ORIGYM

Level 3 Certificate In Personal Training

MODULE 2: AXIAL SKELETON AND THE STRUCTURE AND FUNCTION OF THE CORE

CONTENTS

The Pelvis

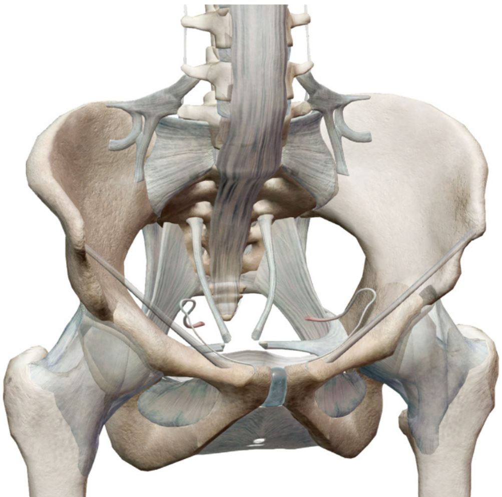
MODULE 2:
AXIAL SKELETON AND THE STRUCTURE AND FUNCTION OF THE CORE

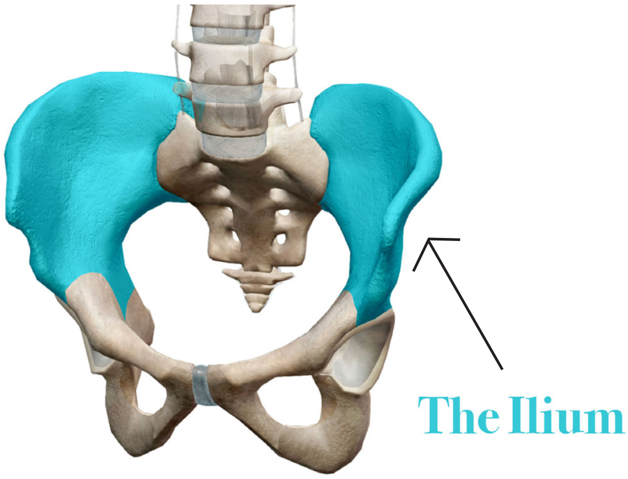
The Structure of the Pelvis (Hip) Girdle

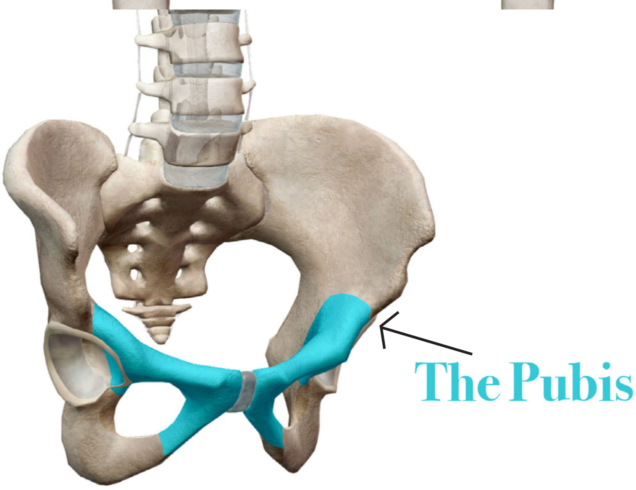
The pelvic girdle consists of the right and left hip bones.

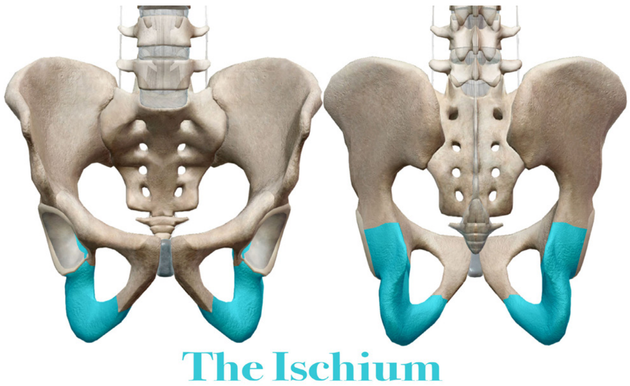
Each hip bone is made up of the:

- **Ilium**
- **Ischium**
- **Pubis**









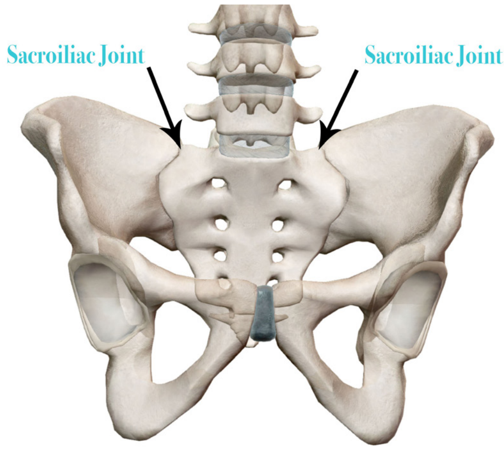
Pelvic Articulations

There are four articulations within the pelvis:

- **Sacroiliac Joints (x2)**
- **Sacrococcygeal symphysis**
- **Pubic symphysis**

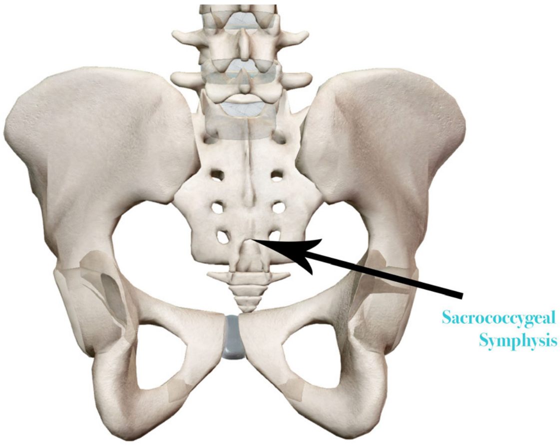
Sacroiliac Joints (x2):

Between the ilium of the hip bones, and the sacrum



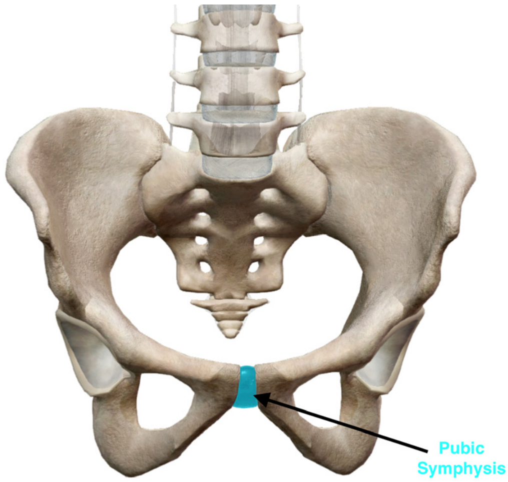
Sacrococcygeal Symphysis

Between the sacrum and the coccyx.



Pubic Symphysis

Between the pubis bodies of the two hip bones.



