proper.html

Unit 3Some Fundamental Movements (Jumping and Throwing)
Contents

1.0 Introduction

We shall consider the approach to studying human movements, and go on to look at examples of jumping and throwing, including the subdivision of these fundamental movements into phases.

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you will be able to:

- analyse stages in jumping and throwing
- explain stages in jumping and throwing.

3.0 Main Content

3.1 Analysis and Stages of Jumping

Jumping involves three phases in each jump load phase, flight phase, and landing phase—and you will perform each of these phases hundreds of times during each jumping session. The load phase requires you to balance your body on the balls of your feet with your knees slightly flexed. The flight phase consists of muscular contractions that propel your body high enough to clear the rope with each jump. In the landing phase, you return to the surface by allowing your body weight to balance on the balls of your feet with your knees flexed to help absorb the impact of the landing. Efficient recovery from the landing phase through the load phase to the flight phase is critical if you are going to enjoy the benefits of jump rope training.

3.1.1 Load Phase

Your body weight should be balanced on the balls of your feet, and your knees should be slightly bent in an upright version of the universal athletic position. This position prepares your body for the multi joint demands of rope jumping. Ideally, you should jump no higher than 1/2 to 3/4 of an inch (1.3 to 1.9 cm) from the jumping surface (the exception to this rule involves power jumping). This approach leaves you virtually no room for error and therefore reinforces your performance of precise movements. Jumping in this manner rising less than an inch from the surface and landing lightly on the balls of your feet requires you to exercise concentration, kinaesthetic awareness, and perfect timing. This is a refined and highly skilled whole-body movement. Many people find that it is relatively easy to “give it all you've got” when asked to jump or leap, but it is quite a different matter to jump with control. In rope jumping, less is more. See figure 3.1 for a diagram of the muscles worked during this phase.

3.1.2 Flight Phase

The flight phase consists of two stages: the propulsion stage and the airborne stage. Understanding what happens from the moment your feet push off the surface to the point when you are in the air is critical to maximizing your training benefits and reducing your risk of injury. You generate propulsion by means of a slight push from your ankles, calves, knees, and hips. Push through the jump rope surface from the balls of your feet and point your toes toward the surface as you become airborne (see figure 1).

During the airborne phase, your feet should rise no more than 1 inch (2.5 cm) from the surface as the rope passes under your feet. Swinging the rope and jumping over it recruits muscles in your upper and lower body (see figure 3.2b). This movement is essential to enhancing your proprioception in your feet and ankles, so that you know where to plant your feet and how to balance so you don't topple over. Proprioception, known as an inner sense, is the ability of your central nervous system to communicate and coordinate parts of your body with each other. This movement also increases your balance, rhythm, and timing, while reducing your risk of injury. Repetition of these movements improves your body's kinaesthetic awareness (known as the outer sense, the body's awareness of where it is in space and time) or the body's ability to coordinate motion knowing where the rope is in relationship to the body during jumping.

3.1.3 Landing Phase

Your shock-absorbing joints (i.e., your knees, ankles, and hips) diffuse the impact of each landing you make during your jumping session. It is the frequency of jumping that poses your greatest threat of injury in jump rope training. If you use proper technique and jump on a surface that both absorb impact and offers rebound properties, you reduce your risk of injury and enable yourself to derive the greatest training benefits from your rope-jumping program.
Regardless of which technique you are using, you must land softly on the balls of your feet. It is during the landing phase that you develop balance while subtle neuromuscular adjustments prepare your body for the subsequent load and flight phases (see figure 3).

Your landing should be soft and silent, forcing you to concentrate on perfect balance and on delicately positioning your feet during each jump. Your heels should not touch. If your heels hit the floor, or if your feet land with an emphatic slap, you are using an improper technique and thus reducing your training benefits and increasing your risk of injury. Intense concentration helps you keep your contact with the jumping surface as short as possible, which reduces stress in your hips, knees, and ankles.

When you do successive jumps, you draw on muscle groups throughout your body to re-establish balance and propulsion during each jump. In this respect, rope jumping is similar to resistance training, which requires subtle adjustments in several muscle groups in order to balance the weight as you lift and lower it. In many ways, rope jumping is also similar to running. If you fail to run with proper form, you risk fatigue and injury. Proper form allows you to maximize the benefits of the exercise and reduce your risk of injury. If you manage the multiple movements required for proper rope-jumping form, you not only enjoy aerobic and anaerobic training effects but also develop the kinaesthetic sense that enhances your balance, rhythm, and timing while producing graceful movement.

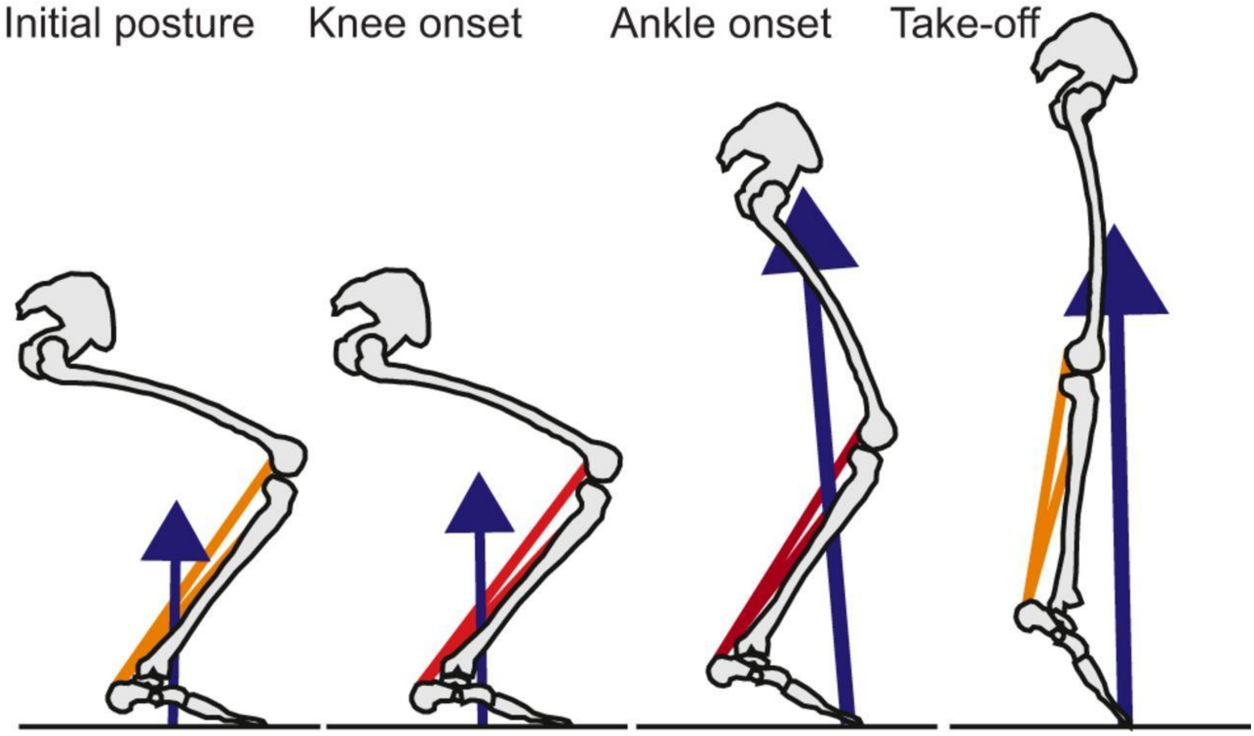


Fig. 3.1: Phases of Jumping

In-Text Question

3.2 Analysis and Stages of Throwing

3.2.1 Wind up (Pitching Phase One)

The entire motion of throwing a ball takes approximately 2 seconds to complete, and the wind up consumes almost 1.5 seconds of that time. It is the beginning of the throwing motion, preparing the "body parts" for the act of throwing a ball. Motion occurs in the lower extremities and torso where the vast majority of "power" to throw a ball is generated. In this phase, the shoulder musculature is minimally active.

3.2.2 Cocking (Pitching Phase Two)

This phase prepares the arm to be able to throw the ball. The posterior shoulder musculature is extremely active and the position of the shoulder is in extreme external rotation. This shoulder position places the anterior upper quadrant musculature on a "stretch" and prepares it to contract forcefully when the arm begins to move forward in the next phase of the throwing motion. The body begins to move forward towards its target during this phase. The lead shoulder is directed at the target and the throwing arm continues to move into extreme external rotation.

3.2.3 Acceleration (Pitching Phase Three)

Now the throwing arm moves forward to actually throw the ball to the target. The anterior upper quadrant muscles are concentrically active and begin to move the arm from extreme external rotation to internal rotation. As the ball moves forward towards the target, the speed of rotation of the humeral head can exceed 7000+ degrees per second. Proper body mechanics places the shoulder in the proper position during the acceleration phase to generate great velocity and accuracy without causing an injury to the throwing shoulder. The end of this phase is marked by the release of the ball out of the thrower's hand.

3.2.4 Deceleration (Pitching Phase Four)

When the ball is released, the posterior quadrant musculature begins to contract eccentrically and violently to slow down and control the rotational speed of the humeral head. In theory, if the eccentric control of the humeral head did not occur the arm would continue to rotate internally and "spin" out of control. Injuries to the throwing shoulder can occur during this phase. The amount of eccentric contractile force that occurs can damage the posterior musculature if they are not trained properly.

3.2.5 Follow-through (Pitching Phase Five)

The final phase of throwing is the follow-through. This phase slows down all body motions and stops the forward movement of the body. The body comes to rest, and the muscle activity returns to a quiet state. If this phase is completed correctly, the thrower's body position is "under control" and balanced.

Throwing a ball "over-hand" involves movement in all parts of the body. If the mechanics are performed properly, the ball can be thrown with great velocity and accuracy. If the body is trained correctly, the act of throwing can be performed repetitively without causing an injury to the throwing shoulder.

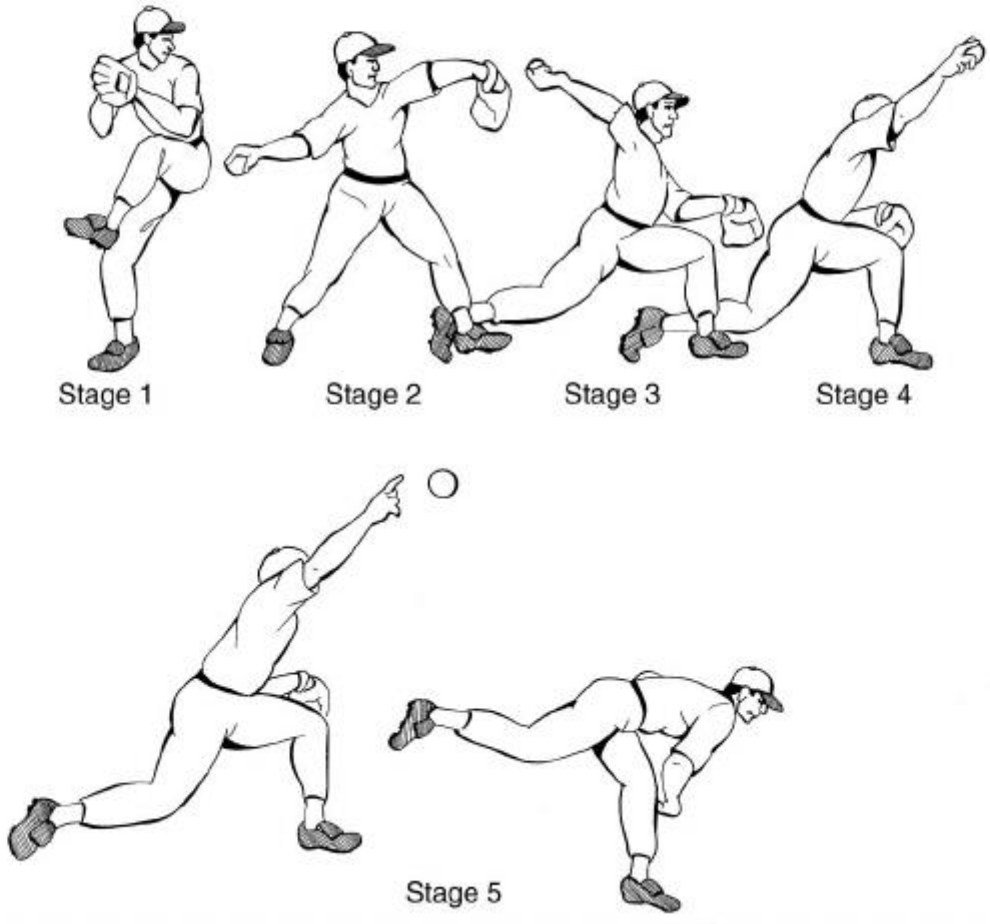


Fig3.2 fig 4: Phases of Throwing

4.0 Self-Assessment Exercise

11. The Stance Phase can be divided into------------------- (A)2 (b) 3 (c) 4 (d)5. ANS (C).
12. **Analysis and Stages of running can be divided into -------- and -------------**

(A) the *stance phase* and the *swing phase* (b) **Initial contact** and the *swing phase* (c) **Braking and absorption** (d) **Braking and** the *swing phase* . ANS (D).

13. In **Analysis of Stages of running,** when the foot is in contact with the ground is called. (A)*swing phase* (b) the *stance phase* (c) **Braking phase** (d)initial *phase* . ANS (B).

14. During the **Analysis of Stages of running, swing phase is also known as** (A) *swing movement* (b) the *stance movement* (c) **passive movement** (d)active movement . ANS (C).

15. During the running movement, the interaction between the upper and lower body is that (a) the upper body and lower body providing balance and promoting efficient movement (b) the upper body and lower body providing balance (c) the upper body and lower body providing balance and promoting inefficient movement (d) There is efficient movement. ANS (a)

16. **Analysis and Stages of jumping** involves --------- phases (a) 2 (b) 3 (c) 4 (d) 5. ANS (B)

5.0 Conclusion

In this unit, it describes and analysis stages, that is involved in some fundamental movement patterns. The major fundamental movement patterns analysis and describes are walking and throwing are describe and analysis in this unit.

6.0 Summary

This unit give various definition of movement analysis and importance in studying human movement analysis. The physical educator and human movement expect need to have good knowledge of major fundamental movement patterns for analysis and improvement of performance in general. Therefore, walking and throwing.

7.0 References/Further Reading

Rosenhahn, B., Klette, R. & Metaxas, D.(2007). *Human motion - Understanding, modeling, capture and animation*. Volume 36 in 'Computational Imaging and Vision', Springer, Dordrecht, 2007.

Sasaki, K & Neptune, R (2005).*Muscle mechanical work and elastic energy utilization during walkingand running near the preferred gait transition speed*http://www.me.utexas.edu/~neptune/Papers/gait&posture23(3).pdf

Magness, S. (n. d.).*Running with proper biomechanics*.http://www.scienceofrunning.com/2010/08/how-to-run-running-with-proper.html

Unit 4 Qualitative and Quantitative Movement Analysis

Contents

1.0 Introduction

In this unit, we shall be discussing qualitative and quantitative movement analyses. Human movement analysis uses two main approaches to analysis human movement patterns in sport – qualitative and quantitative analysis. The unit concludes with a comparison of qualitative and quantitative analyses

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you will be able to:

- distinguish between qualitative and quantitative movement analyses
- compare qualitative and quantitative movement analyses.

3.0 Main Content

3.1 Qualitative Methods of Analysis

Qualitative analysis methods are also referred to as subjective methods (Marshall and Elliot, 2005), it involves a non-numerical evaluation of a skill and is most frequently performed during direct observation of movement. It is a seemingly natural characteristic of good coaches and clinicians. This is the description of quality without the use of number. This skill can be learned and improved upon through practice. However, Adrian and Cooper (2005) explain that, for one to be consistent and reliable both in observing a performer's learning motor skills and in evaluating movement for practical, diagnostic, clinical or research purposes (viewed either in life or film), a researcher must adopt a definite observational plan. The plan might include the following steps:

a. view multiple times
b. view from multiple perspectives (planes)
c. focus on parts, then whole, then parts
d. form a visual mental image of the performance
e. use a checklist: either construct your own or use available ones.

Therefore, qualitatively describing the kinematics of a movement will entail identifying the joint actions, including flexion, extension, adduction/abduction, rotation and so forth. A detailed qualitative analysis might describe the precise sequencing and timing of body segment movement. This translates to the degree of skill evident on the part of the performer.

Most qualitative analyses are carried out through visual observation and, as pointed out by Hoffman (2004), performance deficiencies may result from errors in technique, perception, or decision-making. Hail (2009), therefore, added that it will require more than visual observation to solve the performer's problem, making a combination of both qualitative and quantitative analyses imperative. However, McPherson (2008) and Hay and Reid (2008) proposes the inclusion of a pre-observation phase, where a model of the skill to be analysed is developed and mechanical variables concerned and their relationships are described.

