

Movement 101

if you're going to build your body or others',
knowing the terms and concepts of how it moves will speed the process

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Anatomy is an intimidating topic to lots of people, but it is an important area of study relevant to many professions, including teachers of exercise. Previously, we examined how the recognition of body segment lengths that deviated from "normal" affected how a movement would look (Measure of a Man; CrossFit Journal, July'08 (71):35). It was our first step at developing an "eye" for coaching. In the next step, we will take a look at how we describe human movement in very specific spatial and directional terms and hopefully simplify them for easy use in teaching. After all, if you know something and cannot communicate it in a manner that the listener or reader comprehends, your teaching failed (Man, I hope I don't mess this up after saying that).

"Anatomical Position:" A Universal Reference Point for Any Body

Let's start with the basic reference position used in anatomy, "anatomical position" (Figure 1). Anatomical position—flat on the back with the palms of the hands facing up, like a dead body laying on the dissecting slab—is an artificial construct intended to help anatomists describe the positions the human body's various features. Test out this position yourself by flopping flat on the floor, relaxing completely, and seeing what your hands do. The palms will usually face upwards.

Interestingly, anatomical position is not exactly representative of the normal living body while standing up. Standing in a relaxed position, your arms will hang with palms facing the hip or slightly to the rear. Interesting eh? While this is not too important, having one defined

reference position as a reference point for everyone is—sort of like magnetic north on your compass. A compass allows people from all around the world to be dropped into unfamiliar terrain and find their way to a specific destination. Not surprisingly, magnetic north is useful as is anatomical position when we need to describe precise anatomical locations and directional movements.



Figure 1
Anatomical position compared to relaxed standing posture.

**Describing relative location:
Is the Foot *Distal* to the Hip?**

Orienting yourself to the body is important whether it is on a dissecting table, standing up, or in a convoluted exercise position. You have to know where the parts are relative to other parts, the earth, and to any implement used during the exercise. Anatomists have a nice set of uniformly understood terms describing just that. These will be necessary for the exercise professional to learn. They are arranged in opposing functional pairs as follows:



Figure 2

Anterior or front view of upper body (left) and posterior or back view of upper body (right).

Front/ Back

Anterior: A structure that lies in front of another structure (Figure 2). The toes, for example, are anterior to the heels.

Posterior: A structure located behind another structure (Figure 2). Example: The erector spinae, the long muscle group running vertically along the back, is posterior to the abdominal cavity.

Near/ Far

Proximal: Usually associated with the extremities but relevant to all structures, *proximal* describes a structure as being closer to the center of the body or to the beginning of the extremity than another structure (Figure 3). Example: The knee is proximal to the foot.

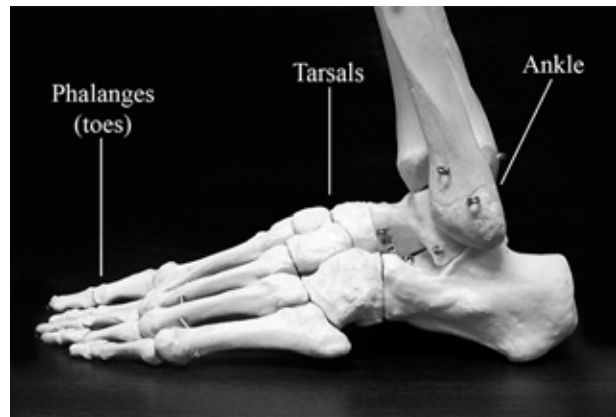


Figure 3

The tarsals are proximal to the ankle joint. The phalanges (toes) are distal to the ankle joint.



Figure 4

A superior structure is above another. In the image to the left, the skull is superior to the pelvis, or we could say that the pelvis is inferior to the skull (below the skull). We can move and change this orientation during exercise. In the image to the right the pelvis is superior to the skull.

Distal: The opposite of proximal, "distal" is a structure farther from center or from the beginning of the extremity than another structure (Figure 3). Example: The hand is distal to the elbow.

Top/ Bottom

Superior: A structure that is higher than another structure (Figure 4). Example: The head is superior to the pelvis for example.

Inferior: A structure that is lower than another (Figure 4). Example: The chin is inferior to the nose.

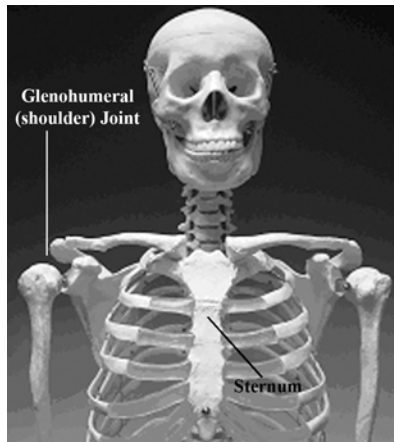


Figure 5
The sternum is medial, or in the middle of the body. The shoulder joints are lateral, or on the outside.