Joint Actions

MODULE 1
INTRODUCTION TO THE HUMAN BODY AND THE SKELETAL SYSTEM

Types of Joint Movement

Shoulder Movements

Flexion

Extension

Medial Rotation

Lateral Rotation

Adduction

Abduction

Horizontal Extension

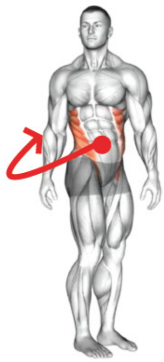
Horizontal Flexion

Spinal Movements

Flexion

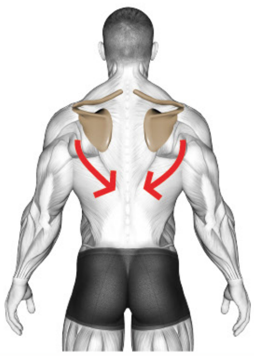
Extension

Lateral Flexion

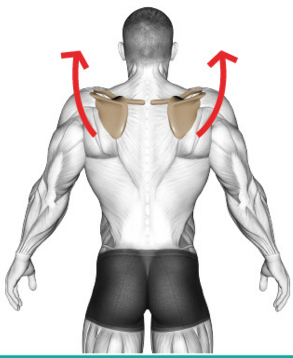


Rotation

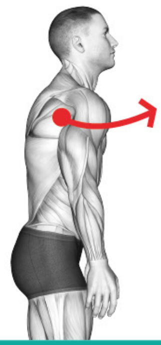
Shoulder Girdle Movements



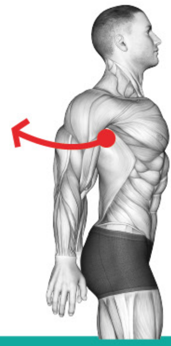
Depression



Elevation

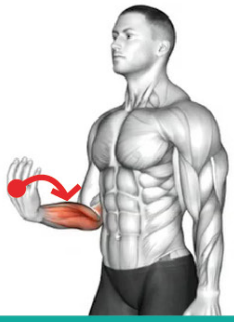


Protraction

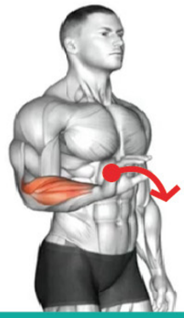


Retraction

Wrist Movements



Flexion



Extension

Wrist Adduction

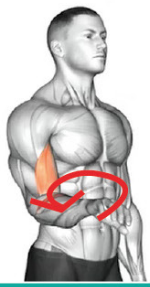
Wrist Abduction

Types of Joint Movement

Elbow Movements

Flexion

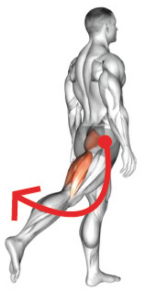
Extension



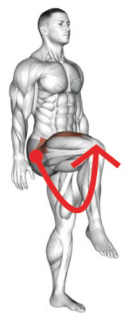
Supination

Pronation

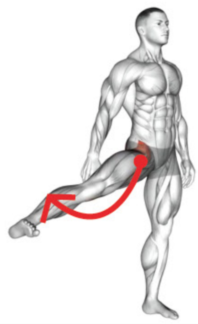
Hip Movements



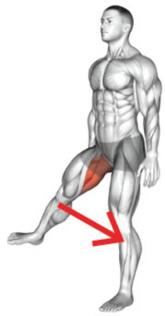
Extension



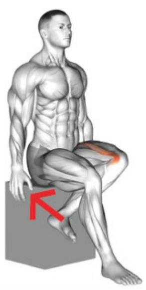
Flexion



Abduction



Adduction

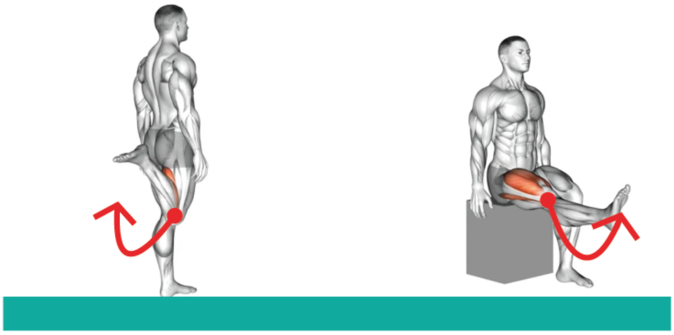


Medial Rotation

Lateral Rotation

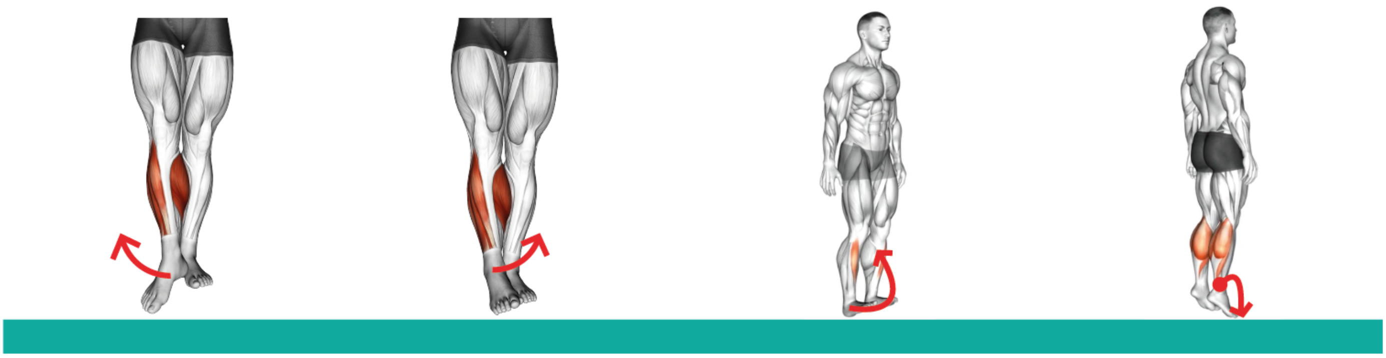
Circumduction

Knee Movements



Flexion Extension

Ankle Movements



Eversion Inversion Dorsiflexion Plantarflexion

Joint Actions

Joint Actions	Description
Flexion	Refers to movement where the angle between two bones decreases
Extension	Refers to movement where the angle between two bones increases
Horizontal Flexion	Refers to movement where the angle between two bones decreases and on the horizontal plane.
Horizontal Extension	Refers to movement where the angle between two bones increases and occurs on the horizontal plane.
Lateral Flexion	Refers to movement of the spine laterally away from the midline of the body. This can be seen when we bend to one side. Refers to movement of the spine laterally away from the midline of the body. Lateral extension refers to the increased angle at the spine. This can be seen when we bend to one side.
Abduction	Movement of a body segment away from the midline of the body.
Adduction	Movement of a body segment toward the midline of the body.
Circumduction	This is a movement where the joint is the pivot and the body segment moves in a combination of flexion, extension, adduction and abduction.
Protraction	This is forward movement of the scapula that results in 'hunching' of the shoulders.
Retraction	This is backward movement of the scapula as they pull together to 'square' the shoulders and push the chest out.
Elevation	Refers to the raising of the scapula to a more superior level (shrugging the shoulders).
Depression	Refers to the scapula moving to a more inferior position as they are pulled downwards.
Supination	Hand - movement so the palm of the hand faces upward or forward (anteriorly). Foot – combination of inversion, plantar flexion and adduction of the foot occurring at the same time.
Pronation	Hand – movement so the palm of the hand faces downward or backward (posteriorly). Foot – combination of eversion, dorsiflexion and abduction of the foot occurring at the same time.
Plantar Flexion	Moving the top of the foot away from the shin or 'pointing' the toes.
Dorsiflexion	Moving the top of the foot toward the shin or 'raising' the toes.
Eversion	The movement of the foot to bring the sole of the foot to face outward.
Inversion	The movement of the foot to bring the sole of the foot to face inward.
Rotation	Refers to a pivoting or 'twisting' movement. Rotation is broken down further into medial and lateral rotation.
Medial Rotation	The movement of a body segment where the front (anterior) of the segment rotates medially (inwards) towards the midline of the body.
Lateral Rotation	The movement of a body segment where the front (anterior) of the segment rotates laterally (outwards) away from the midline of the body.

