Chapter 9: Basic anatomy and biomechanics

by Wayne Spratford

Understanding the structure of the human body and how the body moves is important for coaches who are seeking to improve and develop their coaching. While coaches do not need to become experts on anatomy and biomechanics, developing an understanding of the principles involved in the structure and movement of the body will assist them in a number of ways, including:

- analysing athlete movements, and assisting the athlete to move more efficiently (for example, by changing a technique)
- understanding the effects of movement on the structure of the body, including prevention of sports injuries
- being able to communicate with sports medicine and sports science personnel regarding aspects of the athlete's body and movement (for example, treatment of injuries)
- selecting appropriate techniques and equipment for an individual athlete's size and level of development so that the best possible performance can be achieved.

What do we mean by anatomy and biomechanics?

Anatomy refers to the internal and external structures of the human body and their physical relationship with one another. This includes basic information on anatomical terminology, the skeletal system and the major skeletal muscles.

Biomechanics is the study of how and why the human body moves. Sport biomechanics help coaches to understand this body movement, how to identify and correct flaws in performance, and prepare athletes to learn new skills. It enables coaches to measure forces that come from inside the body (for example, muscles and tendons) or from outside the body (for example, gravity, water or friction).

Anatomical terminology

Coaches may initially be intimidated by some of the terminology associated with anatomy. Some anatomical terminology is used in everyday life, but other terms may be foreign to many coaches. Developing a basic level of knowledge of anatomical terminology will assist coaches in communicating with medical staff, in particular regarding the athletes.

Anatomical position

In order to describe body parts, a reference point is needed. This is called the anatomical position. It is from this position that all anatomical terminology relates, regardless of the body's actual position. The anatomical position refers to a person standing upright, arms by their side with palms facing forward and thumbs pointing away from the body.

Directional terms

This is an explanation of where one body part is in relation to another. The following table outlines some common directional terminology.

Table 9.1 Directional terms

Term	Definition	Example
Superior	Towards the head, above	The chest is superior to the pelvis
Inferior	Away from the head, below	The jaw is inferior to the eyes
Anterior	Towards or at the front of the body	The ribs are anterior to the shoulder blade
Posterior	Towards or at the back of the body	The spine is posterior to the ribs
Medial	Towards or at the midline of the body, on the inner side	The sternum is medial to the arm
Lateral	Away from the midline of the body, on the outer side	The thumb is lateral to the fingers
Proximal	Closer to the origin of the body part or the point of attachment of a limb	The wrist is proximal to the fingers
Distal	Further from the origin of the body part or the point of attachment of a limb	The elbow is distal to the shoulder
Superficial	Towards the surface	The skin is superficial to the skeletal bones
Deep	Away from the surface, more internal	The muscles are deep in relation to the skin

The skeletal system

The skeletal system is made up of 206 bones, as well as cartilages, ligaments and joints. It accounts for about 20 per cent of body mass.

The body's skeletal system performs five important functions:

- support — bones provide a framework, giving the body form and shape
- protection — bones provide protection for our vital organs, such as our central nervous system (the brain and spinal cord) which is completely enclosed in bone)
- movement — articulating bones act as levers enabling us to move
- mineral storage — calcium is the most abundant mineral in the human body. A typical human body contains 1–2 kilograms of calcium, 98 per cent of which can be found within the skeleton
- blood cell formation — red blood cells, white blood cells and other blood elements are produced within red marrow that fills the internal cavities of many bones

The major bones of the body are indicated on the following diagram.

Figure 9.1: Anterior view of the skeleton

Skull	Mandible	Metatarsals
Clavicle	Sternum	
Scapula	Humerus	
Ribs	Vertebra	
Radius	Illium	
Ulna	Ischium	
Metacarpals	Pelvis	
Femur	Pubis	
Fibula	Carpals	
Tarsals	Phalanges	
Phalanges	Patella	
Sacrum	Tibia	

Case study

Joanne coaches a squad of young female gymnasts who train 3–4 times a week and are competing at regional level. One of the girls in the squad, Shauna, who is 12 years old has been complaining of pain in her left shin when she lands. After a week of the pain continuing, Joanne spoke to Shauna's parents and recommended that they take her to a sports medicine physician. Joanne was concerned that it could be an overuse injury, such as a stress fracture. Joanne was keen to address the problem quickly, as Shauna is at a stage of intense bone growth where a small problem could turn into a big problem if not treated. Joanne will need to take advice from Shauna's physician in regard to changes needed to Shauna's training loads and types of training activities that are suitable during rehabilitation.