Middle/ Side or Inner /Outer

Medial: A structure is closer to the cardinal sagittal plane (center) than another structure (Figure 5). Example: The sternum (breastbone) is medial to both shoulders. Example 2: The spinal column is medial to the ribs.

Lateral: A structure that lies farther away from the cardinal sagittal plane than another structure (Figure 5). Example: The shoulders are lateral to the sternum.

The 3 Cardinal Planes: Sagittal, Frontal, and Transverse

Now that we have a starting point, we can take a few more steps toward describing human movement. Anatomists use the convention of anatomical planes to describe the locations of body parts on various sections the body. Most anatomy texts may only passingly refer to anatomical planes because they expect the reader to be familiar with the “cardinal” (important) planes, *sagittal*, *frontal*, and *transverse* (figure 6).

The Sagittal Plane divides the body into right-hand and left-hand sides as it passes front (toe side) to back (heel side).

The Frontal Plane divides the body into front and back halves as it passes side to side (shoulder to shoulder).

The Transverse Plane divides the body into top and bottom (at the waist) as it passes perpendicular to the long axis of the body (the intersection of the Sagittal and Frontal planes).

These three cardinal planes intersect at the body’s theoretical center of gravity or center of mass. This intersection was first reported by Christian Wilhelm Braune in the late 1800’s, when “plane” terminology was first used to describe the cuts made in a dissection. Planes are also useful because they allow us to describe the orientation

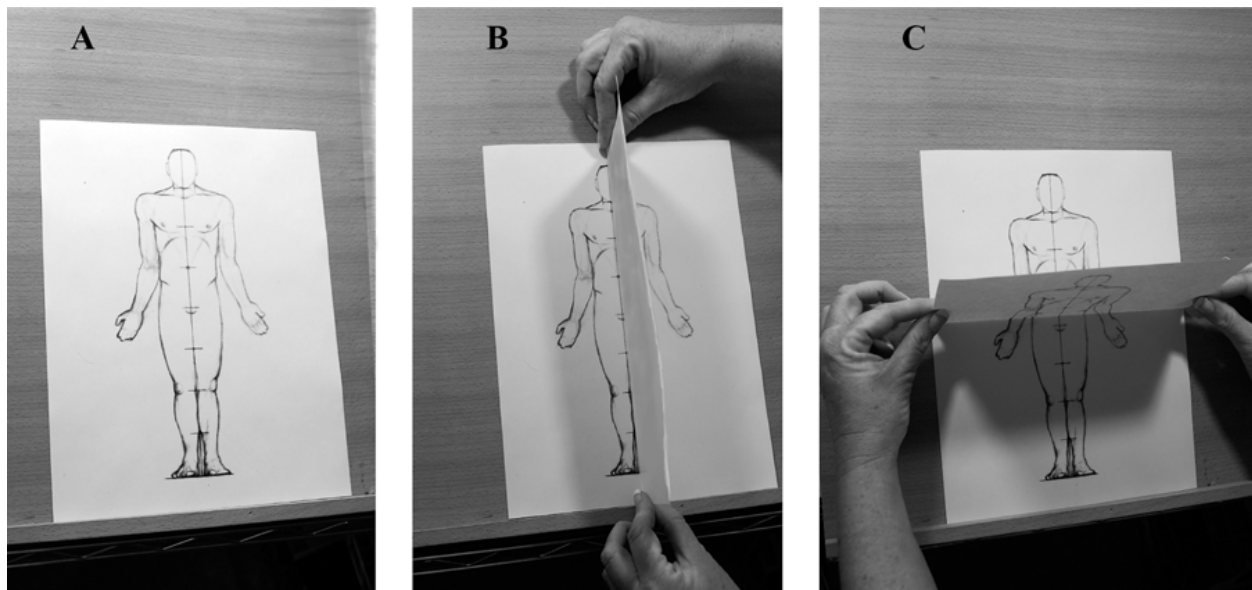


Figure 6
The cardinal planes. (A) Frontal, (B) Sagittal, and (C) Transverse.

of a feature relative to a plane (i.e. The face and the toes are in the front half of the frontal plane.) You might even compare the concept of using anatomical planes in describing the position of a body part to using latitudes and longitudes in describing the location of a geographic feature on the earth.