3.2 Quantitative Methods of Analysis

This method is otherwise known as objective technique in biomechanical analysis. This is the collection, measurement, and evaluation of data from the activity of interest. Quantitative analysis implies that numbers are involved. According to Hall (2009), sports bio-mechanists often quantitatively study kinematics features that characterize elite performance of a particular athlete. Sometimes, this type of analysis results in constructing a model that details the kinematic characteristics of sound performance for practical use by coaches and athletes
Steps in quantitative analysis include the following:

1. Pre-observation stage; and this should include:

    a. determination of performance goal and mechanical variables
    b. identification and selection of critical variables
    c. Determination of acceptable range for these variables.

2. Development of an observation plan; to include:
    a. observation desired
    b. response observed
    c. response diagnosis
    d. discrepancy (allow for individual variation)
    e. identify errors
    f. rank errors
    g. remediation
    h. communicate error correction strategies.

3.3 Comparison of Qualitative and Quantitative Movement Analysis

Movement analyse provides information for a variety of kinesiology professions to analysed human movement to improve effectiveness or decrease the risk of injury. How the movement is analysed falls on a continuum between a qualitative analysis and a quantitative analysis. Quantitative analysis involves the measurement of biomechanical variables and usually requires a computer to do the voluminous numerical calculations performed. Even short movements will have thousands of samples of data to be collected, scaled, and numerically processed. In contrast, qualitative analysis has been defined as the "systematic observation and introspective judgment of the quality of human movement for the purpose of providing the most appropriate intervention to improve performance" (Knudson & Morrison, 2002). Analysis in both quantitative and qualitative contexts means identification of the factors that affect human movement performance, which is then interpreted using other higher levels of thinking (synthesis, evaluation) in applying the information to the movement of interest. Solving problems in human movement involves high levels of critical thinking and an interdisciplinary approach, integrating the many kinesiology sciences.

The advantages of numerical measurements of quantitative over those of qualitative analysis are greater accuracy, consistency, and precision. Most quantitative biomechanical analysis is performed in research settings; however, more and more devices are commercially available that inexpensively measure some biomechanical variables (e.g., radar, timing lights, timing mats, quantitative video graphy systems). Unfortunately, the greater accuracy of quantitative measures comes at the cost of technical skills, calibration, computational and processing time, as well as dangers of increasing errors with the additional computations involved. Even with very fast modern computers; quantitative bio-mechanics is a labour-intensive task requiring considerable graduate training and experience. For these reasons and others, qualitative analysis of human movement remains the main approach kinesiology professionals use in solving most human movement problems. Qualitative analysis will be the main focus of the applications of bio-mechanics presented in this book. Whether your future jobs use qualitative or quantitative biomechanical analysis, you will need to be able to access biomechanical knowledge.

4.0 Self-Assessment Exercise

17. Qualitative analysis methods human movements are also referred to as --------------
    ANS subjective methods

18. Qualitative analysis methods human movements are also referred to as --------------
    ANS Objective methods

19. Qualitative analysis methods human movements involving a non-numerical evaluation of a skill and is most frequently performed during ---------------- (a.) direct observation of movement (b) indirect observation of movement (c.) indefinite observational plan (d.) all of the above. ANS (A).

20. Qualitative analysis methods human movements are seemingly natural characteristic of good (a.) coaches and athletes (b.) clinicians and athletes (c.) coaches and clinicians (d.) athletes only. ANS (B)

5.0 Conclusion

The tools used in the study of movement analysis help determine the types of analysis that are possible and the selection of tools depends on the types of measurements that are needed and their availability. Therefore, there is a need to ensure that appropriate tools are selected for a particular research analysis and the desire, type, precision and amount of data needed should dictate the selection of tools.

6.0 Summary

In human kinetics, movement analysis is important it help in analysis and interpretation of performance. We then compared qualitative and quantitative analysis, looking at their background, uses, and strengths and weaknesses.

7.0 References/Further Reading

Hay, J.C. (1993). *The biomechanics of Sports techniques*. Englewood Cliffs, NJ: Prentice Hall.

This well-regarded book by the late Dr James Hay was the first biomechanics text to influence my approach to the discipline some 30 years ago. He takes a typically mechanistic approach to biomechanics, but it is one of the easiest such texts for a student to follow. Read the sports chapters that interest you, as these are the greatest strength of the book has any other biomechanics author had such knowledge and insight into so many sports movements?

Kurt T. Manal & Thomas S. Buchana. (2001). Biomechanics of human movement. In: *Standard handbook of biomedical engineering and design.* University of Delaware, Newark. https://cmasuki.org/introduction-to-movement-analysis/

Sasaki, K.& Neptune, R. (2005). *Muscle mechanical work and elastic energy utilization during walking and running near the preferred gait transition speed*http://www.me.utexas.edu/~neptune/Papers/gait&posture23(3).pdf

Magness, S. *Running with proper biomechanics*.http://www.scienceofrunning.com/2010/08/how-to-run-running-with-proper.html

Rosenhahn, B., Klette, R. & Metaxas, D.(2007). *Human motion understanding, modeling, capture and animation.* Volume 36 in 'Computational Imaging and Vision', Springer, Dordrecht, 2007.

Module 2 Qualitative Analysis of Sports Movements

Unit 1 Structured Analysis Framework

Contents

1.0 Introduction

The approach outlined in this unit, and focuses on the systematic observation and introspective judgment of the quality of human movement to provide the best intervention for improved performance.

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you will be able to:

- appraise how qualitative biomechanical analysis fits within the multidisciplinary frame-work of qualitative movement analysis
- .

3.0 Main Content

3.1 A Structured Analysis Framework

Computer simulation and optimization techniques have been applied widely in studies of sports and human movement to predict sports movement. Adrian and Cooper (2005) explain that researchers have combined the mathematical modeling of the anatomical characteristics of a living body with simulation techniques for the purpose of predicting performance achievements and developing new performance techniques. The general aim of work in this area is that, by using a computer model of a person or piece of equipment (the 'system') to predict changes which would occur in a movement as a consequence of alterations to the input parameters, answers are provided to such question as: 'what would happen to the movement if this factor were changed to (Marshall and Elliot, 2005).

Computer simulation is the use of a validated computer model (a set of mathematical equations describing the system of interest) to evaluate the response of the model to changes in the system parameters. Computer simulation has been used to evaluate the biomechanics of a wide variety of equipment and body movements, from an equally wide variety of approaches. It is beyond the scope of this write-up to list and comment on the approaches used and the systems modeled, but they vary from the consideration of the human body as a point mass representing the centre of gravity, to a simulation of 3D muscle mechanics and skeletal dynamics of the lower limb during walking and other movements. Most of the programmes are written specially for the system under consideration, although the use of generalized simulation packages, such as symbolic manipulation programs, is increasing (Van den et al., 2009). Schneider and Zemicke (2008) used a validated head-neck-torso model to simulate head impacts in soccer heading in order to estimate the injury risk. Critical output variables were the linear and angular acceleration of the head, and these were compared to standard head-injury tolerance levels. They concluded that head-injury risk can be reduced most effectively in all subjects by increasing the mass ratio between the head and the ball.

Optimization is the interactive use of a computer simulation to determine parameter values or control variables which optimize (minimize or maximize) a specified criterion (the perform-acne objective). Optimization research may be categorized into two general procedures: parameter optimization and optimal control.

Parameter optimization refers to studies in which parameters are successively modified to produce optimal results, such as in the javelin study of Hubbard and Alaways (2007). Changes made in 2006 by the International Amateur Athletics Federation to the rules for the construction of the men's javelin prompted them to simulate the flight of the new javelin and determine the optimum release characteristics. As reported by Marshall et al. (2005), Hubbard and Alaways (2007) discovered that the range of the new javelin was decreased, and that it was less sensitive to release conditions when compared to the old one. They also showed that the optimal release conditions were velocity dependent and concluded that 'the javelin throw has been changed from an event in which finesse and skill were important, to one for which strength and power are once again preeminent'. Gablonsky and Lang (2005) also modeled the basketball free throw shot in relation to the velocity and angle of the shot to the height of the player, to optimize performance.

Optimal control, on the other hand, refers to the technique of altering variables which control or determine the output of a system. Interpretation and appraisal of results from optimization studies are guided by the same considerations as for simulation studies, with the added need to evaluate the appropriateness of the performance objective.

4.0 Self-Assessment Exercise

21. Computer simulation and optimization techniques cannot be applied in studies of sports and human movement to predict sports movement.

(a)True (b)False. ANS (B)

22. ----------- is the interactive use of a computer simulation to determine parameter values or control variables which optimize a specified criterion.(a) Optimization (b) simulate (c) modeled (d) parameter. ANS (A)

23. Optimization research may be categorized into ---------- general procedures. (a)2 (b)3 (c)4 (d)5. ANS (A)

24. Optimization research may be categorized into ---------- and--------------(a) computer and model control (b.) optima and computer control (c)parameter optimization and optimal control (d.) stimulation and parameter control. ANS (D)

25. Which of the following statement is true (a) Quantitative analysis implies that numbers are involved (b.) This is no collection, measurement, and evaluation of data (c.) It does not involve (d) It is other wisely known as objective technique in biomechanical analysis. ANS (D.)

26. The entire motion of throwing a ball takes approximately ---------- to complete, and the wind up time takes ------------- respectively. (a) 1.5 seconds and 2 seconds (b) 2 seconds and 1.5 seconds (c) 2 seconds and 1.3seconds (d) 1.3 seconds and 2seconds
ANS (B.)

5.0 Conclusion

It helps in conducting a needs analysis with the people commissioning the study to ascertain what they want from it. These include: gathering knowledge of activity and performers and knowledge of relevant characteristics of performers. Also the knowledge of effective instruction, including cue words and phrases are discussed. Implementing the systematic observation strategy developed and raises issues about technique or skills training, and other aspects of training.

6.0 Summary

7.0 References/Further Reading

Knudson, D.V. & Morrison, C.S. (2002).*Qualitative analysis of human movement.* Champaign, IL: Human Kinetics.

The first edition of this book was for many years one of the few real gems in the Human Kinetics list of sports science texts; the second edition continues that tradition. However, the authors have not yet welcomed a wider interpretation of qualitative movement analysis and a crucial (perhaps the crucial) 'critical feature' of skilled human movement – coordination – receives only one page reference in the index. The structured approach to movement analysis outlined in this chapter is covered in far more detail in Part II of Knudson and Morrison, while Part I sets the scene nicely and Part III outlines applications of their approach, with many diagrammatic examples. Highly recommended and well written.

Kurt T. Manal & Thomas S. Buchana. (2001). Biomechanics of human movement. In: *Standard handbook of biomedical engineering and design*. University of Delaware, Newark. https://cmasuki.org/introduction-to-movement-analysis/

Unit 2: Four Stages in a Structured Approach to Movement Analysis
Contents

1.0 Introduction

The approach outlined in this unit, and focuses on the systematic observation and introspective judgment of the quality of human movement to provide the best intervention to improve performance.

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you will be able to:

- plan and undertake a qualitative video analysis of a sports technique of your choice
- develop a critical insight into qualitative biomechanical analysis of movement in sport and exercise
- explain the need for a structured approach to qualitative movement analysis
- explain the roles, within qualitative analysis, of phase analysis of movements and the movement principles approach.

3.0 Main Content

3.1 Preparation Stage – Knowing What and How to Observe

The gathering of relevant knowledge is dynamic and ongoing. A successful movement analyst needs knowledge, first and foremost, of the activity or movement, from which he or she will then develop the critical features of performance. Secondly, knowledge is needed of the performers; this includes the needs of the performers, and coaches or therapists, which should be identified in the 'needs analysis' Although the preparation for later stages of the qualitative analysis process takes place, at least in gathering relevant knowledge, in the preparation stage, these will also be dealt with later.

Your knowledge of the activity, as a movement analyst, should draw on many sport and exercise science disciplines. For example, as a primary Physical Education teacher, you would source knowledge mainly from the discipline of motor development: a secondary Physical Education teacher, by contrast, would focus more on an analysis of individual skills and techniques using, primarily, biomechanics. As a movement analyst working with novices, motor learning and practice would be major sources of information for you. On the other hand, a movement analyst working with good club-standard performers would probably focus on a biomechanically-derived identification of critical features, and a movement analyst working with elite performers would concentrate on the critical features at that standard, and might use a more quantitative approach.

In all of our work as movement analysts, whether qualitative or quantitative, we should always seek to adhere to 'evidence-based' practice, which raises the question as to what evidence we gather and from where. A movement analyst has, in general, access to various sources of knowledge about the sports activity being studied. Some issues arise in using these sources, including the fragmentary nature of some sources and weighing conflicting evidence from various sources. Experience also influences success in using source material, and helps to deal with anecdotal evidence and, with care, personal bias. The gathering of valid knowledge of the activity under consideration is invaluable if done systematically, and one needs to keep practicing developing critical features based on the knowledge gathered. A warning here is appropriate – although the Internet is a fruitful source of information, in general there is little, if any, quality control over what appears there. There are exceptions to this warning, particularly peer-reviewed websites such as the Coaches' Information Services site (http://coachesinfo.com/) run by the International Society of Biomechanics in Sports (ISBS; http://www.isbs.org). Valid information is best sourced from such expert opinion, which can also be found in professional journals such as the Sport and Exercise Scientist (British Association of Sport and Exercise Sciences; http://www.bases.org.uk) and sport-specific coaching journals (such as Swimming Technique, now an integral part of Swimming World Magazine; http://www.swimmingworldmagazine.com). Many of these sources are accessible through the Internet. The performers and their support staff included in any 'real-world' study are also a potential source of knowledge about their sport, as may be other coaches and performers involved; not all of their knowledge will normally be evidence-based, so care is needed in using it. Problems associated with synthesng all of this knowledge include conflicts of opinion, a reliance on the 'elite-athlete template' (i.e. what the most successful do must also be right for others) and incorrect notions about critical features.

Scientific research should provide the most valid and accurate sources of information. Movement analysts need some research training, however, to interpret research findings: applied BSc or MSc degrees should provide such training, while a research-focused PhD may not. The best sources of relevant, applied research are applied sports science research journals, such as Sports Biomechanics, published on behalf of the ISBS, and the best coaching journals, such as New Studies in Athletics. Sports-specific scientific review papers draw together knowledge from many sources and provide a valuable source of information for movement analysts, providing the reviews have an applied rather than a fundamental research focus. The Journal of Sports Sciences has been a fruitful source for such review papers. The major problem with scientific research as a source of information for the qualitative movement analyst might be called the validity conflict between internal (research) validity and ecological (real-world) validity.

Knowledge of effective instruction, feedback and intervention provide the appropriate information to translate critical features into intervention cues, couched in behavioural terms, which are appropriate to one's 'clients'. These should not be verbose no more than six words – and figurative not literal. Remember that analogies must be meaningful; advising that the backhand clear in badminton is like 'swiping a fly off the ceiling with a towel' has no meaning to someone who has never performed such an action or seen another person do it. The cues to be devised can be verbal, visual, aural or kinaesthetic, and may differ for various phases of a movement; for example a javelin coach may see value in attending to the aural cues of footfall during the run-up, but would switch to other cues for the delivery phase. The movement analyst needs, there-fore, to derive relevant cues for each movement phase, and should attend to: the cue structure (what the action is); its content (what does the action – the doers); and cue qualification (how to gauge success). Special conditions may be added if more information is needed. Examples include: rotate (action) the hip and trunk (the doers); swing (action) the arm (doer) forwards (qualification).

3.2 Observation stage – observing reliably

We need to record sports movements as they are fast and the human eye cannot resolve movements that occur in less than 0.25 s. Two important benefits of videography are that the performers can observe their own movements in slow motion and frame by frame, and that it makes qualitative analysis much easier. However, there are some potential drawbacks. Performers might be aware of the cameras and, consciously or subconsciously, change movement patterns (the Hawthorne effect). Also, there are ethical considerations about video recording, particularly with minors and the intellectually disadvantaged. Our systematic observation strategy should have addressed both what to focus on and how to record, and observe, the movements of interest. Clearly, we should focus on the critical features of the movement identified in stage 1, but we need to prioritise these. Secondly, we need to decide on the environment in which to videograph, the best camera locations within that environment and how many trials of the movement to record for analysis.

Prioritising critical features can vary with the skill of the performer, the activity being analysed, and whether a movement-phase approach is used, as in the long jump. Our prioritising strategy might, for example, put the critical features in descending order of importance for the performance outcome; or work from the general to the specific, for example from the whole skill to the role of the trunk and the limbs; or focus on balance, in skills in gymnastics.

The other main issues in videography for qualitative analysis are:

- Choice of camera shutter speed.
- Where to conduct the study.
- Choice of camera locations (sometimes, particularly in North America, called vant-age points) and whether the cameras are to be stationary (usually mounted on tripods) or moved to follow the analysed movements.
- How many trials to record, when relevant.
- Use of additional lighting, which must be adequate for the shutter speed and frame rate. The latter is normally fixed for 'domestic-quality' video cameras, at 50 fields per second in Europe and 60 in North America, or 25 frames per second in Europe and 30 in North America (the unit hertz, Hz, is normally used for events per second).
- Who and what to observe.
- The background should be plain and uncluttered to help objective observation, but this is not always feasible, particularly when videographing in competitions.
- Participant preparation briefing, clothing, habituation, debriefing.
  - Size of the performer on the image the bigger the better, but this might require zooming the camera lens (assuming that your camera has a zoom lens) while also panning and tilting the camera during filming.
  - Checks for reliability (within, or intra-, observer) and objectivity (among, or inter-, observer) in any study.