Joints

Joints exist wherever two bones, joined by ligaments, meet and are classified functionally as well as structurally into following three categories:

- fibrous — the ends of the bones are joined by fibrous tissue. No joint cavity is present and little or no movement exists. An example would be the joints of the skull and the joints of the teeth and jaw
- cartilaginous — mainly provide stability, with limited movement. Bones are connected by collagen fibres, cartilage or ligament. An example would be the discs of the vertebral column
- synovial — typically found at the end of long bones and permit a wide range of motion. An example would be the joints of the limbs such as shoulder, hip and knee.

Joint movements

All skeletal muscles are attached to bone, either directly or indirectly, by connective tissue at a minimum of two points. The following table describes the directional movements that take place at these joints.

Table 9.2: Movement terms

Terms	Definition
Extension	Increasing the angle at a joint

Flexion)	Decreasing the angle at a joint. Flexion of the foot at the ankle is called dorsi flexion
Hyperextension	Extension of a segment past the anatomical position
Abduction	Movement away from the body's midline
Adduction	Movement towards the body's midline
Dorsi flexion	Only occurs at the ankle and is the action of moving the toe towards the shin
Plantar flexion	Only occurs at the ankle and is the action of moving the toe towards the ground
Rotation	Movement about an axis, either medially (inward) or laterally (outward)
Circumduction	Moving a limb so that the end of the limb draws a circle
Supination	Moving the flexed forearm so that the palm of the hand is facing out
Pronation	Moving the flexed forearm so that the palm of the hand is facing down
Eversion	Rotation of the foot to turn the sole outwards
Inversion	Rotation of the foot to turn the sole inwards
Elevation	Moving a body part upwards
Depression	Moving a body part downwards
Opposition	This only occurs between the thumb and the fingers of the hand. The action occurs when you touch your thumb to the tips of the other fingers on the same hand

Figure 9.2: Extension

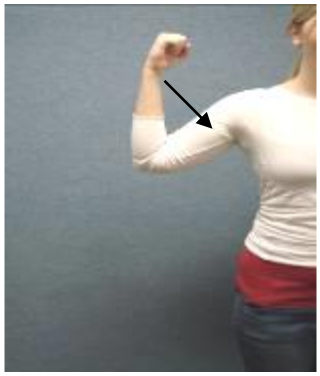


Figure 9.3: Flexion

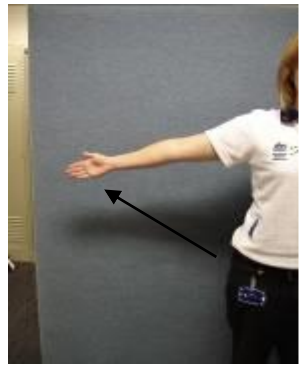


Figure 9.4: Abduction

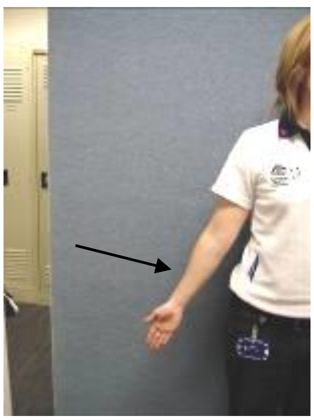


Figure 9.5: Adduction

Figure 9.6: Dorsi flexion

Figure 9.7: Plantar flexion

Figure 9.8: Supination

Figure 9.9: Pronation

Figure 9.10: Eversion

Figure 9.11: Inversion

Muscles

Types of muscles

The three types of muscle tissue found within the human body are:

- smooth muscle tissue —found in the walls of many internal organs and is involuntary (that is, contracts without voluntary control)
- cardiac muscle tissue —found only in the heart and is also involuntary
- skeletal muscle cells — make up our muscles and attach directly or indirectly (via tendons) to the skeleton.