Anatomical planes have been hijacked by the exercise sciences. Every text on kinesiology or biomechanics has a section that lists the “Planes of Motion,” or simply the three anatomical planes. The only difference is that those texts say things like, “the arm moved along the frontal plane.” We’ll see later that we have some handy dandy anatomical terms that obviate the need for saying things like that.

We also see in exercise texts references to “Axes of Movement.” And if you remember your high school geometry, an axis is an imaginary line around which something rotates. The Earth rotates on the Polar axis, an imaginary line between the north and south poles.

Every plane of movement has an axis. To visualize the axis of a plane and the rotation around it, put a flat piece of paper on the table in front of you. Let’s say the paper represents the frontal plane. Now draw a large stick figure human on it in anatomical position (make sure you put a smiley face on it). When looking at the paper now, you are examining the representation of the human (the stick figure) in a frontal perspective.

Now carefully fold that paper in half, the crease running left to right near the waist of the stick figure, just above where the legs begin. The crease represents an axis of rotation, in this case the rotation of the upper and lower body at the hip. If the top half of the paper is folded down, the upper body has rotated around a transverse axis. If you fold the paper with the crease from top to bottom you have created a frontal axis. If you place your pen point on your stick figure’s belly button and spin the paper, it is rotating around a sagittal axis.

OK. That was fun. Let’s move on to something a bit more useful. Really, when have you or any coach or trainer you know used these terms? It is good information needed to understand anatomy but not necessarily useful in communicating information to clients or athletes.

The Movement Test: Is Abduction In or Out?

If these “planar” descriptions are elemental to the study of anatomy but not so practical for describing movement, how do you describe movement?

There exists a standard set of directional terms that specifically deals with both locating anatomical features and describing their movements. Many of the terms are actually familiar. Having used the terms “flex” and “extend,” you are already part-way to a simple understanding of how to describe movement.

Bend/ Straighten

Flexion occurs in the sagittal plane, anterior-posterior (figure 7a). In a flexing movement, the angle formed by the joint decreases. For example, the hamstrings will flex the knee joint from 180° at full extension to around 60° at full flexion (the number gets smaller). Contracting biceps do the same thing for the elbow joint. In the gym we frequently refer to flexion as “closing” the joint. Think of it like closing a book. As the book closes, the two covers go from 180° to 0°. It is worthwhile to note here that Note: It is the joint “flexing” here, not the muscles. Muscles “contract” to flex or extend joints.

Extension, the opposite of flexion, also occurs within the sagittal plane, also anterior-posterior (figure 7b). The angle formed by the joint increases throughout the movement (the number of degrees gets bigger). This is a very common coaching term in the gym and in sport. An analogy here is the opening of a book, increasing the angle between the two covers from 0° to 180°. The hip angle opens as you rise from sitting to standing for example.



Figure 7
Flexion (a) and extension (b) of the knee joint. It should be apparent from the photograph illustrating flexion that muscular involvement is not a pre-requisite of flexion (nor extension). Muscles do not flex, joints do.

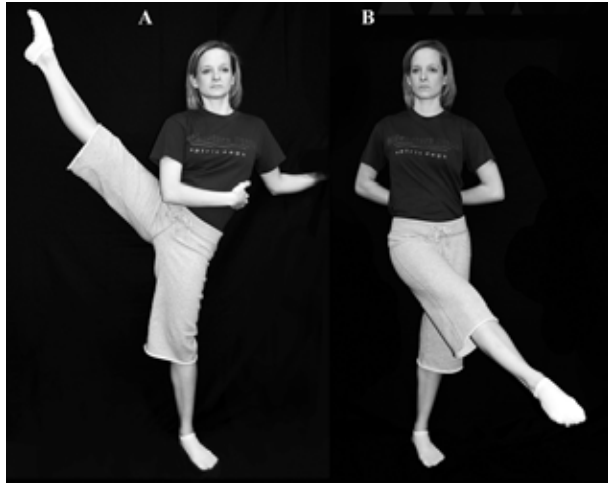


Figure 8
(A) Abduction (B) Adduction

These are pretty extreme examples of abduction and adduction of which most trainees are not capable. Some people would call this hyperabduction and hyperadduction as it is extreme. BUT "hyper" specifically refers to movement beyond the individual joints range of motion capacity. Hyperextension, hyperabduction, hyperflexion, hyperadduction, hyper-anything is potentially injurious. Years of ballet training has made extreme abduction and adduction a normal and non-stressful movement for our model here.

Move Away/ Return

Abduction, which occurs within the frontal plane, is a movement that takes or pushes a body part away from the mid-line of the body (figure 8a). A simple concept to remember: to abduct is to take away (i.e., A kidnapper abducted four school kids).