The Vertebrae

MODULE 2:
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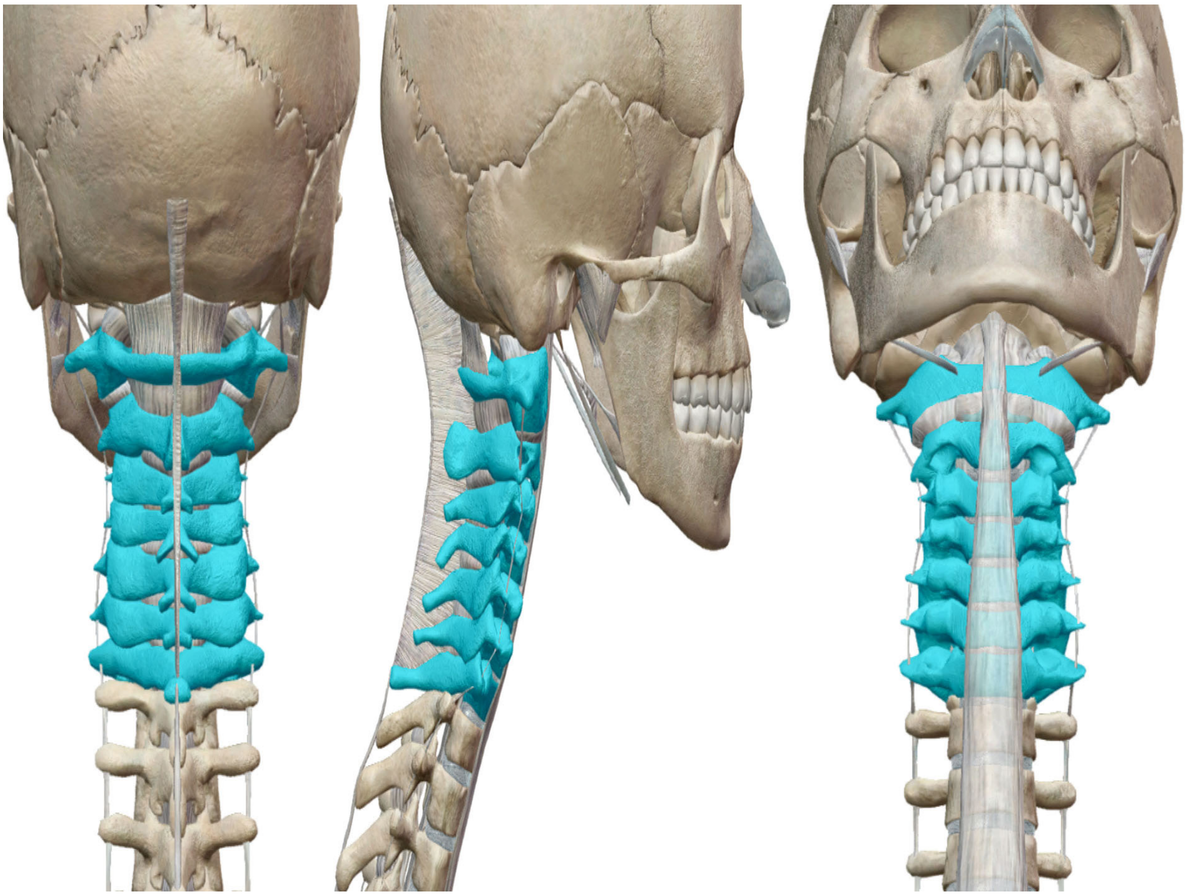
The Vertebral Column

The vertebral column consists of the 24 vertebrae, the sacrum, and the coccyx. A total of 33 vertebrae are within the vertebral column including the sacrum and coccyx. The spinal cord passes from the foramen magnum of the skull through the vertebral canal within the spinal vertebral column.

The Sections of the Vertebral Column

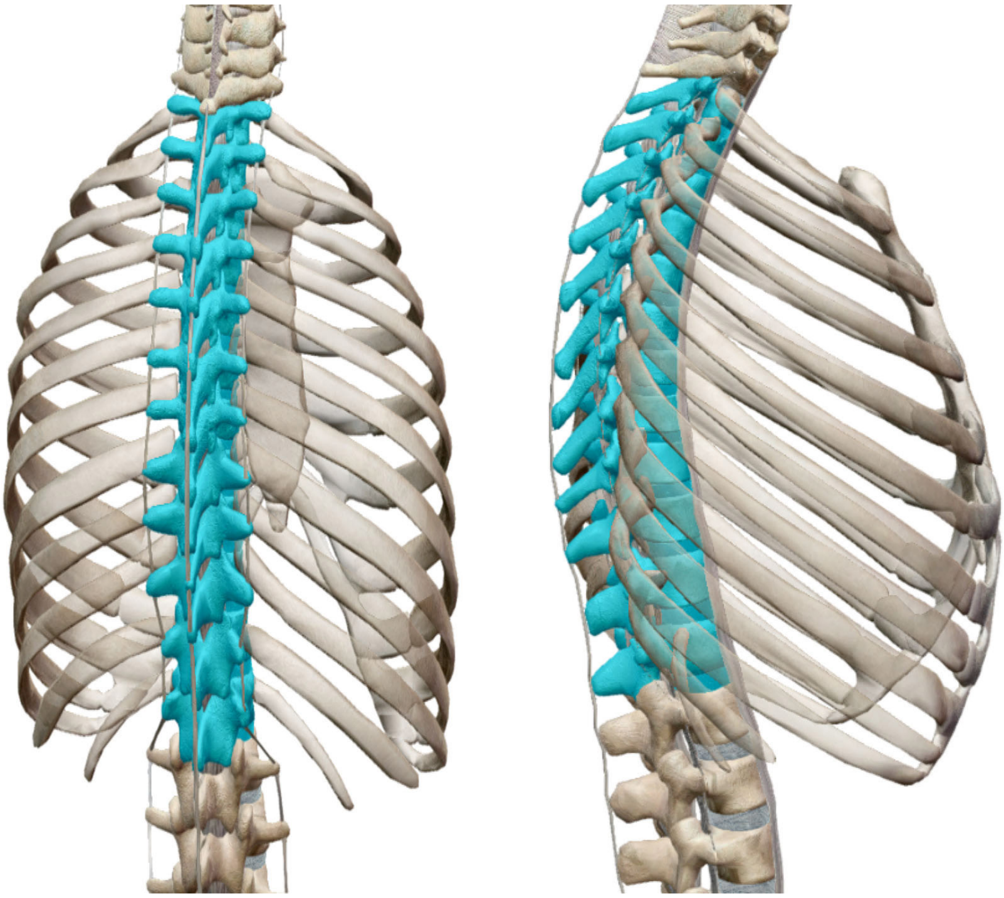
Cervical Vertebrae



The cervical vertebrae are the first seven (C1-C7). C1 is known as the atlas. C2 is known as the axis. C7 is known as the vertebra prominent or vertebra prominens. Each vertebra of the vertebral column consists of an anterior body (except C1) and a posterior vertebral arch. The disc-like body of the vertebrae is weight bearing, and its upper and lower surfaces give attachment to the inter-vertebral discs.