Functions of muscles

Skeletal muscles have five main functions:

- producing movement — contracting muscles pull on tendons to move the bones of the skeleton
- maintaining posture — tensions in our skeletal muscles maintain posture. Without this constant muscle activity, sitting or standing would be impossible
- supporting soft tissues — muscles support the weight of internal organs and protect them from injury. These muscles may be located within areas such as the abdominal wall and the floor of the pelvic cavity

- protection — openings such as orifices in the digestive and urinary tracks are encircled by skeletal muscles. These muscles provide voluntary control over swallowing, defecation and urination
- maintaining temperature — muscle contractions require energy and whenever energy is used in the body some is converted to heat. The heat lost by muscles contracting keeps body temperature in the range required for normal functioning.

Major muscles

There are over 600 muscles in the human body. Some of the main muscles involved in gross motor activities are:

- abdominal (for example, external and internal oblique, rectus and transversus abdominus)
- shoulder girdle (for example, trapezius, rhomboids and the rotator group, comprising infraspinatus, supraspinatus, teres minor and subscapularis)
- arm (for example, pectoralis major, deltoid, biceps, triceps)
- upper leg (for example, gluteal, hamstrings, quadriceps)
- lower leg (for example, gastrocnemius, soleus, tibialis).

Case study

Jake coaches the reserves team for a rugby club that competes in a regional rugby competition. The team has a range of players, including some young up-and-comers, as well as some older players who are on the verge of retiring from playing at competitive level. Two of the older players have ongoing injury issues. One has a problem with the medial ligament in his knee, which has never fully recovered from surgery some years ago. The other has ongoing issues with his right hamstring, with a long history of strains and muscle tears. Jake spends some time discussing with these two players how to manage these injury issues. This includes looking at what specialised conditioning and treatment they need to prevent further injury, what type of training and competition load their bodies can handle, and what type of recovery activities they need so that they pull up okay after each training session and match. Jake seeks specialist help with some aspects that are outside his expertise (for example, he consults with a physiotherapist and massage therapist who are linked with the club for treatment and recovery assistance). With careful management, Jake is able to keep the two players injury free in their final year of competition, and the two players retire at the end of the season on a positive note.

What is biomechanics?

Biomechanics is the study of the forces that produce human motion and the effects of those forces on and within the human body. Forces can be internal, including those created by muscles and tendons, or external, including forces created by gravity, air, water or friction. Once the movement of the body performing a given task is understood and measured, it may then be possible to make changes to technique or equipment to improve performance or reduce the possibility of injury.

By understanding some of the basic principles of movement and forces, coaches can gain a better understanding of why certain movements create particular outcomes. It can also assist them in their analysis of athlete movement and help them to identify and correct performance flaws to produce better performances in the future. An understanding of biomechanics in sport enables each athlete to be coached as an individual, using techniques and equipment that are determined by the coach to be the most suitable for the athlete's unique requirements.

Biomechanical analysis considers movement in two different ways:

- kinematics — concerned with the motion of a body (how far, how fast or how consistently it moves)
- kinetics —concerned with what causes that movement and includes an analysis of the forces acting, momentum, torque and power.

Biomechanical principles

There are a number of scientific principles on which sports biomechanics is based, which include laws of physics and mechanics. While coaches do not need to become experts in the science of these principles, it is valuable to have a grasp of the concepts. The principles that will be covered in this chapter include motion, forces, levers and balance.

Laws of motion

Sir Isaac Newton formulated three laws of motion to explain what causes a body to move and the motion that results. An understanding of these basic principles helps in the knowledge of movement or motion.

1 The law of inertia

A body will remain at rest or it will travel in a straight line at a constant velocity unless a force acts on it to change its state of rest or motion.