• When deciding where to conduct the study, we have to balance an environment in which we have control over extraneous factors, such as lighting and background, and one that is similar to that in which the movement is normally performed; the latter ensures ecological validity. Normally, the latter dominates, but the decision may be affected by the skill of the performers, whether the activities being recorded are open or closed skills, and videographic issues. When selecting camera vantage points, the movement analyst has to address from where he or she would want to view these activities for qualitative analysis, with how many cameras, and whether the cameras need to be stationary.

• The decision of how many trials, or performances, to record is very important for the reliability of qualitative analysis. However, that decision is not always made by the movement analyst. For example, if you were recording from a game, say of football, for notational analysis, you only have control over how many games you will record. If recording for technique analysis in competition, the number of recordable trials is probably fixed, for example, at six throws in the finals of a discus competition, the heats plus the finals of swimming events, and as many attempts as the jumper needs in the high jump until three failures. If recording out of competition, we need to decide how many observations we need; generally, within reason, the more the better. Because of movement variability, there is no such thing as a representative trial even for stereotyped closed skills. The more trials we record, the more likely are our results to be valid. Various rules of thumb have proposed between five and twenty trials as a minimum requirement; ten, if you can record that many, is often highly satisfactory.

3.3 Evaluation and diagnosis stage – analysing what's right and wrong in a movement

The hard work for this stage should already have been completed during the preparation stage the identification of the critical features of the movement. The observation stage should then have allowed you to collect the video footage you need to evaluate these critical features in the performances that you have recorded. This stage also prepares us for the intervention stage. Often, in the evaluation and diagnosis stage probably the most difficult of the four-stage process – you will start by describing the movement and progress to analysing it; trying to analyse a movement before you have thoroughly and scientifically described it can be fraught with difficulties. In this con-text, it should be noted that the work we do in this stage can do more harm than good; that is, we could reduce performance or increase injury risk, particularly if we have not identified and prioritised the correct critical features. This overall stage could be called the analysis stage; however there are two separate aspects to this stage (although they often overlap):

- To evaluate strengths and weaknesses of performance (what the symptoms are).
- To diagnose what weaknesses to tackle and how (diagnose symptoms and prepare to treat the condition).

To evaluate performance we effectively need to compare the observed performances with some model of good form. However, as there is no general optimal performance model, we need a model that is appropriate for the performers being evaluated – the model needs 'individual specificity'. This clearly requires prior identification of critical features in the preparation stage. Furthermore, a ranking of the 'correctness' of the identified critical features on some scale or within some band of correctness can be very helpful; for example, 'joint range of motion: inadequate; within good range; excessive'; or 'excellent 5 . . . . OK 3 . . . . poor 1'. As well as needing a 'model' that is individual-specific, other difficulties arise in the evaluation of performance. The first of these relates to within-performer movement and performance variability; as we noted in the observation stage above, this can only be accounted for by recording multiple trials. Identifying the source of movement errors can also be problematic as they can arise from: body position or movement timing (biomechanical); conditioning (physiological); the performer evaluating environmental cues (perceptual-motor); or motivational factors (psychological). These factors support the need for movement analysts to be able to draw on a range of disciplinary skills and knowledge. In the real world of sport, movement analysts are usually most effective when they work as part of a multidisciplinary team of experts. Analysis bias, reliability and objectivity also present problems. Bias can be reduced by the use of 'correctness' criteria. Assessing reliability and objectivity requires multiple trials or analysts respectively; the latter is often a luxury, the former is vital.

Perhaps the major issues in the evaluation and diagnosis stage relate to the lack of a consistent rationale for diagnosing movement errors: our 'critical features' approach is best, providing that we can identify and prioritise the correct critical features. As only one intervention at any time is best, in the intervention stage, we need to focus on one correction at a time. This raises the question of how we diagnose to prioritise intervention. Five approaches are used, depending on the activity and circumstances.

The first of these focuses on 'what came before', in other words the relationship to previous actions, as in a stroke sequence in tennis. The second, somewhat related to the first, looks at the correct sequence through the phases of the movement. These two approaches are conceptually attractive, as problems usually arise before they are spotted. For example, in our long jump model below, landing problems are often due to poor generation of rotation on the take-off board or control of it in the air. Some problems arise in implementing these approaches for complex multi-segmental sports movements. We need to be aware that body segments interact, such that muscles affect even joints they do not cross. For example, it is normal to record a lack of triceps brachii activity in the action phase of baseball pitching, even though this muscle group is the main extensor of the elbow. In throwing and kicking, it is not entirely clear if a proximal segment speeds up a distal one or a distal one slows down a proximal one.

The third, and perhaps the most obvious, approach seeks to prioritise the critical features that maximise performance improvement. To use the long jump model again, if a long jumper is not jumping far, speed is overwhelmingly the most important factor; so what critical feature would we prioritise to maximise performance? Run-up speed obviously. However in many cases, it is not at all easy to know what will maximise improvement; furthermore, we often need to balance short-term and long-term considerations. In terms of successful outcomes, a fourth, and very attractive, approach is to make the easiest corrections first, in order of difficulty. This is impeccably logical from a motor skills viewpoint if movement errors seem unrelated and cannot be ranked. However there is little, if any, clear support for its efficacy in improving performance.

Finally, for activities in which balance is crucial, such as gymnastics and weightlifting, we might prioritise from the base of support upwards. But would this approach work, for example, in target shooting? From much experience, I would normally recommend to students of movement analysis the 'correct sequence' or 'what came before' approach to prioritising changes.

3.4 Intervention stage – providing appropriate feedback

We come now to the final (intervention) stage of our four-stage process of qualitative analysis. Before getting this far, the movement analyst must have conducted a means analysis with the performer and their coach or therapist, identified the critical features relevant to the question to be answered, and prepared how feedback will be provided, including, for example, key words. Secondly, the movement analyst will have obtained relevant video footage and any other movement patterns. Finally, the movement analyst will have analysed the video and movement patterns and prioritised the critical features to be addressed.

The focus in this final stage is on feedback of information to address the requirements of the needs analysis. If the previous three stages have been done badly, nothing in the intervention stage will sort matters out. On the other hand, provision of inappropriate feedback can jeopardise even good work done in the previous stages.

Several key points relate to providing information feedback. The information fed back should augment that available to the performer from his or her senses; such information is referred to, particularly in motor learning, as augmented feedback. The success of any intervention strategy to improve performance hinges on the way information is provided – fed back – to practitioners. The movement analyst must address what information is communicated, how this is done and when; this should have been partly done in the preparation stage. Practitioners may not always be receptive to feedback, particularly if it is not obviously relevant to the problems that a needs analysis should have identified; this difficulty often arises when no needs analysis has been carried out.

Some fundamental points should be borne in mind about providing feedback. First, we need accurate and reliable information to be fed back. Secondly, the information should provide something that is not directly observable by coaches or other practitioners. Thirdly, what is fed back should relate clearly to differences between good and poor performance. Fourthly, feedback should involve the right information at the right time and in an easily absorbed format. Lastly, the rapidity with which feedback is provided, its presentation and interpretation are all important.

It is worth noting, in this context, that the implicit assumption that feedback is inherently good is not totally supported. Further warning points are, first, that much information relating to movement technique is available, with little clarity about what should be fed back or how. Secondly, providing more information may cause confusion, particularly if unrelated to the problem identified. Thirdly, calls for the provision of immediate feedback, directly after the performance, don't address several very important points. The first of these is that the rapidity of feedback provision may depend on its role and may be different for a technique change to improve performance than for feedback of simple notational data. Next, feedback provision needs to address relevant motor learning research, particularly that of the ecological school. Too few research studies have addressed these issues in sport.

3.5 Identifying Critical Features of a Movement

Much of our work as movement analysts involves the study and evaluation of how sports skills are performed. To analyse the observed movement 'technique', we need to identify 'critical features' of the movement. These features should be crucial to improving performance of a certain skill or reducing the injury risk in performing that skill – sometimes both. For a qualitative biomechanical analyst, this means being able to observe those features of the movement; for the quantitative analyst, this requires measuring those features and often, further mathematical analysis. Identification of these critical features is probably the most important task facing a qualitative or quantitative analyst, and we will look at several approaches to this task in this section. None is foolproof but all are infinitely better at identifying these crucial elements of a skill than an unstructured approach. Sometimes it can be helpful to define a 'scale of correctness' for critical features, for example poor 1 to perfect 5, or a 'range of correctness', such as 'wrist above elbow but below shoulder'.

This involves devising a set of critical features identified from an 'ideal' (sometimes called a 'model') performance, often that of an elite performer, hence the alternative name. This approach has nothing to recommend it except, for a lazy analyst, its minimal need for creative thought. It assumes that the ideal or elite performance is applicable to the person or persons for whom the analyst is performing his or her analysis. There is now wide agreement among movement analysts that there is no universal 'optimal performance model' for any sports movement pattern. Each performer brings a unique set of organismic constraints to a movement task; these determine which movements, out of the many possible solutions for the task under those constraints, are best for him or her.

4.0 Self-Assessment Exercise

1. Explain plan and undertake a qualitative video analysis of a sports technique of your choice.
2. Describe qualitative biomechanical analysis of movement in sport and exercise.
3. Explain the need for a structured approach to qualitative movement analysis.
4. Explain the phase analysis of movements and the movement principles approach.

Answers

5.0 Conclusion

The gathering of relevant knowledge is dynamic and ongoing movement for analysis. Your knowledge of the activity, as a movement analyst, should draw on many sport and exercise science disciplines. In all of our work as movement analysts, whether qualitative or quantitative, we should always seek to adhere to 'evidence-based' practice, which raises the question as to what evidence we gather and from where.

6.0 Summary

In this unit, we considered how qualitative movement analysis of movement is part of a multidisciplinary approach to movement analysis. We looked at several structured approaches to qualitative analysis of movement, all of which have, at their core, the identification of critical features of the movement studied. We identified four stages in a structured approach to movement analysis, considered the main aspects of each stage and noted that the value of each stage depends on how well the previous stages have been implemented.

7.0 References/Further Reading

Kurt T. Manal &Thomas, S. Buchana. (2001). Biomechanics of human movement. In: *Standard handbook of biomedical engineering and design.* University of Delaware, Newark. https://cmasuki.org/introduction-to-movement-analysis/

Sasaki, K.& Neptune, R. (2005).*Muscle mechanical work and elastic energy utilization during walking and running near the preferred gait transition speed*.http://www.me.utexas.edu/~neptune/Papers/gait&posture23(3).pdf

Hay, J.C. (1993).*The biomechanics of sports techniques.* Englewood Cliffs, NJ: Prentice Hall. Some of the sports chapters (Chapters 8 to 17) contain deterministic models of various sports activities, which should be of interest to you as further examples of this approach; some will also help with your study tasks.

Hughes, M.D. & Franks, I.M. (2004).*Notational analysis of sport*. London: Routledge. Although written mainly from a notational analysis viewpoint, Chapters 1 to 3 contain valuable information about performance-enhancing augmented feedback.

Knudson, D.V. & Morrison, C.S. (2002) .*Qualitative analysis of human movement.* Champaign, IL: Human Kinetics. The first edition of this book was for many years one of the few real gems in the Human Kinetics list of sports science texts; the second edition continues that tradition. However, the authors have not yet welcomed a wider interpretation of qualitative movement analysis and a crucial (perhaps the crucial) 'critical feature' of skilled human movement – coordination – receives only one page reference in the index. The structured approach to movement analysis outlined in this chapter is covered in far more detail in Part II of Knudson and Morrison, while Part I sets the scene nicely and Part III outlines applications of their approach, with many diagrammatic examples. Highly recommended and well written.

Kreighbaum, E. & Barthels, K.M. (1996).*Biomechanics: A qualitative approach for studying human movement*,. New York: Macmillan. Find the approach taken by these authors overly mechanics-based; such an approach has turned so many students off sports biomechanics over the years. However, Chapters 13 to 16 have much to recommend them.

Module 3 Musculo-Skeletal-System
Introduction BBB

Unit 1 Functions and the Axial and Appendicular Skeleton
Contents

1.0 Introduction

Knowledge of the skeletal system and how it works helps us to understand movement and explains how skills are performed. The skeleton provides attachments for the muscular system for movement and offers protection for vital organs such as the cardio-respiratory and vascular system. Bones are formed by the ossification. All these will be discussed extensively in this unit.

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, youwillbe able to:

- describe the skeletal system
-
- explain the functions of skeletal system

3.0 Main Content

3.1 Functions and the Axial and Appendicular Skeleton

The skeletal system is the body system composed of bones, cartilages, ligaments and other tissues that perform essential functions for the human body. Bone tissue, or osseous tissue, is a hard, dense connective tissue that forms most of the adult skeleton, the internal support structure of the body. In the areas of the skeleton where whole bones move against each other (for example, joints like the shoulder or between the bones of the spine), cartilages, a semi-rigid form of connective tissue, provide flexibility and smooth surfaces for movement. Additionally, ligaments composed of dense connective tissue surround these joints, tying skeletal elements together (a ligament is the dense connective tissue that connect bones to other bones). The axial skeleton forms the central axis of the human body and includes the bones of the skull, the ossicles of the middle ear, the hyoid bone of the throat, the vertebral column, and the thoracic cage (ribcage). The function of the axial skeleton is to provide support and protection for the brain, spinal cord, and organs in the ventral body cavity. It also provides a surface for the attachment of muscles that move the head, neck, and trunk; performs respiratory movements; and stabilizes parts of the appendicular skeleton, which will be discussed later.The appendicular skeleton (126 bones) is formed by the pectoral girdles, the upper limbs, the pelvic girdle or pelvis, and the lower limbs. Their functions are to make locomotion possible and to protect the major organs of digestion, excretion and reproduction. Together, they perform the following functions:

1. Shape

The skeleton gives the body its shape, which changes with growth. In addition to determining characteristics such as height and the size of the hands and feet, stable body shape enables essential functions. For example, a stable rib cage and spine enable the lungs to fully inflate when breathing. Conditions such as osteoporosis of the spine and broken ribs can alter the shape of the chest and impair this vital body function.

2. Support

Along with the muscular system, the skeleton provides support to the body and keeps the internal organs in their proper place. The strong bones of the spine, pelvis, and legs enable people to stand upright, supporting the weight of the entire body. Body cavities -- hollow spaces framed by the skeleton -- hold the internal organs. For example, the skull holds the brain, the chest cavity houses the heart and lungs, and the abdominal cavity encases the organs of the digestive, urinary and internal reproductive systems.

3. Movement

The skeletal bones are held together by ligaments, and tendons attach the muscles to the bones of the skeleton. The muscular and skeletal systems work together as the musculoskeletal system, which enables body movement and stability. Muscles contract, they pull on bones of the skeleton along with them to produce movement or hold the bones in a stable position.

The shape of the bones and how they fit together at the joints allows for different types of movement. For example, the leg bones come together at the knee to form a hinge joint that enables the knee to bend back and forth. The joining portions of the bones of the hip and shoulder have a much different shape and form ball-and-socket joints that allow movement in multiple directions.

4. Protection

The skeleton protects the internal organs from damage by surrounding them with bone. Bone is living tissue that is hard and strong, yet slightly flexible to resist breaking. The strength of bone comes from its mineral content, which is primarily calcium and phosphorus.

The flexibility is due to a substance called collagen. The combination of strength and flexibility gives the skeleton the capacity to absorb the impact of blows to the body without breaking. Examples of important protecting bones of the skeleton include the skull, spinal column and rib cage, which protect the brain, spinal cord, and heart and lungs.

5. Blood Cell Production

Larger bones contain bone marrow, spongy tissue inside the bones. There are two main types of marrow, red and yellow. Red marrow is responsible for the production of all of the body's red blood cells and many of its white blood cells. Red blood cells are produced at an average rate of approximately 200 million per day. These cells carry life-sustaining oxygen to the body tissues.

In adults, red marrow is found primarily in the breastbone, hips, ribs, skull, spinal bones and at the end of long bones of the arms and legs. Several types of white blood cells, which protect the body from infections, are also produced in the red bone marrow. Yellow bone marrow contains primary fat cells but can transform into red marrow if the body needs to increase blood cell production, such as if anemia develops as seen in the figure (figure 1).

3.3 Mineral and Fat Storage

On a metabolic level, bone tissue performs several critical functions. For one, the bone tissue acts as a reservoir for a number of minerals important to the functioning of the body, especially calcium, and phosphorus. These minerals, incorporated into bone tissue, can be released back into the bloodstream to maintain levels needed to support physiological processes. Calcium ions, for example, are essential for muscle contractions and are involved in the transmission of nerve impulses. Yellow bone marrow contains adipose tissue, and the triglycerides stored in the adipocytes of this tissue can be released to serve as a source of energy for other tissues of the body as seen in the figure (figure1).