The space between the body and the arch is the vertebral foramen, an opening that provides a passage for the spinal cord. Where the body and arch of two vertebra articulate (meet), a foramen is formed. This inter-vertebral foramen is an aperture for the transmission of the spinal nerves. The cervical vertebrae are the smallest of the true vertebrae and are unique in that there is a foramen in the transverse processes of C1-C7 that give passage to the vertebral artery and the vertebral vein.

Thoracic Vertebrae

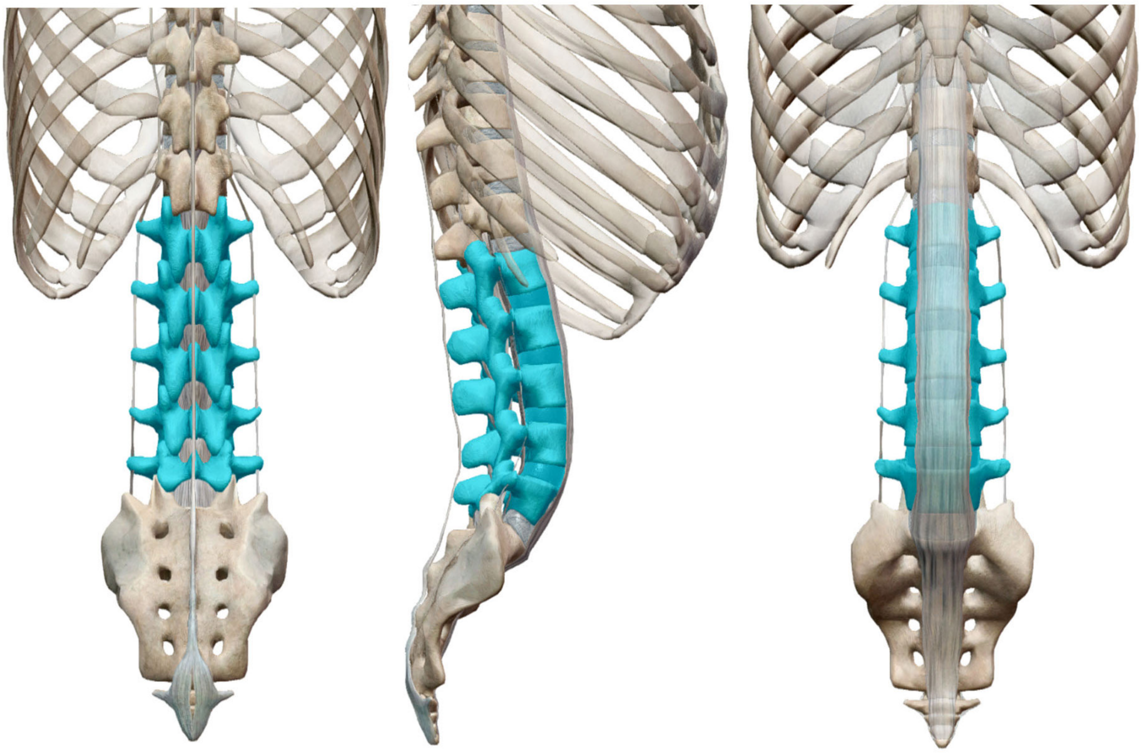


The thoracic vertebrae are the 8th through to 19th vertebrae (T1 - T12). Each thoracic vertebra of the vertebral column consists of an anterior body and a posterior vertebral arch. The disc-like body of the vertebrae is weight-bearing, and its upper and lower surfaces give attachment to the inter-vertebral discs.

Facets on the lateral side of the body articulate with the heads of the vertebrosternal ribs and false ribs. The vertebral arch is a composite structure; it consists of a pair of pedicles and a pair of laminae and supports 7 processes. The space between the body and the arch is the vertebral foramen, an opening that provides a passage for the spinal cord.

Where the body and arch of two vertebra articulate, a foramen is formed for the transmission of the spinal nerves. The transverse processes articulate with the tubercles of the vertebrosternal ribs and false ribs (except T11 and T12).

Lumbar Vertebrae

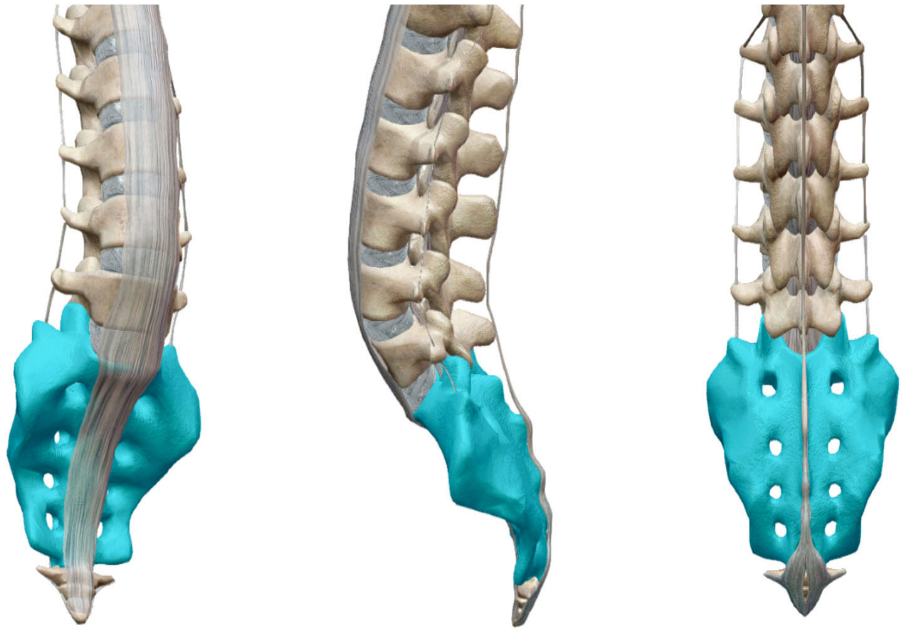


The lumbar vertebrae are the 20th through to 24th vertebrae (L1 - L5). Each lumbar vertebra consists of a heavy anterior body and a posterior vertebral arch. The disc-like body of the vertebrae is weight-bearing, and its upper and lower surfaces give attachment to the inter-vertebral discs. The long, slender transverse processes are situated in front of the articular processes instead of behind them, as in the thoracic vertebrae.