If something needs to be moved we must first overcome its inertia (an object's resistance to change). This resistance is directly proportional to the mass of the object. The heavier the object, the greater the resistance, and the harder the object is to move.

2 The law of acceleration

The acceleration of a body is directly proportional to the amount of force used.

The heavier an object, the more force is needed to move it. To move the same object faster, even more force is needed. For example, with a small light ball, such as a tennis ball, the larger the force applied to it, the greater the acceleration. If the force applied remained the same, but a bigger, heavier ball such as a basketball was used, it would experience less acceleration.

3 The law of action and reaction

For every action there is an equal and opposite reaction.

When a runner pushes down against the ground they exert a downwards and backwards force (action). In turn, the ground exerts the same force upwards and forwards against the runner's foot (reaction).

Body motion

Motion is the process of changing position. All physical activities involve motion of the human body. Motion can be:

- linear — where the body's centre of gravity moves along a straight line and all the body parts travel in the same direction, over the same distance and in the same time. An example of this is an ice-skating glide
- curvilinear — where an object or the body follows a curved line. This can be seen in the flight of a gymnast somersaulting through the air, or a ball after a kick
- angular or rotary — movement around a fixed point, as is seen in most of the joints in the skeleton. For example, when a ball is kicked the femur rotates around the hip joint and the tibia rotates around the knee joint, giving angular motion.

In general, angular motion occurs more often than linear but a combination of the two is the most common. For example, when walking, the body's centre of gravity may move in a linear direction or a straight line, but at the same time movement at the hips, knees, ankles and shoulders gives angular motion.

Motion terminology

- Velocity (or speed) measures how quickly an object or person moves over a distance (distance divided by time equals velocity). Velocity is measured as either the average speed over a distance or the top speed over that distance. For example, a tennis player might serve at 160 kilometres per hour, which is the highest speed reached over the distance. A swimmer, on the other hand, might swim a 100-metre butterfly in 90 seconds by averaging 0.9 metres per second over the race.
- Acceleration is a measure of the rate of change of velocity, or how quickly an athlete can change speed. An example of this is a cyclist accelerating at the beginning of a time trial from zero to 15 kilometres per hour in one second.

Projectile motion

Any object moving through space is called a projectile, including humans when they are diving or jumping, or balls when they are hit, kicked or thrown. For an object to become a projectile, a force must be applied to it.

All things being equal, the greater the force applied to the object, the further a projectile will travel (Newton's second law of motion). Opposing this force are air resistance (acting on horizontal motion) and gravitational force (acting on vertical motion).

The path a projectile follows through the air is called its trajectory. The trajectory of a projectile is predetermined at the moment of release by the:

- velocity (speed) of release — the greater the speed of release, the greater the range, flight time and height or distance obtained
- angle of release or takeoff — the angle will depend on whether maximal height or distance is your goal. For example, 45 degrees is the optimal angle at which an object needs to be projected to obtain the maximum distance.

When we are looking at humans as the projectiles, it is impractical or unobtainable for an angle of release to reach 45 degrees. In reality, research shows that long jumpers leave the ground at between 19 and 25 degrees.

Case study

Angela is a young shot-putter who is keen to increase her throwing distance. Her coach, Kwasi, suggests they start by taking a video of her throwing. He positions the camera directly side on and records a few throws. Kwasi knows that the throw distance depends on factors determined at the exact moment that the shot leaves Angela's hand. These factors are:

- the release velocity, or the speed of release
- the angle of release
- the height of release, or how far above the ground the shot is released.

Kwasi looks carefully at Angela's throws and then estimates how high she reaches when she releases the shot. Kwasi then estimates the angle of release. He explains to Angela that the slower the speed of release, the shallower or smaller the release angle tends to be. He points out that as throwers become able to generate a higher release velocity, they also tend to be able to increase their release angle (world-class throwers release the shot at angles between 32 and 38 degrees). Kwasi tells Angela that he will focus her training specifically on further developing her strength and power, which in turn will increase her speed of release.