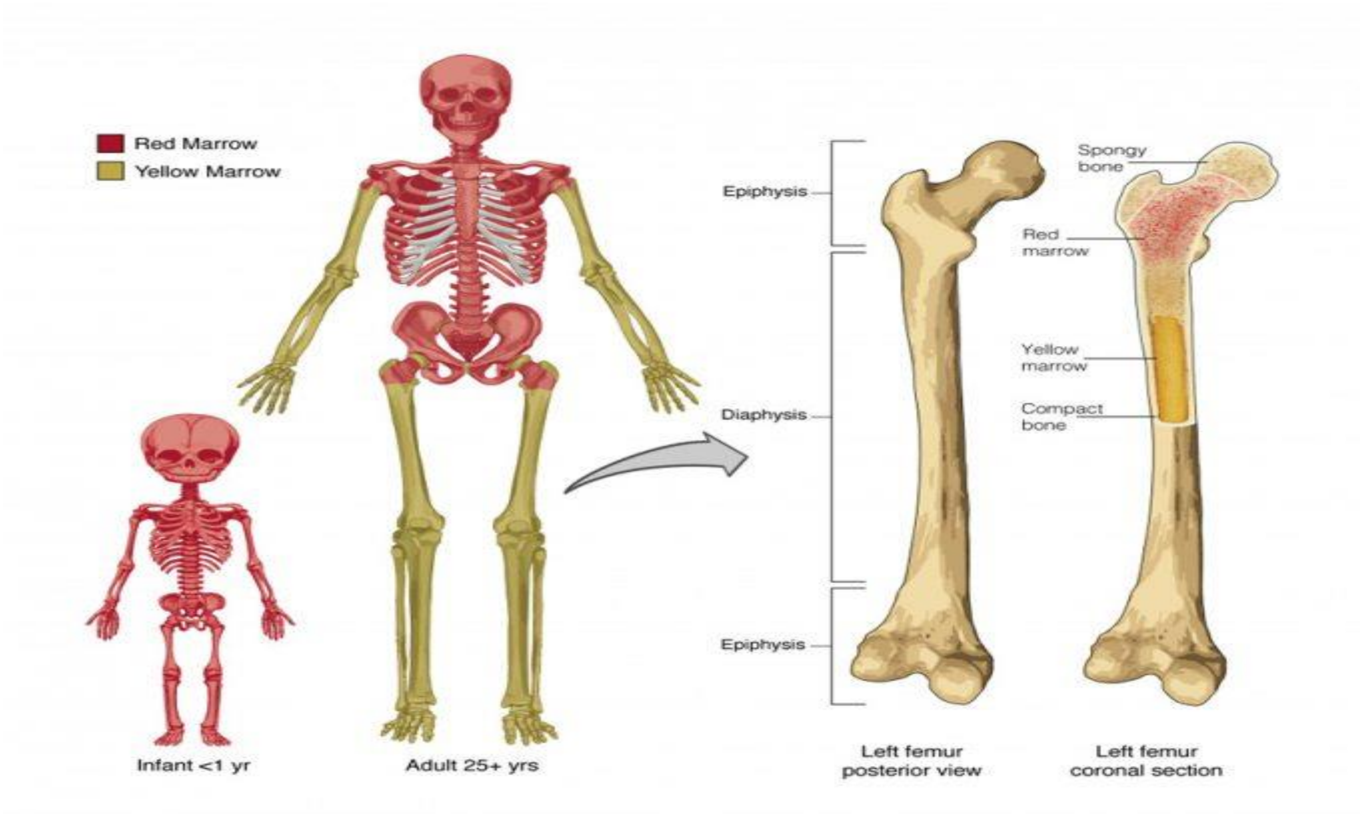


Figure 1: Bones contain variable amounts of yellow and/or red bone marrow. Yellow bone marrow stores fat and red bone marrow is responsible for producing blood cells (hematopoiesis).

4.0 Self-Assessment Exercise

27. The number of bone in the axial skeleton is (a)60 (b)80 (c) 40 (d) 20. ANS (B)

28. The number of bone in the axial skeleton is (a)120 (b)180 (c) 126 (d) 116. ANS (C)

29.Which of the following is an example of uniaxial joint? (a) Condyloid (b)saddle (c) Hinge (d) Condyloid and saddle both. ANS (D)

30.Which of the following is not example of delicate organ? (a) brain (b)spinal cord (c) kidney (d) ribs ANS (D).

31. The two types of marrow are ------------- and-------------- (a) red and yellow (b)white and red (c) yellow and white (d) red and bran. ANS (A).

32. The blood cell that carries oxygen to the body tissues is. (a) yellow blood cell (b)white blood cell (c)red blood cell (d) yellow and white blood cell. ANS (C).

33. Yellow bone marrow contains primary --------- (a) plasma (b) fat cell(c) water (d) fluid. ANS (B)
34. The shortage of blood in human body is called (a) anemia (b) plasma (c) triglycerides (d) adipocytes.ANS (A)
35. Which of the following minerals can be found in the blood.(a) sodium (b) potassium(c) iron (d) calcium. ANS (D).

5.0 Conclusion

The knowledge of description skeleton system, how it function like support, protection, movement, blood production and mineral storage will help students understand movement analysis

6.0 Summary

The bones of the skeletal system protect the body's internal organs, support the weight of the body, and serve as the main storage system for calcium and phosphorus.

7.0 References/Further Reading

Marieb, F.N. (2003).*Human anatomy and physiology*.Redwood City, CA: Benjamin/Cummings. See Chapters 6 to 10. Many anatomy and physiology texts will contain supplementary information about, for example, the attachment points and actions of specific muscles. This one is a highly recommended and readable text with glorious colour illustrations.

Baltzopoulos, V. (2007). Isokinetic dynamometry.In C.J. Payton and R.M. Bartlett (Eds).*Bio-mechanical evaluation of movement in sport and exercise*.Abingdon: Routledge. Chapter 6provides a comprehensive and up-to-date coverage of all aspects of isokinetic dynamometry.

Unit 2: Types of Bone and the Role of Ligaments, Tendons and Cartilage

Contents

1.0 Introduction

The bones are connected to other bones and muscle fibers via connective tissue such as tendons and ligaments. Cartilage prevents the bone ends from rubbing directly on each other.

2.0 Intended Learning Outcome(s)

By the end of this unit, you will be able to:

- differentiate types of bone
- appraise the role of ligaments, tendons and cartilage.

3.0 Main Content

3.1 Types of Bone and the Role of ligaments, tendons and cartilage

The human body consists of 5 types of bones; long, short, flat, irregular and sesamoid bones.

3.1.1 Long Bones

A long bone is one that is cylindrical in shape, being longer than it is wide. Keep in mind, however, that the term describes the shape of a bone, not its size. Long bones are found in the upper limbs (humerus, ulna, radius) and lower limbs (femur, tibia, fibula), as well as in the hands (metacarpals, phalanges) and feet (metatarsals, phalanges). Long bones function as rigid bars that move when muscles contract.

3.1.2 Short Bones

A short bone is one that is cube-like in shape, being approximately equal in length, width, and thickness. The only short bones in the human skeleton are in the carpals of the wrists and the tarsals of the ankles. Short bones provide stability and support as well as some limited motion.

3.1.3 Flat Bones

The term flat bone is somewhat of a misnomer because, although a flat bone is typically thin, it is also often curved. Examples include the cranial (skull) bones, the scapulae (shoulder blades), the sternum (breastbone), and the ribs. Flat bones serve as points of attachment for muscles and often protect internal organs.

3.1.4 Irregular Bones

An irregularbone is one that does not have any easily characterized shape and therefore does not fit any other classification. These bones tend to have more complex shapes, like the vertebrae that support the spinal cord and protect it from compressive forces. Many bones of the face, particularly the jaw bones that contain teeth, are classified as irregular bones.

3.1.5 Sesamoid Bones

A sesamoidbone is a small, round bone that forms in tendons (sesamo- = “sesame” and -oid = “resembling”).Tendons are a dense connective tissue that connect bones to muscles and sesamoid bones form where a great deal of pressure is generated in a joint. The sesamoid bones protect tendons by helping them overcome excessive forces but also allow tendons and their attached muscles to be more effective. Sesamoid bones vary in number and placement from person to person but are typically found in tendons associated with the feet, hands, and knees. The patellae

(singular = patella) are the only sesamoid bones found in common with every person. Table 1 reviews bone classifications with their associated features, functions, and examples.
examples.

Table 1Bone Classifications			
Bone classification	**Features**	**Function(s)**	**Examples**
Long	Cylinder-like shape, longer than it is wide	Movement, support	Femur, tibia, fibula, metatarsals, humerus, ulna, radius, metacarpals, phalanges
Short	Cube-like shape, approximately equal in length, width, and thickness	Provide stability, support, while allowing for some motion	Carpals, tarsals
Flat	Thin and curved	Points of attachment for muscles; protectors of internal organs	Sternum, ribs, scapulae, cranial bones
Irregular	Complex shape	Protect internal organs, movement, support	Vertebrae, facial bones
Sesamoid	Small and round; embedded in tendons	Protect tendons from excessive forces, allow effective muscle action	Patellae

3.2 Role of Cartilage

There are different types of cartilages found in human body and the functions vary accordingly .Here are some of the functions performed by cartilage in our body-

1- It works just like a cushion in the joints. Preventing rubbing of bones against each other is one of the main functions of cartilage. For example, the cartilage in the knees and elbows works like a cushion in the bones and helps avoid joint pain.

2-Cartilage holds some bones together, for instance, rib cartilage. It makes the area shock-proof.

3.3 Role ofTendon

1. Tendons carry tensile forces from muscle to bone
2.They carry compressive forces when wrapped around bone like a pulley.

3.4 Role ofLigament

Ligaments function to create stability in joints and to support internal organs.
It helps in supporting and keeping the organ in position,it is made of fibrous tissue.

4.0 Self-Assessment Exercise

36.The cartilage which serves to cushion the impact of large forces on bone ends is called (a) fibrous cartilage (b) hyaline cartilage (c) notch(d) fossa ANS (B)

37. Function of long bone in the body is to (a) give strength (b) function as rigid bars that move when muscles contract (c) act as lever (d) Provides surface area for attachment. ANS (B)

38. One of the following is not example of long bone (a) humerus, ulna, radius (b) femur, and fibula, (c) wrists and the tarsals (d) metacarpals and phalanges. ANS (C)

39. Which of the following is example of short bone (a) humerus, ulna, radius (b) femur, and fibula, (c) wrists and the tarsals (d) metacarpals and phalanges. ANS (C)

40. The largest bone in human body is (a) humerus, (b) femur (c)tibia (d) fibula. ANS (B)

41. The shortest bone in human body is (a) phalange (b) metatarsal (c)in nominate bone (d) tarsal ANS (D)

42. Which of the following is responsible for limiting the range of movement of joint? (a) tendons (b) ligament (c) cartilage (d) muscle fibre. ANS (B)

43. Which of the following type bones serve as points of attachment for muscles and often protect internal organs (a) shortest bone (b) long bone (c) irregular bone (d) flat bone. ANS (D)

44. The type of **bone** which does not have any easily characterized shape is (a) shortest bone (b) long bone (c) irregular bone (d) flat bone. ANS (C)

45. Irregular bones can be found in (a)upper arm (b) face (c) lower arm (d) phalanges. ANS (B)

5.0 Conclusion

The knowledge of description skeleton system, how it function like support, protection, movement, blood production and mineral storage will help students understand movement analysis

6.0 Summary

Joints, also known as articulations, occur between the bones or cartilage of the skeleton. They allow free movement of the various parts of the body or more restricted movements, for example during growth or childbirth. Other tissues that may be present in the joints of the body are dense, fibrous connective tissue, which includes ligaments, and synovial membrane. The nature and biomechanical functions of these and other structures associated with joints will not be considered here.

7.0 References/Further Reading

Baltzopoulos, V. (2007). Isokinetic dynamometry., In C.J. Payton and R.M. Bartlett (Eds).*Bio-mechanical evaluation of movement in sport and exercise.* Abingdon: Routledge. Chapter 6provides a comprehensive and up-to-date coverage of all aspects of isokinetic dynamometry.

Burden, A.M. (2007). Surface electromyography.In C.J. Payton and R.M. Bartlett (Eds).*Bio-mechanical evaluation of movement in sport and exercise*. Abingdon: Routledge. Chapter 5provides an up-to-date coverage of many aspects of electromyography related to sports movements.

Axis of movement animation https://www.youtube.com/watch?v=iP7fpHuVaiA

Understanding planes and axes of movement (pdf)www.physical-solutions.co.uk/wp-content/uploads/2015/05/

Understanding-Planes-and-Axes-of-Movement.pdf
Understanding exercise – planes, axes and movement
www.todaysfitnesstrainer.com/understanding-exercise-planes-axesmovement/

Unit 3 Functions and Structure of the Muscular System Including: Major Skeletal Muscles of the Human Body

CONTENTS

1.0 Introduction

Skeletal muscles are those musclesattach to bones and have the main function of contracting to create movement. They are also sometimes known as: Striated muscles due to their appearance or voluntary because we have direct control over them contracting.

2.0 Intended Learning Outcome(s)

By the end of this unit, you willbe able to:

- categorisevoluntary and reflexive movement
- describe the functions of the muscular system
- describe patterns of fascicle organization
- appraise lever system of muscle and bone interactions.

3.0 Main Content

3.1 Voluntary and Reflexive Movement

Skeletal muscles normally account for at least 40 percent of your body weight and are categorized as appendicular or axial based on body location. The large muscles of your arms and legs are appendicular skeletal muscles. The axial skeletal muscles include those of your trunk, head and neck. Contraction of skeletal muscle produces voluntary gross and fine movements, a primary function of the muscular system.

Gross movement refers to large coordinated movements such as walking, running, jumping, sitting down, standing up, lifting large objects, swimming, and swinging a bat or racket. Gross movements rely primarily on large skeletal muscles. Fine motor skills refer to smaller, more intricate body movements. Examples include speaking, writing and playing a musical instrument. Fine motor skills typically involve small skeletal muscles of your hands, face or feet. Although most skeletal muscles are under voluntary control, they can also contract reflexively -- such as blinking when an insect flies toward your face or pulling your hand away from a hot surface.

3.2 Functions of the Muscular System

Functions of the muscular system include**:**

1. Skeletal Stability and Organ Protection

Your bones provide the frame for your body. Your skeleton, however, lacks structural stability without the skeletal muscles and their associated tendons that hold your bones together and keep them in place. Even in a static posture, such as when you're standing still, numerous skeletal muscles of the trunk, neck and legs must remain in a contracted state to support your body and head. The axial skeletal muscles are particularly important for maintaining an upright position, and enabling you to twist your head and body.
In conjunction with the rib and spinal bones of your trunk, the axial skeletal muscles also provide protection for your internal organs. For example, your rectus abdominus, transverse abdominus and oblique muscles protect your abdominal organs from the front and side. Your latissimus dorsi, quadratus lumborum and psoas muscles protect the organs of your abdominal cavity from the back.

2 Blood Circulation

Your heart is the hardest working muscle in your body, contracting at least 60 to 100 times per minute from cradle to grave. The wall of your heart consists of highly specialized cardiac muscle tissue, which contracts involuntarily in response to electrical signals generated within the heart. With each contraction of your heart, blood is pumped through your circulatory system. This essential function provides life-sustaining oxygen and nutrients to your body organs and tissues.

Smooth muscle cells in the walls of your arteries and veins also contribute to blood circulation by altering the diameter of these blood vessels in different situations. For example, arteries supplying exercising skeletal muscles relax to enable increased blood flow to meet the increased metabolic demand. Conversely, if you're dehydrated or suffer a significant blood loss, the smooth muscle of your blood vessels contracts to help maintain your blood pressure and ensure continued circulation to your brain and other vital organs.

3. Internal Organ Function

Several internal organs contain smooth muscle tissue, which contracts automatically to support their normal function. For example, smooth muscle tissue in the walls of your esophagus, stomach, and small and large intestines produce rhythmic contractions that propel food through your digestive tract. Similarly, smooth muscle in the wall of your bladder enables you to expel urine. Uterine smooth muscle tissue, called the myometrium, proliferates during pregnancy and provides the strong propulsive force that enables a vaginal delivery. Other internal organs and structures that rely on smooth muscle to support some of their functions include the gallbladder, male reproductive ducts and glands, and the irises of the eyes.

4. Body Temperature Regulation

A normal body temperature of roughly 98.6 F is generally lower than the environmental temperature. Since body heat is lost to the environment in typical conditions, your body must generate heat to maintain a normal temperature. Most of this needed heat is generated by your skeletal muscles. When your body temperature decreases, skeletal muscle activity automatically increases to generate heat. Shivering is the most obvious manifestation of this response. Smooth muscle in the blood vessels supplying your skin also automatically constricts in cold conditions to conserve heat by limiting loss at your body surface. The opposite effect occurs when you're exercising or otherwise overheated. Smooth muscle cells in surface blood vessels relax, increasing blood flow and heat release through your skin • .