The superior tubercle of the transverse process is connected with the superior articular process to form the mammillary process; the inferior tubercle at the base of the transverse process is called the accessory process.

The spinal cord ends and the cauda equina begins, at or near L3. Because of this lumbar punctures are most often done between L4 and L5, where potential damage to the spinal cord is minimised.

Sacral Vertebrae (Sacrum)

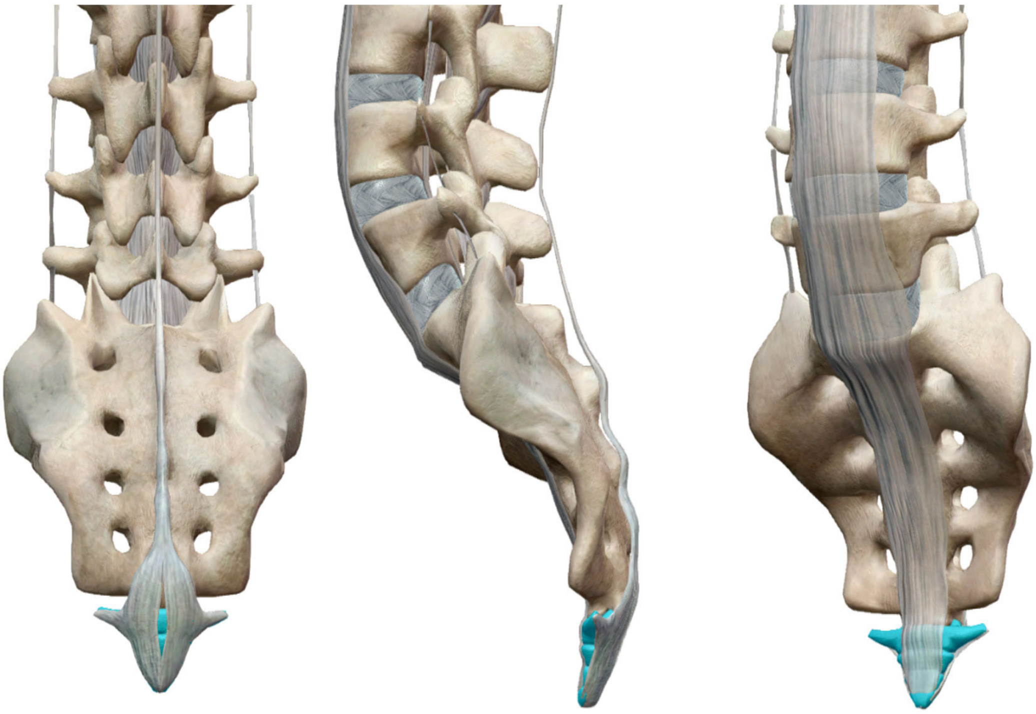


The Sacrum includes the sacral vertebrae, and are the 25th through to 29th (S1 - S5). These 5 vertebrae fuse in early adulthood to for the sacrum, a large triangular bone located between the hip bones.

Its upper part (base) articulates with the last lumbar vertebra (L5) by an inter-vertebral disc and its lower part (apex) articulates with the coccyx. The body of the first segment is large, resembling that of a lumbar vertebra, but each succeeding segment is smaller, flatter and more curved. The upper half of the lateral surface is a cartilage-covered articulation for the ilium.

The vertebral canal runs throughout the greater part of the bone, forming a passage for the sacral nerves and its walls are perforated by the anterior and posterior sacral foramina, through which these nerves exit. The female sacrum is shorter and wider than the male and directed more obliquely backwards, increasing the size of the pelvic cavity.

Coccygeal Vertebrae (Coccyx)

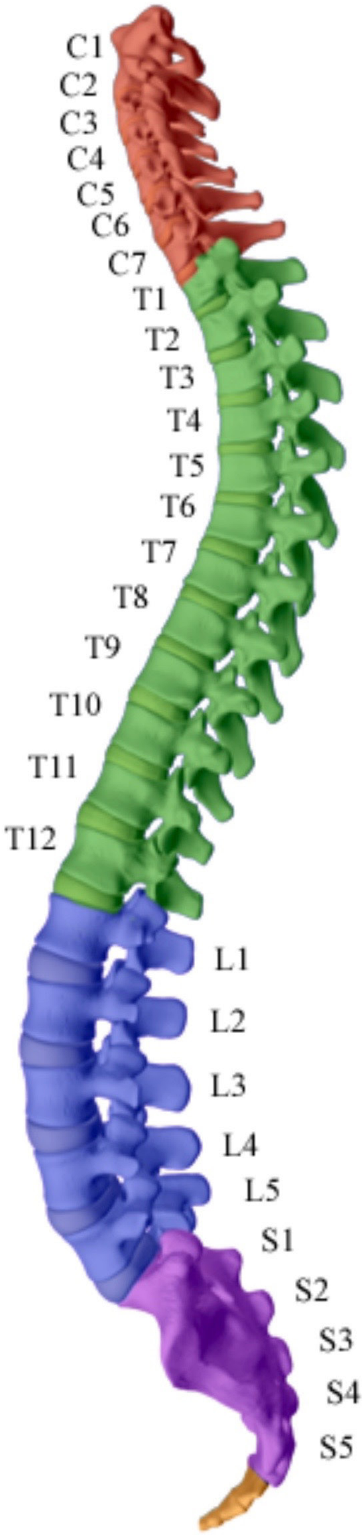


The coccyx (tail-bone) is the terminal portion, 30th through to 33rd vertebra of the vertebral column and forms part of the posterior wall of the pelvic cavity. It is formed by the fusion of the 4 vertebrae.

The first is the largest and resembles the lumbar vertebrae. The last 3 diminish in size; the last piece is often simply a nodule of bone. The anterior surface of the coccyx provides attachment for the anterior sacrococcygeal ligament and the levator ani and supports part of the rectum.

The posterior surface, at the base, articulates with the sacrum by a fibrocartilage joint. The borders of the coccyx are narrow and provide attachment on either side to several ligaments. The terminus, or apex, is rounded, and is attached to the tendon of the external sphincter.