The second area that Kwasi knows they can work on is Angela's technique in moving across the circle. He uses what he knows about the summation of forces and the need for a smooth and efficient action to ensure that the forces generated by the thrower from the legs, hips and arms are then transferred to the shot-put leading to an increased speed of release.

Force

A force is a push or pull that alters the state of motion of a person or object. Force can cause a moving body to increase its speed, slow down, stop or change direction. It can also cause a body that is at rest to move (Newton's first law). The strength or size of the force required to change the state of motion of the body will depend on the:

- weight of the body
- point of application of the force

- direction of the force
- time over which the force is applied.

Forces that act on the body may originate internally or externally. Internal forces come from the actions of muscles or tendons, which act on bones with sufficient force to set them in motion. External forces that oppose motion include gravity, friction and fluid resistance, which are defined in the following table:

Table 9.3: External force definitions

External force	Definition	Example
Gravity	This refers to the earth's gravitational pull of 9.8 m/s^2	Runners who raise and lower their body excessively with each stride waste energy by continually trying to overcome the force of gravity
Friction	Resistance to motion caused by two surfaces touching each other	Friction may work for or against an athlete depending on their sport. For example, a gymnast tries to reduce friction by using chalk on their hands, while a table tennis player uses a bat with a special surface to increase friction to assist their grip
Fluid resistance	When a body moves through air or fluid, resistance to motion (drag) occurs. The faster you move, the more drag you encounter	Cyclists ride closely behind another rider to decrease air resistance (drag) and conserve energy

Summation of forces

Many sports involve an all-out effort, such as throwing a javelin, or jumping as high or far as possible. In order to achieve the optimum result, it is necessary for the athlete to combine the movement of different body parts into a coordinated sequence of movement. By also limiting the use of muscles that are not needed, less energy will be wasted.

When a maximal effort is required, summation of force (adding of forces together) is necessary. The summation of force can happen when everything happens at the same time or sequentially. When everything happens together, all the body parts move explosively at the same time, which results in the greatest possible force. This includes actions such as the high jump, gymnastic vault or judo kick.

In sequential body movements such as a tennis serve, the movement begins with the larger, heavier body parts with the greatest inertia (trunk and hips) and ends with the smaller, lighter body parts (lower arm and hand). In this type of action, the power generated in one body part is transferred to the next moving part. To get the greatest possible power, each part must contribute by developing its greatest velocity before the next part starts its action.

Momentum

Momentum is the product of the mass and velocity of an object (momentum = mass x velocity).

Linear momentum can be described as how difficult it is to stop an object or a body. All bodies have both mass and velocity, and when multiplied together they give a measure of linear momentum. Tenpin bowlers like to use heavier balls even if they are harder to control, as they have more chance of success because of the greater momentum at impact.

Angular momentum is the momentum of a rotating body such as a golf club or a figure skater and equals the body’s moment of inertia multiplied by its angular velocity, or how fast it is turning.

Moment of inertia is a body’s resistance to change when rotating about a specific axis. This varies not only with mass, but also with how this mass is spread from the axis of rotation. If the mass is spread a long way along the axis, the moment of inertia will be faster. For example, a figure skater who begins a spin with arms outstretched pulls in her arms and so reduces her moment of inertia, causing her to spin faster. A junior tennis player who grasps their racquet midway along the handle reduces the moment of inertia, causing their racquet to swing slower and so making it easier for them to control. This is why it is important for junior athletes to use shorter racquets or bats suitable for their size and strength.

Conservation of momentum

When two or more bodies collide with each other, momentum is conserved. In other words the total momentum of the bodies before impact is the same as their total momentum after impact.

For example, when a bat meets a ball, the total momentum is equal to the momentum of the bat and the momentum of the ball. After impact, the momentum of both objects may change (for example, the bat will usually slow down and the ball will travel much more quickly, but the total momentum still stays the same). This means that some momentum from the bat has in fact been transferred to the ball, or vice versa.

Case study

Vincent is a softball coach and is keen to increase the speed of the batted ball and so give his players more time to make it to first base without getting out.