3.3 Patterns of Fascicle Organization

Skeletal muscle is enclosed in connective tissue scaffolding at three levels. Each muscle fiber (cell) is covered by endomysium and the entire muscle is covered by epimysium. When a group of muscle fibers is “bundled” as a unit within the whole muscle it is called a fascicle**.** Fascicles are covered by a layer of connective tissue called perimysium. Fascicle arrangement is correlated to the force generated by a muscle and affects the muscle’s range of motion. Based on the patterns of fascicle arrangement, skeletal muscles can be classified in several ways. What follows are the most common fascicle arrangements.

Parallel muscles have fascicles that are arranged in the same direction as the long axis of the muscle (Figure 1). The majority of skeletal muscles in the body have this type of organization. Some parallel muscles are flat sheets that expand at the ends to make broad attachments such as the sartorius. Other parallel muscles have a larger central region called a muscle belly tapering to tendons on each end. This arrangement is called fusiform such as the biceps brachii.

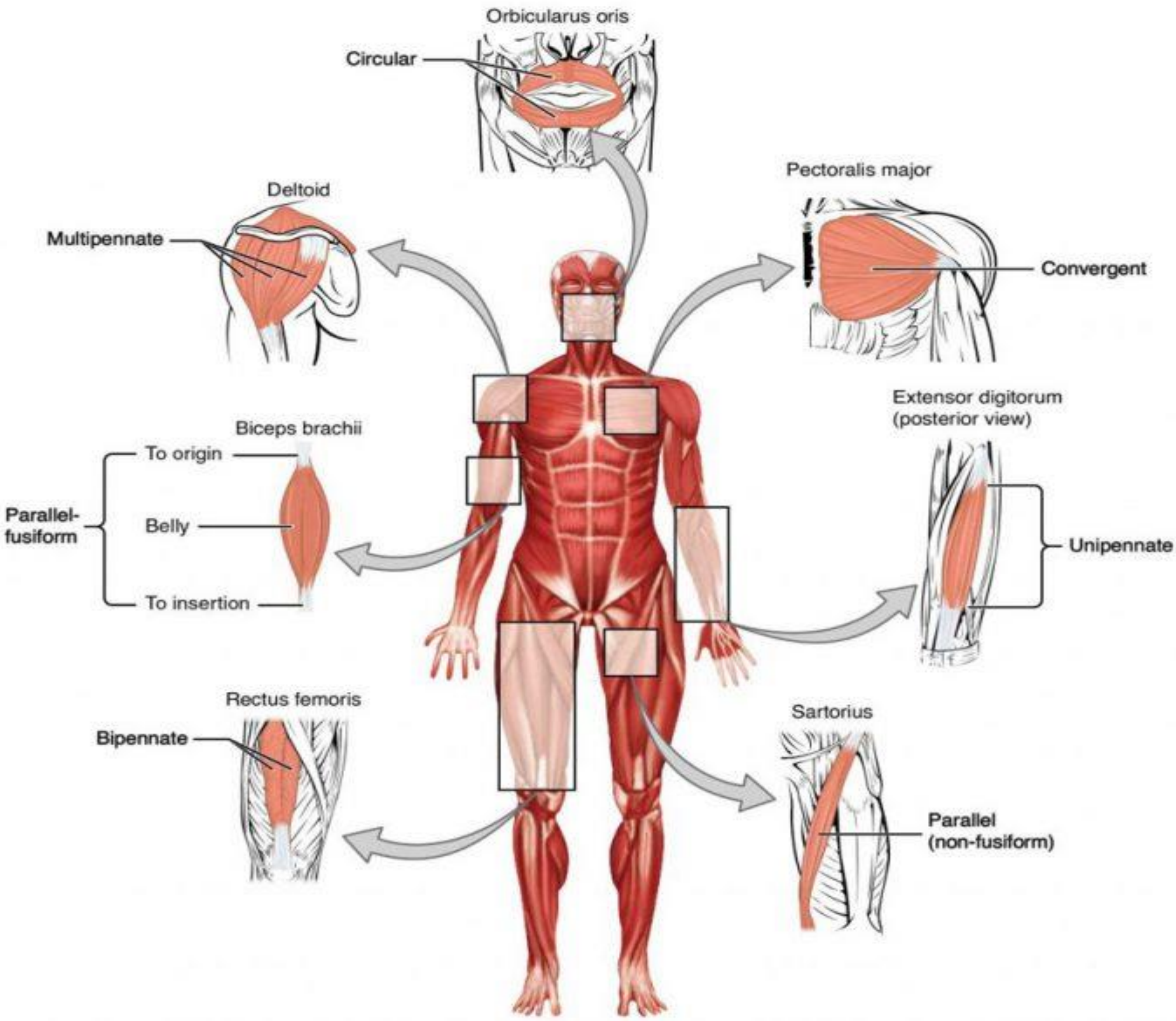


Fig. 1. Muscle Shapes and Fiber Alignment. The skeletal muscles of the body typically come in seven different general shapes.

Circular muscles are also called sphincters (see Figure 1). When they relax, the sphincters' concentrically arranged bundles of muscle fibers increase the size of the opening, and when they contract, the size of the opening shrinks to the point of closure. The orbicularis oris muscle is a circular muscle that goes around the mouth. When it contracts, the oral opening becomes smaller, as when puckering the lips for whistling. Another example is the orbicularis oculi, one of which surrounds each eye. Consider, for example, the names of the two orbicularis muscles (orbicularis oris and oribicularis oculi), where part of the first name of both muscles is the same. The first part of orbicularis, orb (orb = "circular"), is a reference to a round or circular structure; it may also make one think of orbit, such as the moon's path around the earth. The word oris (oris = "oral") refers to the oral cavity, or the mouth. The word oculi (ocular = "eye") refers to the eye.
When a muscle has a widespread expansion over a sizable area and the fascicles come to a single, common attachment point, the muscle is called convergent. The attachment point for a convergent muscle could be a tendon, an aponeurosis (a flat, broad tendon), or a raphe (a very slender tendon). The large muscle on the chest, the pectoralis major, is an example of a

convergent muscle because it converges on the intertubercular groove and greater tubercle of the humerus via a tendon.

Pennate muscles (penna = “feathers”) blend into a tendon that runs through the central region of the muscle for its whole length, somewhat like the quill of a feather with the muscle fascicles arranged similar to the feathers. Due to this design, the muscle fibers in a pennate muscle can only pull at an angle, and as a result, contracting pennate muscles do not move their tendons very far. However, because a pennate muscle generally can hold more muscle fibers within it, it can produce relatively more tension for its size. There are three subtypes of pennate muscles.
In a unipennate muscle, the fascicles are located on one side of the tendon. The extensor digitorum of the forearm is an example of a unipennate muscle. A bipennate muscle such as the rectus femurs has fascicles on both sides of the tendon as in the arrangement of a single feather. Multipennate muscles have fascicles that insert on multiple tendons tapering towards a common tendon, like multiple feathers converging on a central point. A common example is the deltoid muscle of the shoulder, which covers the shoulder but has a single tendon that inserts on the deltoid tuberosity of the humerus.

3.4 The Lever System of Muscle and Bone Interactions

Skeletal muscles do not work by themselves. Muscles are arranged in pairs based on their functions. For muscles attached to the bones of the skeleton, the connection determines the force, speed, and range of movement. These characteristics depend on each other and can explain the general organization of the muscular and skeletal systems.
The skeleton and muscles act together to move the body. Have you ever used the back of a hammer to remove a nail from wood? The handle acts as a lever and the head of the hammer acts as a fulcrum, the fixed point that the force is applied to when you pull back or pushes down on the handle. The effort applied to this system is the pulling or pushing on the handle to remove the nail, which is the load, or “resistance” to the movement of the handle in the system. Our musculoskeletal system works in a similar manner, with bones being stiff levers and the articular endings of the bones—encased in synovial joints—acting as fulcrums. The load would be an object being lifted or any resistance to a movement (your head is a load when you are lifting it), and the effort, or applied force, comes from contracting skeletal muscle.

4.0 Self-Assessment Exercise

46. Skeletal muscles are categorized as ----------- and---------- based on body location

    (a) appendicular and axial (b)axial and abdominal (c) appendicular and abdominal (d) legs and arms. ANS (A.)

47. Example of axial skeletal are (a) arms and legs (b) arms and trunk (c) head and neck (d) trunk and neck. ANS (C.)

48.------------- refers to large coordinated movements (a) Fine motor skills (b) axial movement(c) appendicular movement (d) Gross movement. ANS(D.)

49. Which of the following attach muscle to bone? (a)tendon (b) ligament (c) cartilage (d) vein. ANS (A)

5.0 Conclusion

The knowledge of description skeleton system, how it function like support, protection, movement, blood production and mineral storage will help students understand movement analysis

6.0 Summary

The muscles of the muscular system keep bones in place; they also play a role in movement of the bones by contracting and pulling on the bones, allowing for movements as diverse as standing, walking, running, and grasping items. To allow motion, different bones are connected by joints.

7.0 References/Further Reading

Collins, D.F., Cameron, T., Gillard, D.M., Prochazka, A. (1998). Muscular sense is attenuated when humans move. *J Physiol.;508:635–643*. [PMC free article] [PubMed] [Google Scholar]

Collins, D.F., Refshauge, K. M., Todd, G, &Gandevia, S. C. (2005). Cutaneous receptors contribute to kinesthesia at the index finger, elbow, and knee. *J Neurophysiol*.;94:1699–1706. [PubMed] [Google Scholar]

Cordo, P.J., Horn, J. L., Kunster, D., Cherry, A., Bratt, A, &Gurfinkel V. (2011). Contributions of skin and muscle afferent input to movement sense in the human hand. *J Neurophysiol.;*105:1879–1888. [PMC free article] [PubMed] [Google Scholar]

Unit 4 Muscle Fibres and their Characteristics
CONTENTS
1.0 Introduction

Muscle Fibre Types Within skeletal muscles, there are three types of fibre. Type one (I), type two A (IIa) and type two B (IIb). Each fibre types has different qualities in the way they perform and how quickly they fatigue.

2.0 Intended Learning Outcome(s) (ILOs)
By the end of this unit, you willbe able to:

- explainmuscle fibres and their characteristics
- discuss slow twitch (Type I)
- appraise fast twitch (Type IIa and IIb).

3.0 Main Content
3.1 Muscle Fibres and their Characteristics

Slow twitch (Type I) and fast twitch (Type IIa and IIb). Skeletal muscle is made up of bundles of individual muscle fibers called myocytes. Each myocyte contains many myofibrils, which are strands of proteins (actin and myosin) that can grab on to each other and pull. This shortens the muscle and causes muscle contraction. It is generally accepted that muscle fibre types can be broken down into two main types: slow twitch (Type I) muscle fibers and fast twitch (Type II) muscle fibers. Fast twitch fibers can be further categorized into Type IIa and Type IIb fibers.
These distinctions seem to influence how muscles respond to training and physical activity, and each fiber type is unique in its ability to contract in a certain way. Human muscles contain a genetically determined mixture of both slow and fast fibre types. On average, we have about 50 percent slow twitch and 50 percent fast twitch fibers in most of the muscles used for movement.
slow twitch (Type I) muscle fibers

Slow Twitch (Type I)The slow muscles are more efficient at using oxygen to generate more fuel (known as ATP) for continuous, extended muscle contractions over a long time. They fire more slowly than fast twitch fibers and can go for a long time before they fatigue. Therefore, slow twitch fibers are great at helping athletes run marathons and bicycle for hours.
fast twitch (Type II) muscle fibers

Fast Twitch (Type II) Because fast twitch fibres use anaerobic metabolism to create fuel, they are much better at generating short bursts of strength or speed than slow muscles. However, they fatigue more quickly. Fast twitch fibers generally produce the same amount of force per contraction as slow muscles, but they get their name because they are able to fire more rapidly. Having more fast twitch fibers can be an asset to a sprinter since she needs to quickly generate a lot of force.

Type IIa Fibers These fast twitch muscle fibres are also known as intermediate fast twitch fibers. They can use both aerobic and anaerobic metabolism almost equally to create energy. In this way, they are a combination of Type I and Type II muscle fibers.

Type IIb Fibers These fast twitch fibers use anaerobic metabolism to create energy and are the "classic" fast twitch muscle fibers that excel at producing quick, powerful bursts of speed. This muscle fiber has the highest rate of contraction (rapid firing) of all the muscle fiber types, but it also has a much faster rate of fatigue and can't last as long before it needs rest.

Fiber Type and Performance Our muscle fiber type may influence what sports we are naturally good at or whether we are fast or strong. Olympic athletes tend to fall into sports that match their genetic makeup. Olympic sprinters have been shown to possess about 80 percent fast twitch fibers, while those who excel in marathons tend to have 80 percent slow twitch fibers.

Characteristics of the Muscle Fibres:

Characteristic	Type I (oxidative)	Type IIa (oxidative glycolytic)	Type IIb (fast glycolytic)
		Structural Differences	
Fibre size	Small	Large	Large
No of capillaries	Large	Moderate	Small
No of mitochondria	Large	Moderate	Small
Myoglobin store	High	Moderate	Low
CP stores	Low	High	High
Glycogen stores	Low	High	High
		Functional Differences	
Aerobic capacity	High	Low/moderate	Low
Fatigue resistance	High	Low/moderate	Low
Anaerobic capacity	Low	High/Moderate	High
Speed of contraction	Slow	Fast	Fastest
Force of contraction	Low	High	Highest
Activity	Long Distance	1500m	Sprint

4.0 Self-Assessment Exercise

1. Explain muscle fibres and their characteristics.
2. Explain the following slow twitch (Type I) and fast twitch (Type IIa and IIb)

Answers

5.0 Conclusion

It is generally accepted that muscle fiber types can be broken down into two main types: slow twitch (type I) muscle fibers and fast twitch (type II) muscle fibers. Fast twitch fibers can be further categorized into type IIa and type IIb fibers.

6.0 Summary

These distinctions seem to influence how muscles respond to training and physical activity, and each fiber type is unique in its ability to contract in a certain way. Human muscles contain a genetically determined mixture of both slow and fast fiber types.

7.0 References/Further Reading

Elizabeth, Q. (2007). *Fast and slow twitch muscle fibers.* About.com. Retrieved on 2008-05-13.

Baggett, K. (2009). *Understanding muscle fiber types.* Bodybuilding.com. Retrieved on 2008-10-17.

Leyland, Tony (2008). Human power output and crossfit metcon workouts. *CrossFit Journal (71).*

Karp, J. R. (2010). *Muscle fiber types and training.* Coachr.org. Retrieved on 2008-10-17.

Unit 4 Roles of Agonists, Antagonists and Synergists

CONTENTS

1.0 Introduction

There are four different roles that a muscle can fulfil during movement, these roles are agonists, antagonists, synergists andfixators.

2.0 Intended Learning Outcome(s)

By the end of this unit, you willbe able to:

- discuss the interactions of skeletal muscles in the body
- describe the roles of agonists, antagonists and synergists

3.0 Main Content

3.1 Interactions of Skeletal Muscles in the Body

The moveable end of the muscle that attaches to the bone being pulled is called the muscle's insertion, and the end of the muscle attached to a fixed (stabilized) bone is called the origin.
Although a number of muscles may be involved in an action, the principal muscle involved is called the primemover, or agonist. During forearm flexion**,** for example lifting a cup, a muscle called the biceps brachii is the prime mover. Because it can be assisted by the brachialis, the brachialis is called a synergist in this action. A synergist can also be a fixator that stabilizes the muscle's origin.
Muscles usually work in pairs or groups, e.g. the biceps flexes the elbow and the triceps extends it.

This is called antagonistic muscle action. The working muscle is called the prime mover or agonist. (It's in agony!) The relaxing muscle is the antagonist. The other main pair of muscle that work together are the quadriceps and hamstrings.

The prime mover is helped by other muscles called synergists. Synergists muscles contracts at the same time as the prime mover. They hold the body in position so that the prime mover can work smoothly.
When muscles cause a limb to move through the joint's range of motion, they usually act in the following cooperating groups:

Agonists

Agonistsmuscles cause the movement to occur. They create the normal range of movement in a joint by contraction. Agonists are also referred to as prime movers since they are the muscles that are primarily responsible for generating the movement.

Antagonists

Antagonists muscles act in opposition to the movement generated by the agonists and are responsible for returning a limb to its initial position.

Synergists

Synergists muscles perform, or assist in performing, the same set of joint motion as the agonists. Synergists are sometimes referred to as neutralizers because they help cancel out, or neutralize, extra motion from the agonists to make sure that the force generated works within the desired plane of motion.

Fixators

Fixatorsmuscles provide the necessary support to assist in holding the rest of the body in place while the movement occurs. Fixators are also sometimes called stabilizers.