Vertebral Positions C1 - S5



Ligaments Of The Spine

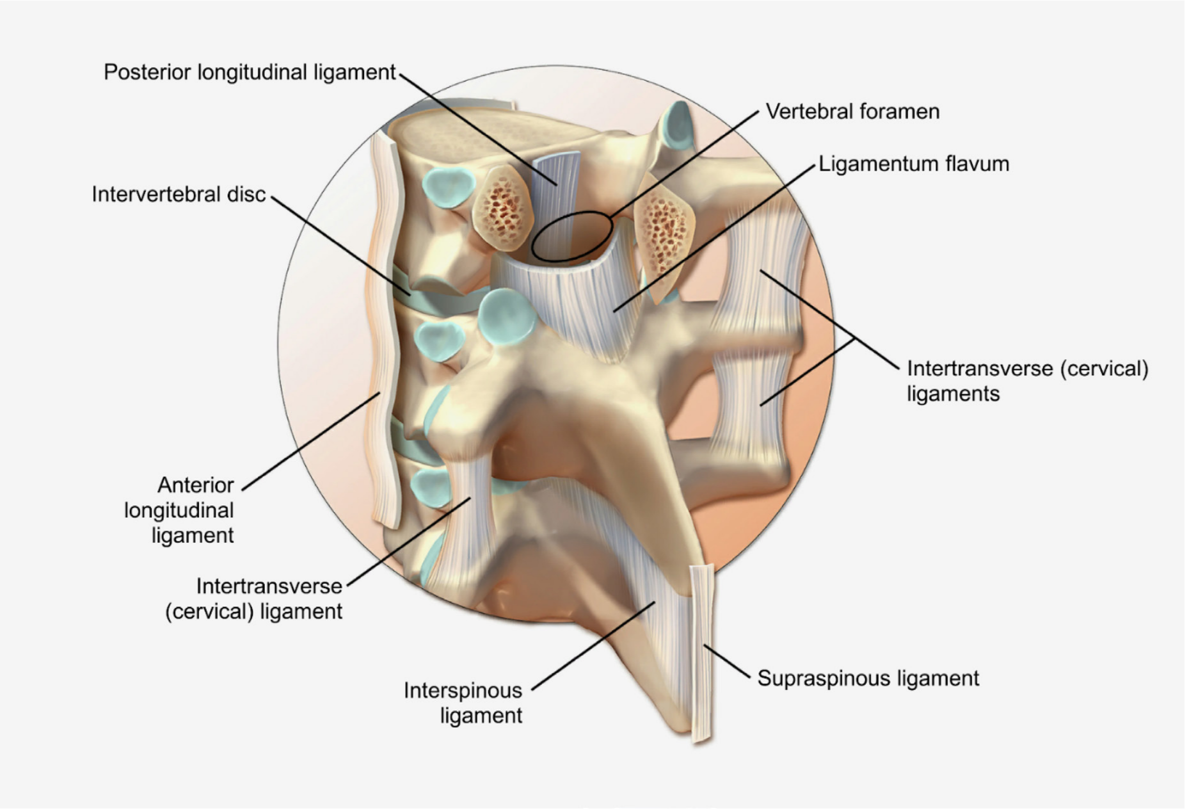
The ligaments of the spine support and reinforce the joints of the vertebral column.

These joints include the joints between the vertebral bodies, joints between vertebral arches and the craniovertebral joints. Ligaments connecting the vertebral bodies include the anterior and posterior longitudinal ligaments.

The vertebral arches are connected by the ligamentum flavum, the interspinous ligaments, the supraspinous ligament, the nuchal ligament, and the inter transverse ligaments.

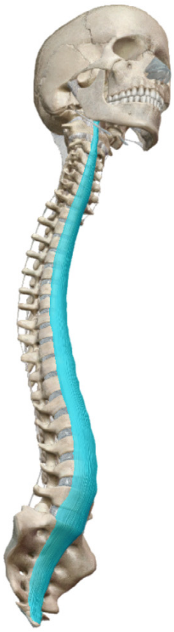
Two types of the craniovertebral joints exist: The atlantoaxial and the atlantic-occipital.

The former connects the axis to the atlas, while the latter connects the atlas to the occipital bone. The craniovertebral joints are reinforced by the atlantic-occipital membranes, the alar ligaments, the transverse ligaments of the atlas, and the tectorial membranes.



Ligaments of the spine reinforce the articulations of the vertebral column as the spine moves and bends. The anterior and posterior longitudinal ligaments connect the vertebral bodies and limit extension and flexion, respectively. Adjacent transverse processes are connected and supported by the inter transverse ligaments.

NB: Light blue highlights the ligament.

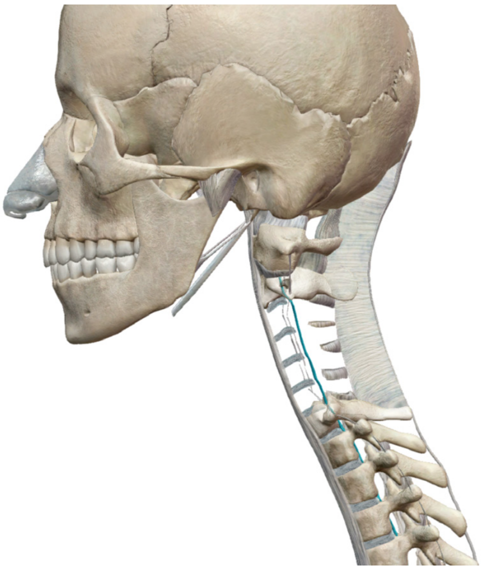


Anterior Longitudinal Ligament (ALL)

Primary spine stabiliser. About one inch wide, the ALL runs the entire length of the spine from the base of the skull to the sacrum. It connects the front (anterior) of the vertebral body to the front of the annulus fibrosis.

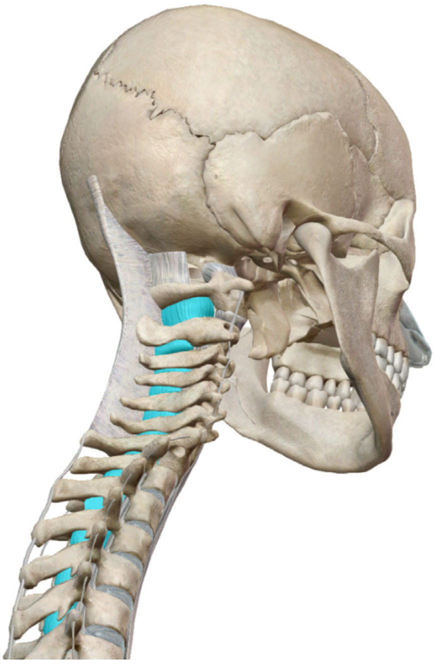
Supraspinous Ligament

This ligament attaches the tip of each spinous process to the other.



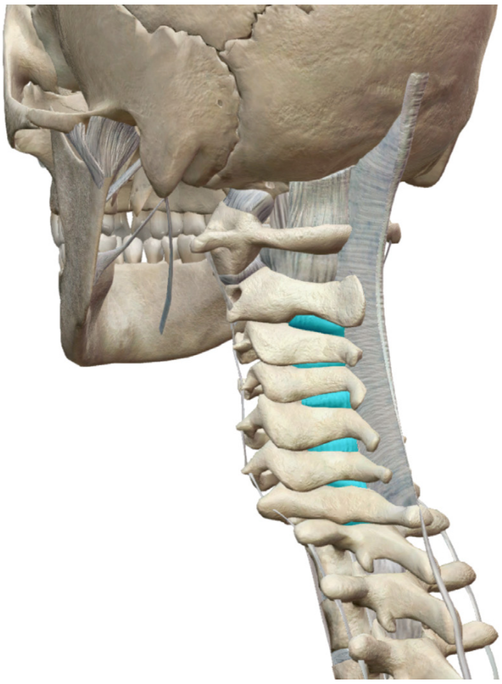
Posterior Longitudinal Ligament (PLL)

Primary spine stabiliser. About one inch wide, the PLL runs the entire length of the spine from the base of the skull to sacrum. It connects the back (posterior) of the vertebral body to the back of the annulus fibrosus.