Vincent knows that to improve this skill he can apply the basic principle of the conservation of momentum. This principle tells him that momentum is neither created nor destroyed, or in other words, the momentum of objects before a collision will equal the amount of momentum after the collision.

Vincent decides to set up a simple experiment with his players to work out the most effective way of increasing the batted-ball speed. He knows the momentum depends on both mass and velocity of the bat and the ball. He uses teeball equipment where the initial velocity of the ball is zero and gets the players to hit the ball with a slow swing, a medium swing and a fast swing. He estimates the ball velocity by how far the ball goes. Vincent finds that the faster bat swings lead to the fastest ball speeds.

Next the players hit the ball with a variety of bats that each have a different mass. From what he knows of conservation of momentum, Vincent could assume that the heaviest bat will result in the fastest batted-ball speed, but in reality that does not happen. It is far easier to swing a lighter bat and so if bat mass is increased too much, the batters are unable to swing the bat with enough speed. Vincent decides to note for each player which weight bat suits them the best and results in the fastest swings. This will help players when choosing a bat, as they can select the one best suited to their own size and strength, and so hit the ball with the greatest possible speed.

While decreasing the mass of the ball would also work, this is not practical as the minimum ball mass is dictated by the laws of the game.

Levers

Mechanical lever systems are seen in many day-to-day tasks — wheelbarrows are used to carry heavy loads and bottle openers are used to open bottles. The human body is also made up of many levers (bones), which are pulled and moved by the forces of muscles acting via tendons. In sport, our arms and legs act as levers and in many cases we use a racquet, bat or stick, which adds an extra length to the body's lever.

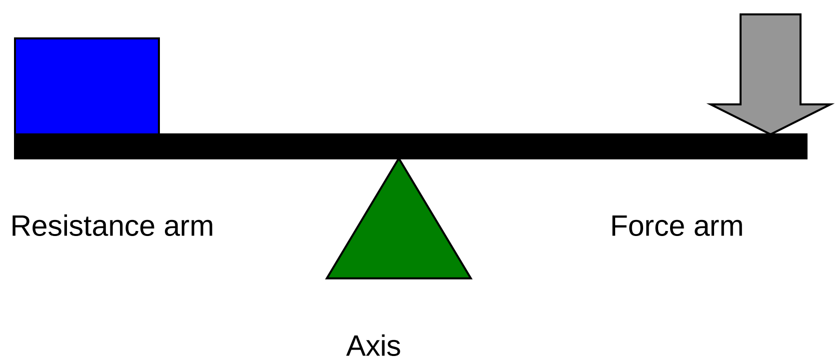
Levers have three main segments:

- a force arm (between the axis and where the force is applied)
- a resistance arm (between the axis and what is to be moved)
- an axis.

Levers have two main functions:

- to increase or magnify the force
- to increase the distance or speed with which the lever can be moved.

Figure 9.2: Basic lever system



Levers that increase force make it easier to do the work, as the lever carries out the function of force magnification. Its advantage comes when the axis is closer to the resistance than the force (the force arm is longer than the resistance arm).

Levers that increase speed operate at a mechanical disadvantage, meaning that more effort is required to move something, but the speed that it can be moved has increased. This occurs when the axis is closer to the force (the force arm is shorter than the resistance arm).

Figure 9.3: A force lever and a speed lever

Force lever   Speed lever

In many sports (such as tennis, squash, cricket and golf) technique has combined the use of both systems (speed and force). In the tennis serve, the arm and the racquet is the lever. The service action starts with the arm bent at the elbow and the racquet in the back scratch position, which gives a shorter lever and greater initial acceleration. The lever is extended to its maximum at the point of impact, as here the arm is fully extended and the racquet is at its highest point overhead. Thus, the head of the racquet will be moving faster than at any other point on the lever so that you can get the most powerful serve possible.