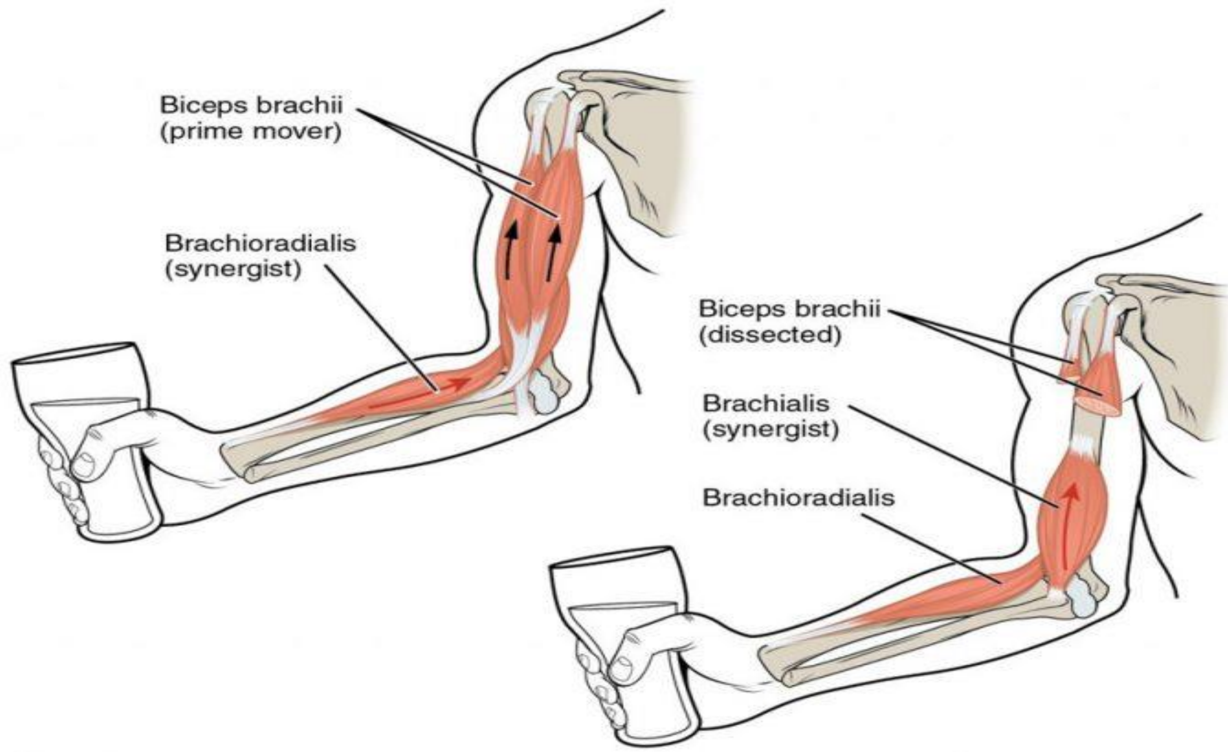


Fig. 1 – Prime Movers and Synergists: The biceps brachii flex the lower arm. The brachoradialis, in the forearm, and brachialis, located deep to the biceps in the upper arm, are both synergists that aid in this motion.

4.0 Self-Assessment Exercise

50. The moveable end of the muscle that attaches to the bone being pulled is called the **(a) muscle's** insertion (b) origin (c) agonist (d) flexion. ANS (A)

51. When muscles act in opposition to the movement generated by the agonists and are responsible for returning a limb to its initial position is called (a) *agonists* (b) *antagonists* (c) *synergists* (d) *fixators* . ANS (B)

52. Agonists are also referred to as (a) *synergists* (b) *fixators* (c)*prime movers(d) stabilizers* ANS (C)

53. Fixators are also sometimes called (a) *neutralizers* (b) *fixators* (c) *stabilizers* (d)*stabilizers.* ANS (D)

5.0 Conclusion

Usually, the muscles that are directly involved in producing a certain joint movement are called agonists and muscles that are indirectly involved, by some other role, are called synergists. However, even if a muscle adds directly to a joint's movement by adding its own torque, it can still correctly be called a synergist. Other muscles, such as stabilizers, neutralizers, and fixators, that help the movement by opposing unwanted movement or by helping to stabilize the joint are also synergists. So, the word synergists is not a very useful word, in itself, when describing muscular roles since it is much too inclusive, and the way it is used is contradictory to its definition as it excludes muscles that could rightly be called synergists by their synergistic role in a joint movement. This happens when all the muscles involved in a movement besides the primemovers are termed synergists as if the prime movers themselves are not synergists. These muscles, which contribute to a movement indirectly could more clearly be called supporters.

6.0 Summary

The transarticular component is a parallel or horizontal component. It acts along the shaft of the bone and may produce a force that pulls the bone away from the joint or toward it, depending on the angle of the joint. This component, therefore, is also known as either a stabilizing component or a destabilizing component. When the component is stabilizing it is also known as a shunt component and shunt muscles are muscles that tend pull the bones of a joint together.

7.0 References/Further Reading

Whiting, W. C., &Stuart R. (2006). Muscular control of movement and movement assessment.*Dynatomy: Dynamic human anatomy*. Champaign, IL: Human Kinetics. 121. Print.

McGinnis, P. M. (2005). The muscular system. *Biomechanics of Sport and Exercise.* Champaign, IL: Human Kinetics. 259. Print.

Pitt-Brooke, J. &Heather, R. (2004). Musculoskeletal requirements for normal movements.*Rehabilitation of movement: Theoretical basis of clinical practice.* Edinburgh [etc.: W. B. Saunders. 97-99. Print.

Kulkarni, G. S. (2008). Muscle: Structure and function.*Textbook of orthopedics and trauma*. New Delhi: Jaypee Brothers. 79-80. Print.

Unit 5 Types of Muscle Contractions
CONTENTS

1.0 Introduction

Muscle contractions are classified according to the movements they cause and in fitness we are primarily concerned with the following types of contraction.

2.0 Intended Learning Outcome(s)

By the end of this unit, you willbe able to:

- differentiate the types of muscle contractions
- classify isotonic; concentric and eccentric isometric.

3.0 Main content

3.1 Types of Muscle Contractions

The contraction of a muscle does not necessarily imply that the muscle shortens; it only means that tension has been generated. Muscles can contract in the following ways:

3.1.1 Isotonic Contractions

Isotonic contractions are those which cause the muscle to change length as it contracts and causes movement of a body part. There are two types of Isotonic contraction can be either concentric or eccentric:

Concentric

Concentric contractions are those which cause the muscle to shorten as it contracts. An example is bending the elbow from straight to fully flexed, causing a concentric contraction of the Biceps Brachii muscle. Concentric contractions are the most common type of muscle contraction and occur frequently in daily and sporting activities.

Eccentric

Eccentric contractions are the opposite of concentric and occur when the muscle lengthens as it contracts. This occurs when lowering the dumbbell down in a bicep curl exercise. The muscle is still contracting to hold the weight all the way down but the bicep muscle is lengthening.
Another very common example is the quadriceps muscles at the front of the thigh when landing from a jump. As you land the thigh muscles and in particular the quad muscles at the front of the leg are strongly contracting but also lengthening at the same time. This type of contraction puts a lot of strain through the muscle and is commonly involved in muscle injuries. Plyometric training exercises (hopping and bounding) involve a lot of eccentric muscle contractions and can lead to severe muscles soreness (DOMS) if you overdo it too soon.

Isometric Contractions

Isometric contractions occur when there is no change in the length of the contracting muscle. This occurs when carrying an object in front of you as the weight of the object is pulling your arms down but your muscles are contracting to hold the object at the same level. Another example is when you grip something, such as a tennis racket. There is no movement in the joints of the hand, but the muscles are contracting to provide a force sufficient enough to keep a steady hold on the racket.

The amount of force a muscle is able to produce during an isometric contraction depends on the length of the muscle at the point of contraction. Each muscle has an optimum length at which the maximum isometric force can be produced.

Isokinetic Contractions

Isokinetic contractions are similar to Isotonic in that the muscle changes length during the contraction, where they differ is that Isokinetic contractions produce movements of a constant speed. To measure this, a special piece of equipment known as an Isokinetic dynamometer is required. Examples of using Isokinetic contractions in day-to-day and sporting activities are rare. The best is breaststroke in swimming, where the water provides a constant, even resistance to the movement of adduction

4.0 Self-Assessment Exercise

54. When the muscle change length as it contracts and causes movement of a body part is called (a) isotonic (b) concentric (c) contraction(d) eccentric isometric. ANS (A)

55. ---------- is the opposite of concentric muscle and occur when the muscle lengthens as it contracts. Is called (a)isotonic (b) concentric (c) contraction(d) eccentric isometric. ANS (D)

5.0 Conclusion

Muscle fiber generates tension through the action of actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten, or remain the same. Although the term contraction implies shortening, when referring to the muscular system, it means muscle fibers generating tension with the help of motor neurons. Several types of muscle contractions occur and they are defined by the changes in the length of the muscle during contraction.

6.0 Summary

Muscle contraction is the activation of tension-generating sites within muscle fibers. In physiology, muscle contraction does not necessarily mean muscle shortening because muscle tension can be produced without changes in muscle length such as holding a heavy book or a dumbbell at the same position.

7.0 References/Further Reading

Widmaier, Eric P.,Raff, Hersel, & Strang, Kevin T. (2010). "Muscle". *Vander's human physiology: The mechanisms of body function.* (12th ed.). New York, NY: McGraw-Hill. pp. 250–291. ISBN 978-0-321-98122-6.

Silverthorn, Dee Unglaub (2016). "Muscles". *Human physiology: An integrated approach.* (7th ed.). San Francisco, CA: Pearson. pp. 377–416. ISBN 978-0-321-98122-6.

Aidley, David J. (1998). Mechanics and energetics of muscular contraction. *The physiology of excitable cells* (4th ed.). New York, NY: Cambridge University Press. pp. 323–335. ISBN 978-0-521-57421-1.

Sircar, Sabyasachi (2008). Muscle elasticity. *Principles of medical physiology*. (1st ed.). New York, NY: Thieme. p. 113. ISBN 978-1-588-90572-7.

Bullock, John; Boyle, Joseph; &Wang, Michael B. (2001). Muscle contraction. *NMS Physiology*. **578** (4th ed.). Baltimore, Maryland: Lippincott Williams and Wilkins. pp. 37–56.

Module 4 Analysis of Movement
Introduction

Unit 1 Joints
Contents
1.0 Introduction
Joints, responsible for movement and stability of the skeleton, can be classified based on structure or function. Synovial joints allow for many types of movement including gliding, angular, rotational, and special movements.

2.0 Intended Learning Outcome(s)
By the end of this unit, you willbe able to:
• classifyjoints to: fibrous, cartilaginous and synovial.
• highlight different types of joints
• appraise how joint types are linked in movement patterns when analysing sporting activities.

3.0 Main Content
3.1 Classification of Joints: Fibrous, Cartilaginous and Synovial

A joint, also called an articulation, is any place where adjacent bones or bone and cartilage come together (articulate with each other) to form a connection. Joints are classified both structurally and functionally. Structural classifications of joints take into account whether the adjacent bones are strongly anchored to each other by fibrous connective tissue or cartilage, or whether the adjacent bones articulate with each other within a fluid-filled space called a joint cavity. Functional classifications describe the degree of movement available between the bones, ranging from immobile, to slightly mobile, to freely moveable joints. The amount of movement available at a particular joint of the body is related to the functional requirements for that joint. Thus immobile or slightly moveable joints serve to protect internal organs, give stability to the body, and allow for limited body movement. In contrast, freely moveable joints allow for much more extensive movements of the body and limbs.

3.2 Structural Classification of Joints

The structural classification of joints is based on whether the articulating surfaces of the adjacent bones are directly connected by fibrous connective tissue or cartilage, or whether the articulating surfaces contact each other within a fluid-filled joint cavity. These differences serve to divide the joints of the body into three structural classifications. A fibrous joint is where the adjacent bones are united by fibrous connective tissue. At a cartilaginous joint, the bones are joined by hyaline cartilage or fibrocartilage. At a synovial joint, the articulating surfaces of the bones are not directly connected, but instead come into contact with each other within a joint cavity that is filled with a lubricating fluid. Synovial joints allow for free movement between the bones and are the most common joints of the body.

3.2.1 Fibrous Joint
The fibrous joint, the adjacent bones are directly connected to each other by fibrous connective tissue, and thus the bones do not have a joint cavity between them (Figure 1). The fibers joining

the bones may be short or long, thus the gap between bones at fibrous joints vary from narrow to wide. There are three types of fibrous joints. A suture is the narrow fibrous joint found between most bones of the skull. At a syndesmosis, the bones are more widely separated but are held together by a strap of fibrous connective tissue called **a** ligament or a wide sheet of connective tissue called an interosseous membrane. This type of fibrous joint is found between the shaft regions of the long bones in the forearm and in the leg. Lastly, a gomphosis is the narrow fibrous joint between the roots of a tooth and the bony socket in the jaw into which the tooth fits.

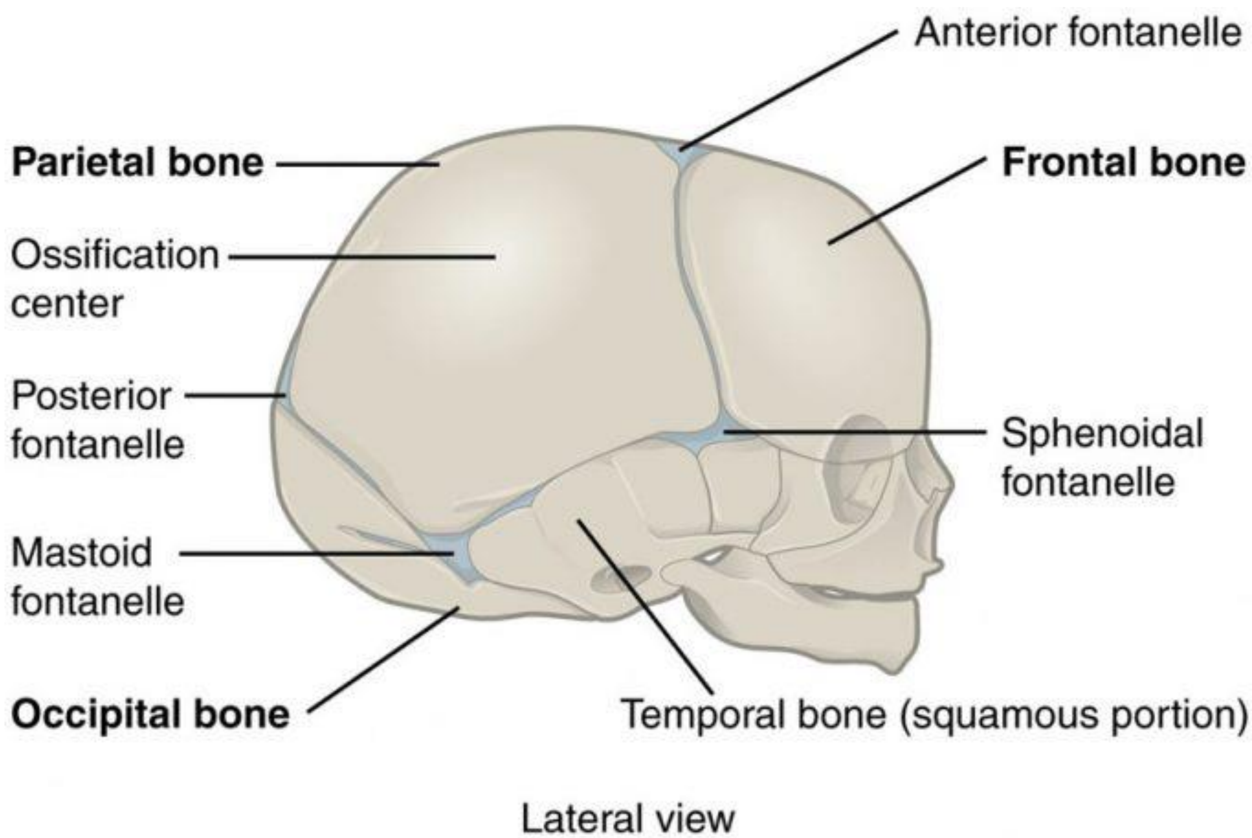


Fig. 1: Cavity

3.2.2 Cartilaginous Joint

As the name indicates, at a cartilaginous joint, the adjacent bones are united by cartilage, a tough but somewhat flexible type of connective tissue. These types of joints lack a joint cavity and involve bones that are joined together by either hyaline cartilage or fibrocartilage (Figure 1). There are two types of cartilaginous joints. A synchondrosis is a cartilaginous joint where the bones are joined by hyaline cartilage, or where a bone is united to hyaline cartilage. The second type of cartilaginous joint is a symphysis, where the bones are joined by fibrocartilage.