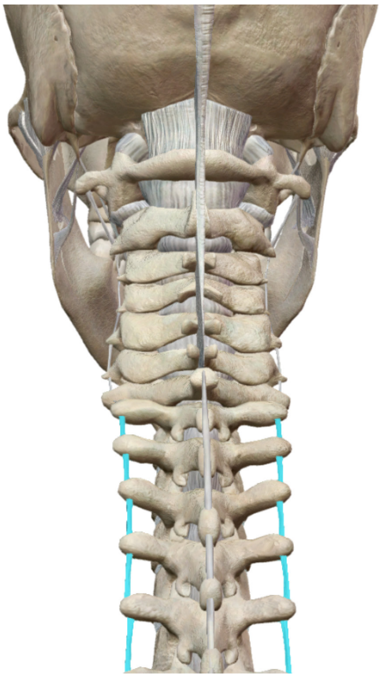
Interspinous Ligament

This thin ligament attaches to another ligament, called the ligamentum flavum, which runs deep into the spinal column.



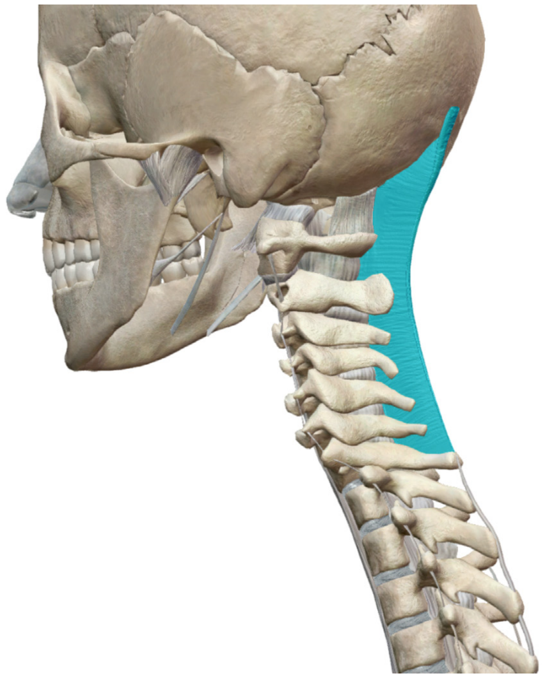
Ligamentum Flavum

The strongest ligament. This yellow ligament is the strongest one. It runs from the base of the skull to the pelvis, in front of and between the lamina, and protects the spinal cord and nerves. The ligamentum flavum also runs in front of the facet joint capsules.



Intertransverse Ligament

The intertransverse ligaments are ligaments that are placed between the transverse processes of the spine. In the cervical region, they consist of a few irregular, scattered fibres that are often replaced by muscles.



Nuchal Ligament

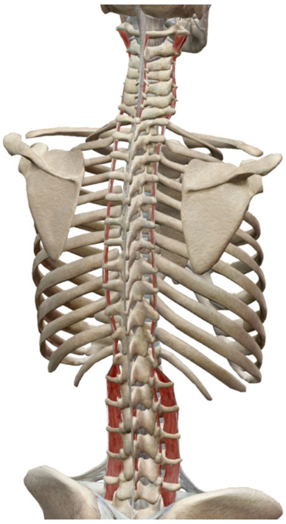
The ligament that runs from the base of your external occipital protuberance (the bump on the back of your head) to the spinous process of the 7th cervical vertebrae.

Muscles And Tendons Of The Spine

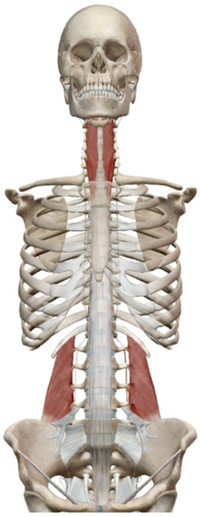
The muscular system of the spine is complex, with several different muscles playing important roles. The primary function of the muscles is to support and stabilise the spine. Specific muscles are associated with the movement of parts of the anatomy. For example, the Sternocleidomastoid muscle assists with movement of the head, while the Psoas Major muscle is associated with flexion of the thigh.

Muscles, either individually or in groups, are supported by fascia. Fascia is strong connective tissue. The tendon that attaches muscle to bone is part of the fascia. The muscles in the vertebral column serve to flex, rotate, or extend the spine.

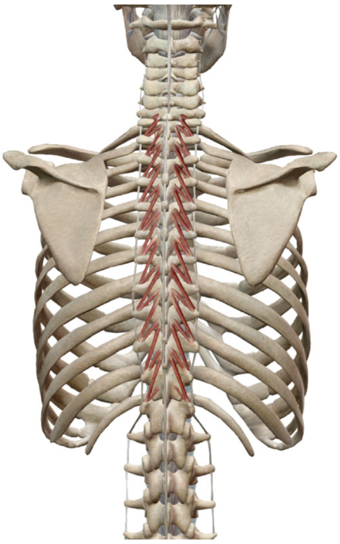
- **Anterior Scalene**
- **Middle Scalene**
- **Posterior Scalene**



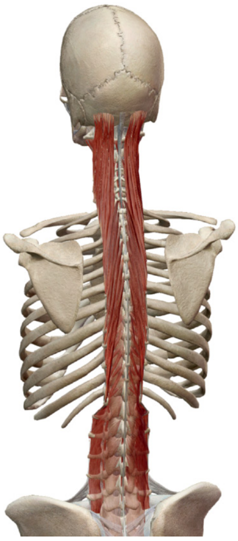
- **Interspinales**
- **Intertransversarii**



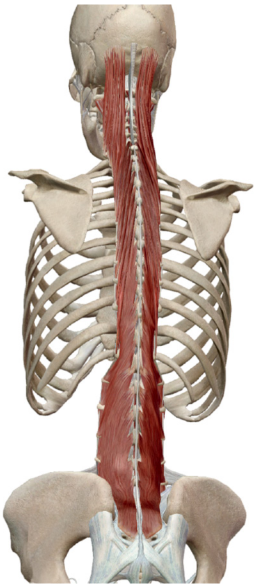
- **Longus Capitis**
- **Longus Colli**
- **Quadratus Lumborum**



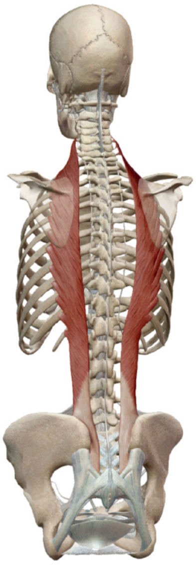
- **Rotatores Breves**
- **Rotatores Longi**



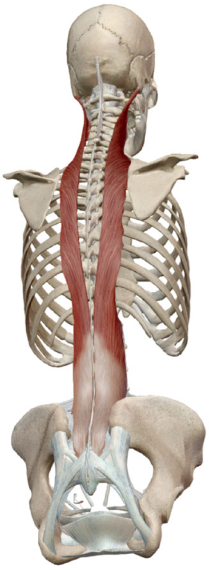
- **Semispinalis Capitis**
- **Semispinalis Cervicis**
- **Semispinalis Thoracis**