Case study

Jim is a weight-lifting coach who works with a young squad of lifters. The technique involved in lifting is one of the main areas that Jim is focusing on with his squad. Using the principles of levers, Jim works with his athletes to ensure that their technique for the clean and jerk lift maximises the force lever. Keeping the bar close to their body is important in improving their lifting capacity. Poor technique in some athletes results in them increasing the length of the resistance arm, which results in greater speed of movement but reduced lifting capacity. Jim is trying to ensure that their clean and jerk technique focuses on increasing the force arm, but with sufficient speed to successfully lift the weight.

Balance

Balance can be either static (standing still), or dynamic (moving).

- Static balance is required in sports where athletes stand still in a set position for a long time (for example archery, wrestling or shooting).
- Dynamic balance is required in sports where balance needs to be shifted easily (for example, fast-changing sports such as tennis or netball).

Stability

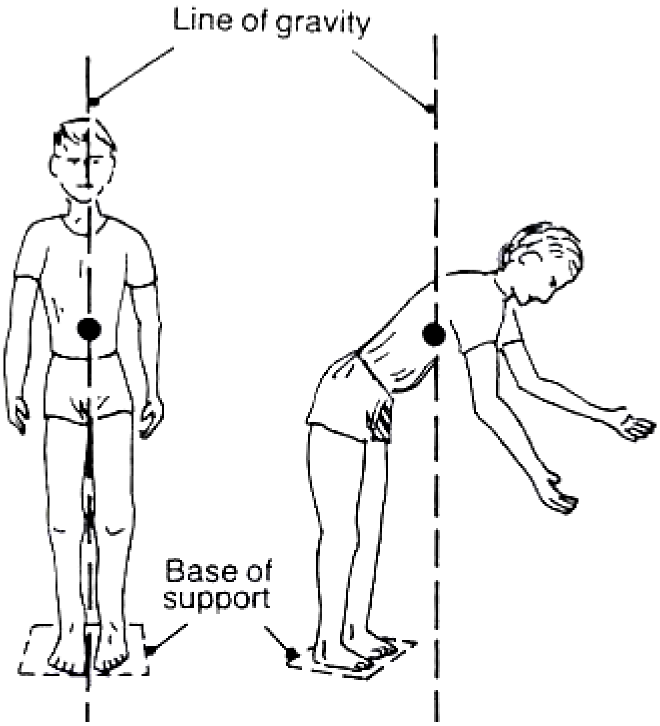
A key concept in stability is the centre of gravity of an object. This is an imaginary point where the weight of a body is balanced; that is, its balancing point. Due to the constant changing of the body's shape, the centre of gravity is also always changing. Usually it is located somewhere near the pelvic region. For females it is often slightly lower, but this depends on their body composition. Centre of gravity is directly related to a person's stability and balance.

A position with a high degree of stability requires a stronger force to be moved than a position with low stability. Not all sports require a high degree of stability — wrestling and gymnastics do, but others such as tennis and rugby union require stability to be shifted and varied.

The five basic principles to keep in mind regarding stability and balance are:

- weight — the greater the weight of an athlete the more stable they are, and in contact sports such as rugby union the more difficult they are to move. For example, in a rugby scrum, the weight and the techniques used affect the scrum's stability
- base of support — the base of support is comprised of the two feet and the area between them. For a body to remain balanced, the centre of gravity must be within the base of support. The wider the base of support or the further apart the feet are, the more stable a person is (for example, in surfing and archery)
- height — the lower the centre of gravity is above the base of support, the more stable the athlete is. The higher the centre of gravity, the less stable the body is and the easier it is to move or push off balance
- line of the centre of gravity — when a person's line of gravity is outside their base of support (see Figure 9.4), they are less stable. When the position of the centre of gravity is well centred over the base of support, it is difficult for wind or an opponent to move the body from its position. When quick movement is required athletes bend their knees slightly, which lowers their centre of gravity. They then position their centre of gravity close to the edge of the base of support area by leaning or tilting their body. A 100-metre sprinter in the 'set' position has their body positioned forwards over their hands ready for a quick start
- rotation — when something is rotating or turning around, such as a spinning ice skater or a bike with rotating wheels, stability is increased.