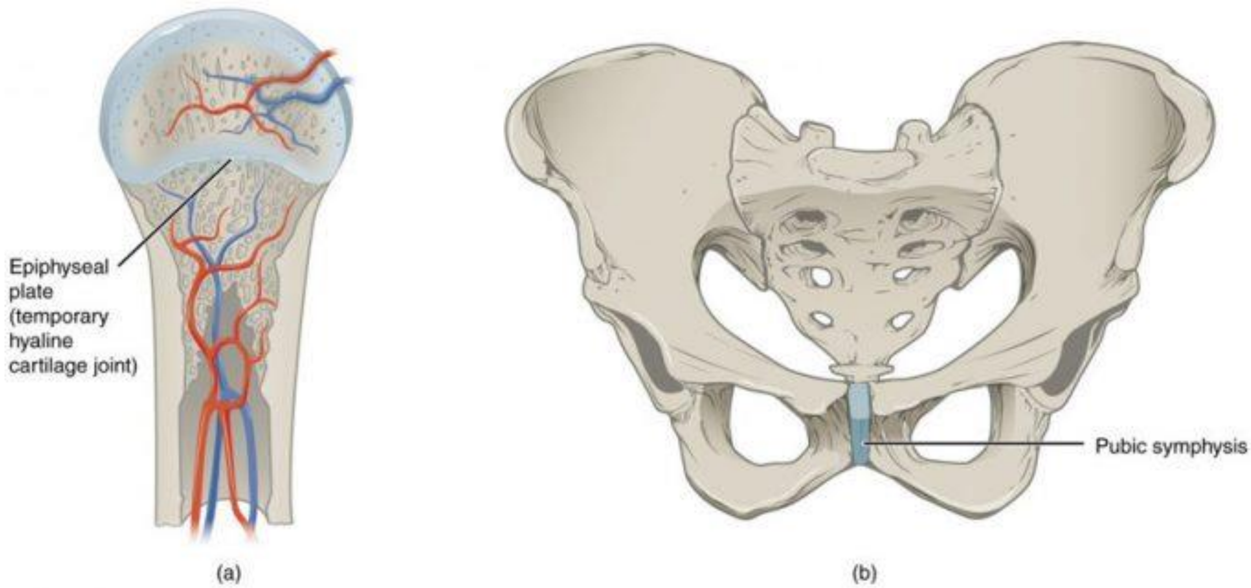


Fig.2: Cartilaginous Joints

At cartilaginous joints, bones are united by hyaline cartilage to form a synchondrosis or by fibrocartilage to form a symphysis. (a) The hyaline cartilage of the epiphyseal plate (growth plate) forms a synchondrosis that unites the shaft (diaphysis) and end (epiphysis) of a long bone and allows the bone to grow in length. (b) The pubic portions of the right and left hip bones of the pelvis are joined together by fibrocartilage, forming the pubic symphysis.

3.2.3 Synovial joint

Synovial joints are the most common type of joint in the body. A key structural characteristic for a synovial joint that is not seen at fibrous or cartilaginous joints is the presence of a joint cavity. This fluid-filled space is the site at which the articulating surfaces of the bones contact each other. At synovial joints, the articular surfaces of bones are covered with smooth articular cartilage. This gives the bones of a synovial joint the ability to move smoothly against each other, allowing for increased joint mobility.

Types of joints: hinge, pivot, ball and socket, gliding and ellipsoidSynovial joints are subdivided based on the shapes of the articulating surfaces of the bones that form each joint. The six types of synovial joints are pivot, hinge, condyloid, saddle, plane, and ball-and socket-joints (Figure 2).

3.2.4 Pivot Joint

At a **pivot joint**, a rounded portion of a bone is enclosed within a ring formed partially by the articulation with another bone and partially by a ligament (see Figure 9.43**a**). The bone rotates within this ring. Since the rotation is around a single axis, pivot joints are functionally classified as a uniaxial diarthrosis type of joint. An example of a pivot joint is the atlantoaxial joint, found between the C1 (atlas) and C2 (axis) vertebrae. Here, the upward projecting dens of the axis articulates with the inner aspect of the atlas, where it is held in place by a ligament. Rotation at this joint allows you to turn your head from side to side. A second pivot joint is found at the proximal radioulnar joint. Here, the head of the radius is largely encircled by a ligament that holds it in place as it articulates with the radial notch of the ulna. Rotation of the radius allows for forearm movements.

3.2.5 Hinge Joint

In a **hinge joint**, the convex end of one bone articulates with the concave end of the adjoining bone (see Figure 1). This type of joint allows only for bending and straightening motions along a single axis, and thus hinge joints are functionally classified as uniaxial joints. A good example is the elbow joint, with the articulation between the trochlea of the humerus and the trochlear notch of the ulna. Other hinge joints of the body include the knee, ankle, and interphalangeal joints between the phalanges of the fingers and toes.

3.2.6 Condyloid Joint

At a **condyloid joint** (ellipsoid joint), the shallow depression at the end of one bone articulates with a rounded structure from an adjacent bone or bones (see Figure 1). The knuckle (metacarpophalangeal) joints of the hand between the distal end of a metacarpal bone and the proximal phalanx are condyloid joints. Another example is the radiocarpal joint of the wrist, between the shallow depression at the distal end of the radius bone and the rounded scaphoid, lunate, and triquetrum carpal bones. In this case, the articulation area has a more oval (elliptical) shape. Functionally, condyloid joints are biaxial joints that allow for two planes of movement. One movement involves the bending and straightening of the fingers or the anterior-posterior movements of the hand. The second movement is a side-to-side movement, which allows you to spread your fingers apart and bring them together, or to move your hand in a medial or lateral direction.

3.2.7 Saddle Joint

At a **saddle joint**, both of the articulating surfaces for the bones have a saddle shape, which is concave in one direction and convex in the other (see Figure 3). This allows the two bones to fit together like a rider sitting on a saddle. Saddle joints are functionally classified as biaxial joints. The primary example is the first carpometacarpal joint, between the trapezium (a carpal bone) and the first metacarpal bone at the base of the thumb. This joint provides the thumb the ability to move away from the palm of the hand along two planes. Thus, the thumb can move within the same plane as the palm of the hand, or it can jut out anteriorly, perpendicular to the palm. This movement of the first carpometacarpal joint is what gives humans their distinctive “opposable” thumbs. The sternoclavicular joint is also classified as a saddle joint.

3.2.8 Plane Joint

At a **plane joint** (gliding joint), the articulating surfaces of the bones are flat or slightly curved and of approximately the same size, which allows the bones to slide against each other (see Figure 9.43**d**). The motion at this type of joint is usually small and tightly constrained by surrounding ligaments. Based only on their shape, plane joints can allow multiple movements, including rotation and can be functionally classified as a multiaxial joint. However, not all of these movements are available to every plane joint due to limitations placed on it by ligaments or neighboring bones. Depending upon the specific joint of the body, a plane joint may exhibit movement in a single plane or in multiple planes. Plane joints are found between the carpal bones (intercarpal joints) of the wrist or tarsal bones (intertarsal joints) of the foot, between the clavicle and acromion of the scapula (acromioclavicular joint), and between the superior and inferior articular processes of adjacent vertebrae (zygapophysial joints).

3.2.9 Ball-and-Socket Joint

The joint with the greatest range of motion is the **ball-and-socket joint**. At these joints, the rounded head of one bone (the ball) fits into the concave articulation (the socket) of the adjacent bone (see Figure 9.43**f**). The hip joint and the glenohumeral (shoulder) joint are the only ball-and-socket joints of the body. At the hip joint, the head of the femur articulates with the acetabulum of the hip bone, and at the shoulder joint, the head of the humerus articulates with the glenoid cavity of the scapula.

Ball-and-socket joints are classified functionally as multiaxial joints. The femur and the humerus are able to move in both anterior-posterior and medial-lateral directions and they can also rotate around their long axis. The shallow socket formed by the glenoid cavity allows the shoulder joint an extensive range of motion. In contrast, the deep socket of the acetabulum and the strong supporting ligaments of the hip joint serve to constrain movements of the femur, reflecting the need for stability and weight-bearing ability at the hip

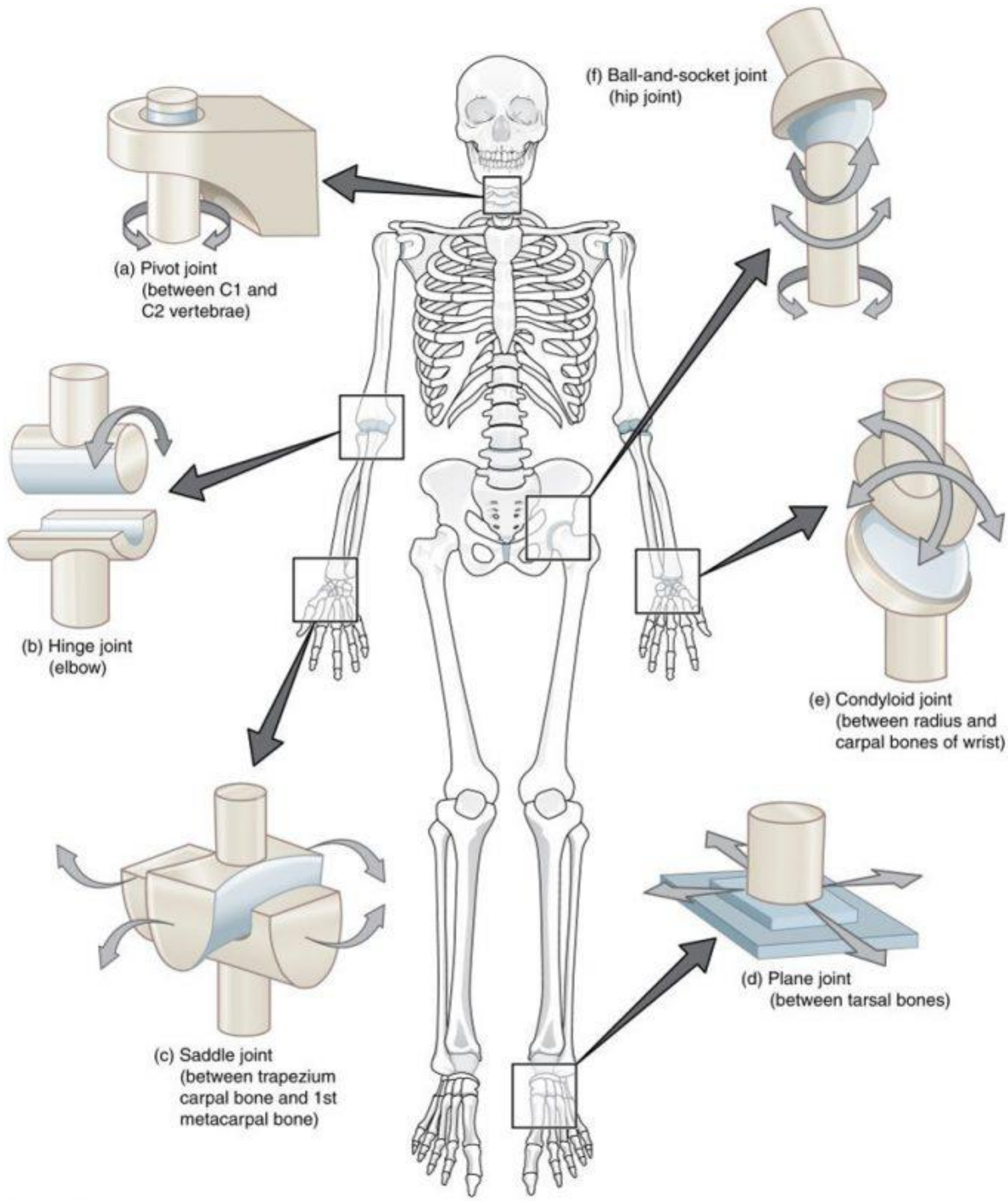


Fig.3: Types of Synovial Joints: The six types of synovial joints allow the body to move in a variety of ways. (a) Pivot joints allow for rotation around an axis, such as between the first and second cervical vertebrae, which allows for side-to-side rotation of the head. (b) The hinge joint of the elbow works like a door hinge. (c) The articulation between the trapezium carpal bone and the first metacarpal bone at the base of the thumb is a saddle joint. (d) Plane joints, such as those between the tarsal bones of the foot, allow for limited gliding movements between bones. (e) The

radiocarpal joint of the wrist is a condyloid joint. (f) The hip and shoulder joints are the only ball-and-socket joints of the body.

3.3 How Joint Types are Linked Movement Patterns when Analysing Sporting Activities

3.3.1 Flexion and Extension

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

For the upper limb, all anterior motions are flexion and all posterior motions are extension. These include anterior-posterior movements of the arm at the shoulder, the forearm at the elbow, the hand at the wrist, and the fingers at the metacarpophalangeal and interphalangeal joints. For the thumb, extension moves the thumb away from the palm of the hand, within the same plane as the palm, while flexion brings the thumb back against the index finger or into the palm. These motions take place at the first carpometacarpal joint. In the lower limb, bringing the thigh forward and upward is flexion at the hip joint, while any posterior-going motion of the thigh is extension. Note that extension of the thigh beyond the anatomical (standing) position is greatly limited by the ligaments that support the hip joint. Knee flexion is the bending of the knee to bring the foot toward the posterior thigh, and extension is the straightening of the knee. Flexion and extension movements are seen at the hinge, condyloid, saddle, and ball-and-socket joints of the limbs (see Figure 3a-d).

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

3.3.2 Abduction and Adduction

Abduction and adduction motions occur within the coronal plane and involve medial-lateral motions of the limbs, fingers, toes, or thumb. Abduction moves the limb laterally away from the midline of the body, while adduction is the opposing movement that brings the limb toward the body or across the midline. For example, abduction is raising the arm at the shoulder joint, moving it laterally away from the body, while adduction brings the arm down to the side of the body. Similarly, abduction and adduction at the wrist moves the hand away from or toward the midline of the body. Spreading the fingers or toes apart is also abduction, while bringing the fingers or toes together is adduction. For the thumb, abduction is the anterior movement that brings the thumb to a 90° perpendicular position, pointing straight out from the palm. Adduction moves the thumb back to the anatomical position, next to the index finger. Abduction and adduction movements are seen at condyloid, saddle, and ball-and-socket joints (see Figure 3**e**).

3.3.3 Circumduction

Circumduction is the movement of a body region in a circular manner, in which one end of the body region being moved stays relatively stationary while the other end describes a circle. It involves the sequential combination of flexion, adduction, extension, and abduction at a joint. This type of motion is found at biaxial condyloid and saddle joints, and at multiaxial ball-and-sockets joints (see Figure 3**e**).

3.3.4 Rotation

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

Rotation can also occur at the ball-and-socket joints of the shoulder and hip. Here, the humerus and femur rotate around their long axis, which moves the anterior surface of the arm or thigh either toward or away from the midline of the body. Movement that brings the anterior surface of the limb toward the midline of the body is called medial (internal) rotation. Conversely, rotation of the limb so that the anterior surface moves away from the midline is lateral (external) rotation (see Figure 3**f**). Be sure to distinguish medial and lateral rotation, which can only occur at the multiaxial shoulder and hip joints, from circumduction, which can occur at either biaxial or multiaxial joints.

3.3.5 Supination and Pronation

Supination and pronation are movements of the forearm. In the anatomical position, the upper limb is held next to the body with the palm facing forward. This is the supinated position of the forearm. In this position, the radius and ulna are parallel to each other. When the palm of the hand faces backward, the forearm is in the pronatedposition, and the radius and ulna form an X-shape.
Supination and pronation are the movements of the forearm that go between these two positions. Pronation is the motion that moves the forearm from the supinated (anatomical) position to the pronated (palm backward) position. This motion is produced by rotation of the radius at the proximal radioulnar joint, accompanied by movement of the radius at the distal radioulnar joint. The proximal radioulnar joint is a pivot joint that allows for rotation of the head of the radius. Because of the slight curvature of the shaft of the radius, this rotation causes the distal end of the radius to cross over the distal ulna at the distal radioulnar joint. This crossing over brings the radius

and ulna into an X-shape position.Supination is the opposite motion, in which rotation of the radius returns the bones to their parallel positions and moves the palm to the anterior facing (supinated) position. It helps to remember that supination is the motion you use when scooping up soup with a spoon (see Figure 3g**)**.

3.3.6 Dorsiflexion and Plantar Flexion

Dorsiflexion and **plantar flexion** are movements at the ankle joint, which is a hinge joint. Lifting the front of the foot, so that the top of the foot moves toward the anterior leg is dorsiflexion, while lifting the heel of the foot from the ground or pointing the toes downward is plantar flexion. These are the only movements available at the ankle joint (see Figure 3**h**).

3.3.7 Inversion and Eversion

Inversion and eversion are complex movements that involve the multiple plane joints among the tarsal bones of the posterior foot (intertarsal joints) and thus are not motions that take place at the ankle joint. Inversion is the turning of the foot to angle the bottom of the foot toward the midline, while eversion turns the bottom of the foot away from the midline. The foot has a greater range of inversion than eversion motion. These are important motions that help to stabilize the foot when walking or running on an uneven surface and aid in the quick side-to-side changes in direction used during active sports such as basketball, racquetball, or soccer (see Figure 9.52**i**).