Adduction, like abduction, occurs within the frontal plane, but unlike abduction is a movement of a body part towards the mid-line of the body (figure 8b).



Figure 9

In the sequence above, the radius (thumb side of the hand) is rotated over the ulna. Another way to say this is to say that the hand at the far left is supinated and the hand to the far right is pronated.

Spin/ Fling

Rotation, as its name implies, is a rotational or pivoting motion around the long axis of the body (where the sagittal and frontal planes meet) or any body segment (figure 9).

Circumduction, which can occur within any plane, is where the joint acts as a pivot point and the distal segment then moves in a circle around the joint (figure 10). Example: The arc traced by the toes when you open and close your ankle joint. In general, circumduction is a combination of flexion, abduction, extension, and adduction ordered into a defined sequence. It can only occur at any joint that is capable of movement in two or more planes.

For Best Understanding, Use All the Terms—and Common Sense.

All of these terms—*flex/extend, abduct/adduct, rotate*, and to a lesser extent *circumduct*—can be used to teach a client or athlete correct form. There are lots of other specific terms like *invert, evert, depress, elevate, supinate, pronate*, and more that have specific meaning within



Figure 10
Circumduction at the shoulder is part of softball pitch technique.

specific anatomical segments (Table 1) but the basic few described here will suffice for most exercise teaching purposes.

In fact, you will probably have to come up with 15 different ways to tell a trainee to flex, extend, abduct, adduct, or rotate a joint or body part without using the correct anatomical term. Instead of saying “*abduct your femurs*” during a squat, say “*push your knees out*” and the trainee will get the idea better. Instead of telling the trainee to “*internally rotate the humerus*” in the set-up for a clean, say “*point your elbows out,*” and they will engage the latissimus dorsi correctly for proper force application.

In this application of anatomy there are two tasks to be accomplished:

1. An understanding of the anatomical nature of the movement, what is actually occurring, and where it is occurring in order to detect segmental deviations from a reference standard (the prototypical example of good technique), and

2. An ability to convey anatomical feedback to your trainee in a vocabulary that is understandable to them. The former point is science applied to exercise; the latter is at its core part of the art of coaching. Failure to accomplish either makes for a less successful coach or trainer.



About The Author

Lon Kilgore, Ph.D., is a professor of kinesiology at Midwestern State University where he teaches sport and fitness physiology and applied anatomy. He has authored or co-authored several professional exercise textbooks, numerous research articles on the biology of exercise, and many articles that interpret exercise science for the average coach and trainee. His students have become university faculty, high school and university sport coaches, private fitness practitioners, physicians, physical therapists, wellness directors, and US national team coaches in weightlifting and cycling. He has been a member or Chair of the Sports Science Committee for USA Weightlifting for more than a decade, a researcher on the USOC Weightlifting Performance Enhancement Team project, and a member of the Board of Certification for the American Society of Exercise Physiologists.

Table 1
Basic anatomical terms and their descriptions.

Movement	Body Parts Affected	Description
Flexion	Any applicable joint	Bending movement where the joint angle decreases
Extension	Any applicable joint	Straightening movement where the joint angle increases
Abduction	Any applicable joint	Movement of a segment away from midline
Adduction	Any applicable joint	Movement of a segment towards midline
Rotation	Any applicable joint	Circular motion around an axis
Elevation	Any applicable joint	Movement upwards
Depression	Any applicable joint	Movement downwards
Internal rotation	Some appendicular skeletal joints	Rotation of the part anteriorly
External rotation	Some appendicular skeletal joints	Rotation of the part posteriorly
Circumduction	Ball and socket joints	Flexion extension abduction and rotation around the joint
Pronation	Elbow and wrist joints	Rotation of the hand to a palms down orientation
Supination	Elbow and wrist joints	Rotation of the hand to a palms up orientation
Dorsiflexion	Ankle	Lifting the toes and ball of the foot up
Plantarflexion	Ankle	Pushing the toes and ball of the foot down
Eversion	Ankle	Rolling the ankle with the sole of the foot facing out
Inversion	Ankle	Rolling the ankle with the sole of the foot facing the midline
Opposition	Thumb	Moving the thumb and fingers together
Reposition	Thumb	Moving the thumb away from the fingers
Protrusion	Jaw	Moving the jaw move forward (towards underbite)
Retrusion	Jaw	Moving the jaw backwards (towards overbite)
Protraction	Shoulder	Movement of the shoulders forward (abduction)
Retraction	Shoulder	Movement of the shoulders backward (adduction)