Figure 9.4: The line of gravity



Stable **Unstable**

Case study

Rosemary is a coach of an under-15 boys' basketball team and notices that Kamil, one of her taller players, seems quite unstable and is frequently being knocked over on court during defence. She decides to talk to Kamil at their next training session about maintaining a strong position on court, and to give him some key points to remember to help maintain his balance. Rosemary knows that stability depends on three factors:

- the base of support
- the height of the centre of gravity
- the line of the centre of gravity in relation to the base of support.

She explains to him that while it is good to be on his toes at times when he may want to move quickly in any direction, this also means that the line of his centre of gravity is close to the edge of the base of support, and it only takes a small knock or push from an opponent to then put him off balance. Rosemary suggests to Kamil that to stop him being pushed off his position he needs to increase his base of support by moving his feet further apart and lowering his centre of gravity by bending his knees. By keeping his weight in the centre of his feet (not on the heels or toes) he keeps the line of the centre of gravity well within his base of support.

Methods of analysing movement

A coach with an understanding of biomechanical principles, together with knowledge and experience of their own sport, can analyse an athlete’s technique.

Movement analysis can be broken into two areas — qualitative and quantitative. Qualitative analysis can be as simple as a coach watching their athlete train or compete. While this assessment can be instantaneous it is subjective and non-numerical, meaning results or athletes are difficult to compare. This is the key difference with a quantitative style of analysis, which is numerical, and as such allows comparison to other athletes as well comparisons to previous performances.

There are a number of tools that provide quantitative analysis to many different sports. The simplest is video analysis, which is accessible to most coaches. Through the use of freeze-frame techniques, coaches can analyse an athlete’s body position and movements at critical moments in the execution of a technique. Other tools that are accessible to most coaches include ‘radar guns’ to measure speed.

At the higher end of quantitative analysis, there are a variety of laboratory and field-testing devices. These are generally only accessible to coaches working in higher-level programs such as state or national institutes or national team programs. Within the laboratory setting there are motion analysis systems that are used to measure kinematics, as well as force platforms that can measure kinetics. Some sport-specific field testing devices include instrumented force blocks (athletics), and force systems that mount on rowing and kayak paddles to give detailed kinetic feedback. High-speed cameras capable of capturing images at over 2000 pictures per second can enable access to detailed information on ballistic movements.

Using biomechanical analysis information to make changes

While there is a wealth of information that can be collected on athlete movement, coaches should carefully consider what they wish to do with this information, and how they go about making changes to technique.

When considering making technique changes a coach should keep in mind the following:

- Consider whether the athlete is actually ready to change the technique. Sometimes anxiety or self-confidence can affect technique, and if this is the case it should be addressed first before any work on modifying technique begins.
- Consider whether the athlete understands the modifications that are needed and the reason for the change.
- Consider if the athlete has the physical capacity to do the required technique. Is the athlete strong or flexible enough to do what is required?
- Sometimes error in technique can be the result of a poor choice of technique or inappropriate response, rather than a problem with the technique itself.
- A technique flaw in the performance of gymnasts or ice skaters must be corrected because it relates directly to how their performance is judged. On the other hand, a basketballer with some technique variation that does not affect performance could be left alone. Natural flair may also lead to an athlete having an alternative technique, but this variation does not necessarily mean their technique should be changed.

Summary

By gaining a better knowledge of the structure of the human body, and how and why the body moves, coaches can undertake better analysis of their athletes, and use that information to improve athlete performance. Identifying and correcting errors in performance is part of the coach’s role. Using scientific principles as the basis of obtaining information and recommending change is a valuable tool for coaches.

While coaches do not need to become experts on anatomy and biomechanics, by understanding and applying the principles involved with the structure and movement of the body they can become a better coach. Once a coach understands how a body works and performs a movement, then they can:

- change technique to improve performance
- change technique to reduce the risk of injuries
- select the appropriate techniques and equipment to suit an athlete’s individual needs
- communicate effectively with sports medicine and sports science personnel.

References and further reading

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