3.3.8 Protraction and Retraction

Protraction and retraction are anterior-posterior movements of the scapula or mandible. Protraction of the scapula occurs when the shoulder is moved forward, as when pushing against something or throwing a ball. Retraction is the opposite motion, with the scapula being pulled posteriorly and medially, toward the vertebral column. For the mandible, protraction occurs when the lower jaw is pushed forward, to stick out the chin, while retraction pulls the lower jaw backward. (See Figure 9.52**j**.)

3.3.9 Depression and Elevation

Depression and elevation are downward and upward movements of the scapula or mandible. The upward movement of the scapula and shoulder is elevation, while a downward movement is depression. These movements are used to shrug your shoulders. Similarly, elevation of the mandible is the upward movement of the lower jaw used to close the mouth or bite on something, and depression is the downward movement that produces opening of the mouth (see Figure 9.52**k**).

3.3.10 Excursion

Excursion is the side to side movement of the mandible. Laterbalexcbbursion moves the mandible away from the midline, toward either the right or left side. Medialexcursion returns the mandible to its resting position at the midline.

3.3.11 Superior Rotation and Inferior Rotation

Superior and inferior rotation are movements of the scapula and are defined by the direction of movement of the glenoid cavity. These motions involve rotation of the scapula around a point inferior to the scapular spine and are produced by combinations of muscles acting on the scapula. During superiorrotation, the glenoid cavity moves upward as the medial end of the scapular spine moves downward. This is a very important motion that contributes to upper limb abduction. Without superior rotation of the scapula, the greater tubercle of the humerus would hit the acromion of the scapula, thus preventing any abduction of the arm above shoulder height. Superior rotation of the scapula is thus required for full abduction of the upper limb. Superior rotation is also used without arm abduction when carrying a heavy load with your hand or on your shoulder. You can feel this rotation when you pick up a load, such as a heavy book bag and carry it on only one shoulder. To increase its weight-bearing support for the bag, the shoulder lifts as the scapula superiorly rotates. Inferiorrotation occurs during limb adduction and involves the downward motion of the glenoid cavity with upward movement of the medial end of the scapular spine.

3.3.12 Opposition and Reposition

Opposition is the thumb movement that brings the tip of the thumb in contact with the tip of a finger. This movement is produced at the first carpometacarpal joint, which is a saddle joint formed between the trapezium carpal bone and the first metacarpal bone. Thumb opposition is produced by a combination of flexion and abduction of the thumb at this joint. Returning the thumb to its anatomical position next to the index finger is called reposition (see Figure 3**l**)

4.0 Self-Assessment Exercise

56. Which of the following is an example of bi-axial joint? (a) hinge(b) pivot(c) both (a) and (b) (d) none of the above. ANS (D)

57. Synovial joins are (a) slightly movable(b) freely movable(c) both (a) and (b) (d) none of the above. ANS (B)
58. The movement around ball and socket joints are (a) flexion and extension (b) rotation and circumduction (c) hyper extension (d) all of the above ANS(B)

5.0 Conclusion

The point at which two or more bones meet is called a joint or articulation. Joints are responsible for movement (e.g., the movement of limbs) and stability (e.g., the stability found in the bones of the skull). There are two ways to classify joints: on the basis of their structure or on the basis of their function. The structural classification divides joints into fibrous, cartilaginous, and synovial joints depending on the material composing the joint and the presence or absence of a cavity in the joint. The functional classification divides joints into three categories: synarthroses, amphiarthroses, and diarthroses. And special movements are all the other movements that cannot be classified as gliding, angular, or rotational; these movements include inversion, eversion, protraction, and retraction.

5.0 Summary

Synovial joints are further classified into six different categories on the basis of the shape and structure of the joint. The shape of the joint affects the type of movement permitted by the joint. These joints can be described as planar, hinge, pivot, condyloid, saddle, or ball-and-socket joints.

6.0 References/Further Readings

Whiting, W.C.&RuggDynatomy, S.(2006).*Dynamic human anatomy,* Volume 10 p.40

"Articulation definition". eMedicine Dictionary. 30 October 2013. Retrieved 18 November 2013.

Platzer, Werner (2008).*Color atlas of human anatomy,* Volume 1

Standing, Susan (Ed). (2006). *Gray's anatomy : The anatomical basis of clinical practice.* (39th ed.). Edinburgh: Elsevier Churchill Livingstone. p. 38. ISBN 0-443-07168-3

Saladin, Ken. (n. d.). *Anatomy & Physiology*. (7th ed.). McGraw-Hill Connect. Web. p.274

Marieb, Elaine Nicpon,&Hoehn, Katja. (2012). *Human anatomy &physiology*. Boston: Pearson, Ch.8

Unit 2 Planes of Movement and Axes of Rotation

Contents

1.0 Introduction

Human movements are described in three dimensions based on a series of planes and axis. There are three planes of motion that pass through the human body.Movement at ajoint takesplace in a plane about an axis

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you willbe able to:

- discussthe planes and axes of movement
- name and describe all of the principal movements in those planes in sport and exercise.

3.0 Main Content

Planes of movement including: Frontal, sagittal and horizontal/transverse planes of the body; sporting examples and patterns that occur along planes

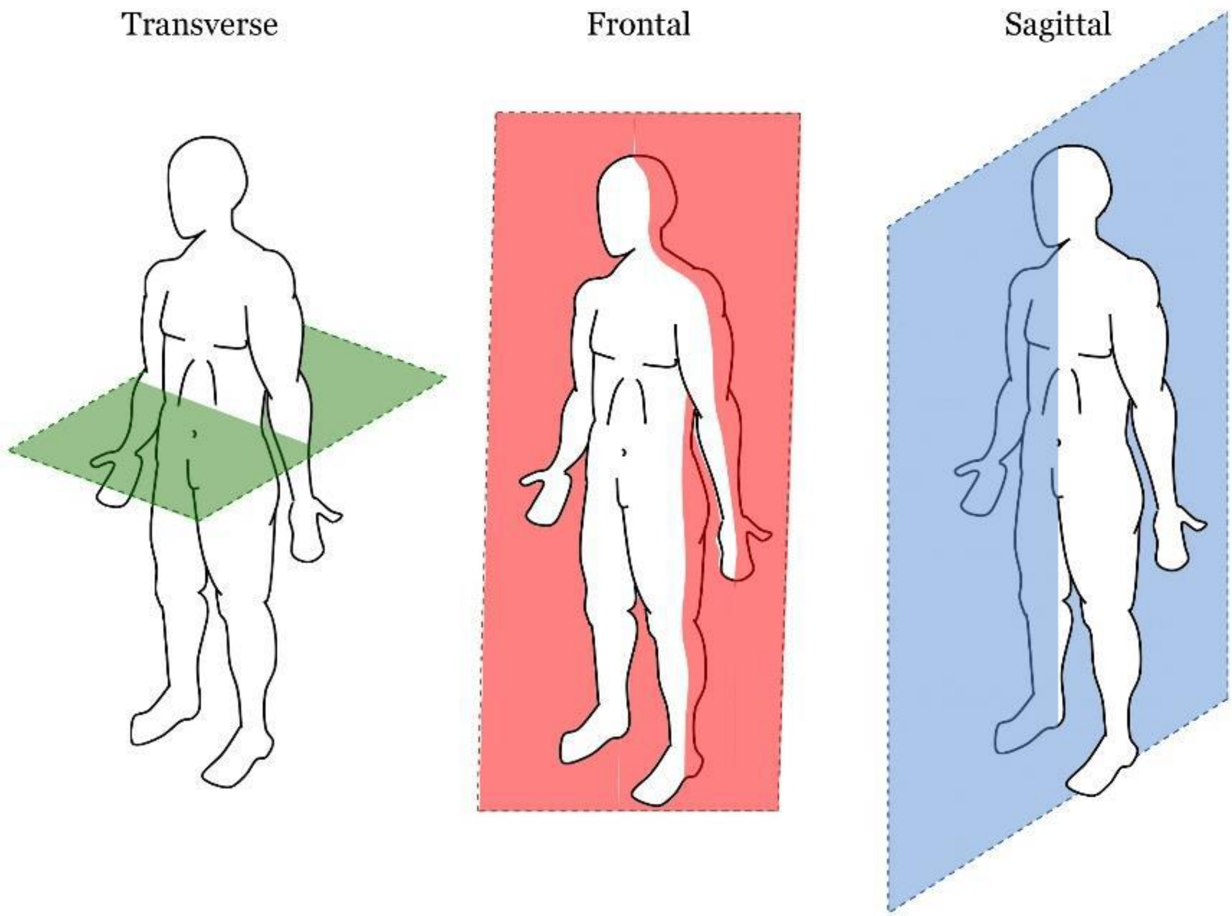
3.1 Planes of Movement

All body movements occur in different planes and around different axes. A plane is an imaginary flat surface running through the body. An axis is an imaginary line at right angles to the plane, about which the body rotates or spins.

There are three planes of movement:

1. **Sagittal plane** - a vertical plane that divides the body into left and right sides. Flexion and extension types of movement occur in this plane, eg kicking a football, chest pass in netball, walking, jumping, squatting.
2. **Frontal plane** - passes from side to side and divides the body into the front and back. Abduction and adduction movements occur in this plane, eg jumping jack exercises, raising and lowering arms and legs sideways, cartwheel.

3. **Transverse plane** - passes through the middle of the body and divides the body horizontally in an upper and lower half. Rotation types of movement occur in this plane, eg hip rotation in a golf swing, twisting in a discus throw, pivoting in netball, spinning in skating.



3.2 Axes of Movement

There are three axes of movement around which the body or body parts rotate:

1. **Frontal axis** - this line runs from left to right through the centre of the body. For example, when a person performs a somersault they rotate around this axis.
2. **Sagittal (also known as the antero-posterior) axis** - this line runs from front to back through the centre of the body. For example, when a person performs a cartwheel they are rotating about the sagittal axis.
3. **Vertical axis** - this line runs from top to bottom through the centre of the body. For example, when a skater performs a spin they are rotating around the vertical axis.

4.0 Self-Assessment Exercise

1. Define the planes and axes of movement
2. Describe all of the principal movements in those planes in sport and exercise.

Answers

5.0 Conclusion

When describing anatomical motion, these planes describe the axis along which an action is performed. So by moving through the transverse plane, movement travels from head to toe. For example, if a person jumped directly up and then down, their body would be moving through the transverse plane in the coronal and sagittal planes.

6.0 Summary

There are three planes of motion in which we move. If you think about it, most of our movements are not straight up and down, or side to side etc, especially in sports. They tend to combine a mixture of movements in different planes and axes.

7.0 References/Further Reading

Tim Huffines. Anatomical position and cardinal planes. Available from: http://www.youtube.com/watch?v=aDxfe5Ny6zM[last accessed 22/02/13]

Physiotutors. Anatomical Planes & Axes Explained. Published on July 15, 2016. Available from: https://www.youtube.com/watch?v=yq8cE-EDtuE. (last accessed 11 June 2019)

Axis of movement animation https://www.youtube.com/watch?v=iP7fpHuVaiA

Understanding planes and axes of movement (pdf) www.physical-solutions.co.uk/wp-content/uploads/2015/05/

Understanding-Planes-and-Axes-of-Movement.pdf

Understanding exercise – planes, axes and movement www.todaysfitnesstrainer.com/understanding-exercise-planes-axesmovement/

Unit 3 Components of a Lever System and 1st, 2nd and 3rd Order Levers
CONTENTS

1.0 Introduction

Levers are normally used to make physical work easier, for example, to make it easier to move something that is heavy, or to move something quickly. When we exercise most of our movements will involve the use of levers. For example, when we run, lift weights, kick or throw a ball, all of these actions will involve the use of levers. A lever system within the body would use a lever (bone) to move an object, for example, when we run we are the object being moved, but when kicking a ball, the object being moved is the ball.

2.0 Intended Learning Outcome(s) (ILOs)

By the end of this unit, you willbe able to:
• classify components of a lever system: pivot/fulcrum, effort and load/resistance.
• apply 1st, 2nd and 3rd order levers
- apply knowledge of levers to

sporting examples, e.g. 3rd order lever used for bicep curl.

3.0 Main Content

3.1 Components of a Lever System: Pivot/Fulcrum, Effort and Load/Resistance

Levers are normally used to make physical work easier, for example, to make it easier to move something that is heavy, or to move something quickly. When we exercise most of our movements will involve the use of levers. For example, when we run, lift weights, kick or throw a ball, all of these actions will involve the use of levers. A lever system within the body would use a lever (bone) to move an object, for example, when we run
we are the object being moved, but when kicking a ball, the object being moved is the ball.

All lever systems are made up of four components:

- the load
- the fulcrum
- the effort
- the lever.

The load is the object requiring moving, the effort is the muscular force we use to move the object, the fulcrum is the joint around which the movement occurs and the bones of the skeleton are the levers. If asked to sketch a diagram of a lever system, you would need to include all four parts. To get the idea, we can use non-sporting examples of lever systems:
A. Imagine a road is blocked with a fallen tree. A tree would be too heavy to lift, but a person could move the tree a little by using a lever system. By placing one end of a long length of wood under the fallen tree and then pushing down on the other end of the wood, the fallen tree could be moved.
B. Wheelbarrows are used to move heavy objects more easily. The heavy object is placed in the wheelbarrow and then the handles lifted to push the wheelbarrow containing the heavy object.

1st, 2nd and 3rd order levers. Learners apply their knowledge of levers to sporting examples, e.g. 3rd order lever used for bicep curl

3.2 First Class Levers

First class lever systems are arranged so that the fulcrum is between the effort and the load (see Figure 7.2). This is the arrangement of a first class lever system. Example A (see p xx) of the fallen tree would use a first class lever system: the tree would be the load, the end of the wooden bar under the tree would be the fulcrum and the effort would be the muscular force applied to the other end of the wooden bar. If you were to sketch this lever system, which way would the arrow, that represents the effort, point?There are a limited number of examples of first class lever systems in the body. In the examples of levers given so far it has been clear to see where the effort is applied in relation to the other parts of the lever system. However, this is not always as clear when we look at lever systems within the body. For example, due to where the triceps attach to the elbow joint, elbow extension is considered to be use of a first class lever system. Further explanation of this can be left for level 3 Sport or PE courses; it is sufficient for you to appreciate that elbow extension involves a first class lever. (The elbow is the fulcrum, the effort is provided by the triceps due to their insertion point at the elbow and the load is whatever is being thrown, for example a javelin). Nodding of the head is another example of a first class lever system, important in sport when watching the flight of a ball for example; in this example the load would be the weight of the head.

3.3 Second Class Levers

The components of the second class lever system are arranged as shown in Figure 7.3. What component is at the centre of this lever system? Again there are limited examples of these lever systems in the body. The one with possibly the greatest application for sport is the second class lever system formed between the ball of the foot, the gastrocnemius and
the load of the bodyweight as we point our toes, or go onto our toes (the foot is the lever bar).

3.4 Third Class Levers

The final class of lever is shown in Figure 7.4. What is the component in the middle of this lever system? One way to remember the difference between each system is to remember the component in the middle of each one. A popular method is 1-2-3 = F-L-E. You can tell when it's a first class lever system as the fulcrum is in-between the other components; in the second class it is the load and in the third it is the effort. Load Effort Fulcrum Figure 7.3. Second class lever system Load Fulcrum Effort Figure 7.4 Third class lever system Third class lever systems are the most common in the body and therefore are involved in a lot of our movements. For example, a biceps curl uses a third class lever system, as does hitting a ball with a racket or bat, or at the knee when we kick a ball, or the hip when we run.

4.0 Self-Assessment Exercise

59. When the fulcrum of a lever is between the effort and the load is called (a) first class lever (b) second class lever(c) third class lever (d) all of the above. ANS (A)

60. Which type of lever is most effective in sport movement (a) third class (b) second class (c) first class (d) none of the above ANS(A)

5.0 Conclusion

The load is the object requiring moving, the effort is the muscular force we use to move the object, the fulcrum is the joint around which the movement occurs and the bones of the skeleton are the levers.

6.0 Summary

Understanding lever systems are a very important part of movement analysis. It helps to conceptualize the amount of effort force required for movement and also can determine the efficiency of static and dynamic positions. Once you determine the lever arm system, you can then begin to quantify moment and torque.

7.0 References/Further Reading

Davidovits, Paul (2008). "Chapter 1". *Physics in biology and medicine.*(3rd ed.). Academic Press. p. 10. ISBN 978-0-12-369411-9.

Uicker, John; Pennock, Gordon; &Shigley, Joseph (2010). *Theory of machines and mechanisms.* (4th ed.). Oxford University Press, USA. ISBN 978-0-19-537123-9.

Usher, A. P. (1929). *A history of mechanical inventions*. Harvard University Press (reprinted by Dover Publications 1988). p. 94. ISBN 978-0-486-14359-0. OCLC 514178. Retrieved 7 April 2013.