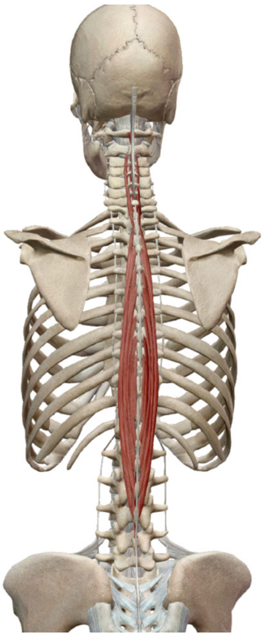
- Semispinalis
- Multifidus
- Rotatores



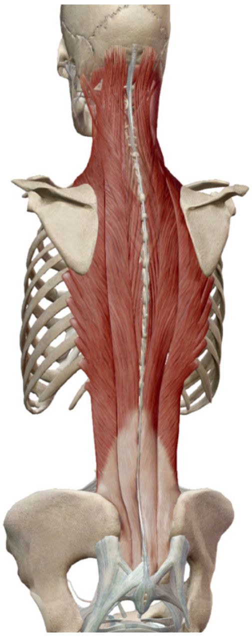
- Iliocostalis Cervicis
- Iliocostalis Thoracis
- Iliocostalis Lumborum



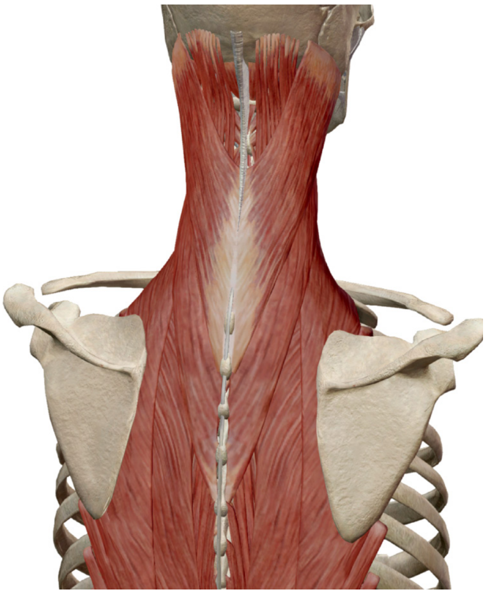
- Longissimus Capitis
- Longissimus Cervicis
- Longissimus Thoracis



- Spinalis Cervicis
- Spinalis Thoracis



- Spinalis
- Longissimus
- Iliocostalis

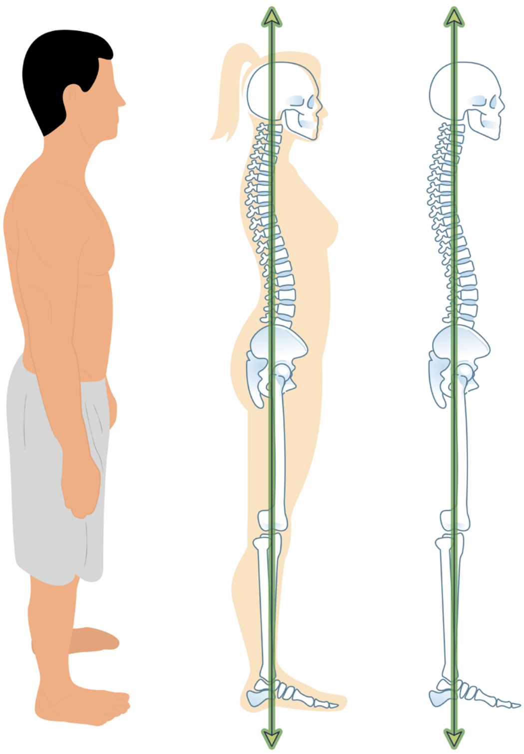


- Splenius Capitis
- Splenius Cervicis

Posture

The spine develops from a single curve during foetal development into four curves, two concave, and two convex. The cervical and lumbar regions with concave curves give the greatest range of movement.

Neutral Balanced

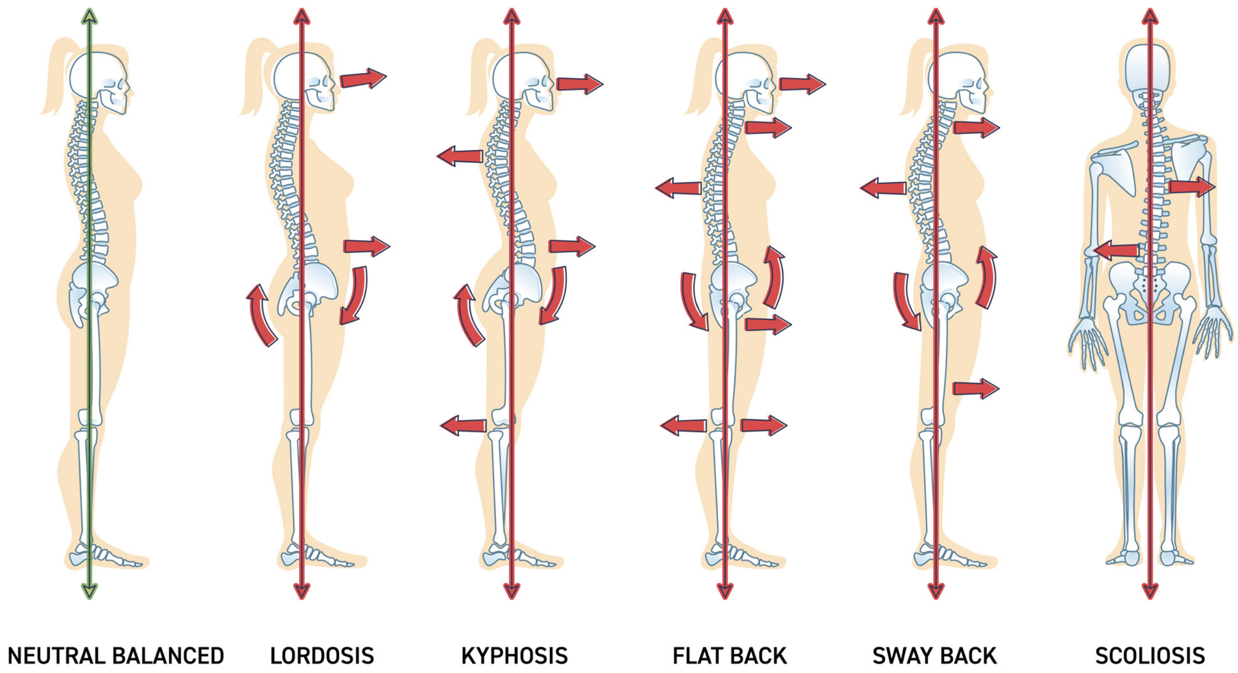


NEUTRAL SPINE

A neutral spine describes the ideal position to minimise stress on the vertebrae and its ligaments.

In turn, achieving this posture during physical activity will help to reduce the risks of back pain.
It will also allow musculature to perform in a balanced way and maintain this optimal spinal curvature.

POSTURAL ABNORMALITY (DEVIATION)



Deviation from optimal spinal posture can be common. Pregnancy can enhance the curvature of the lower spine to shift the centre of gravity backwards and compensate for the extra weight at the front.

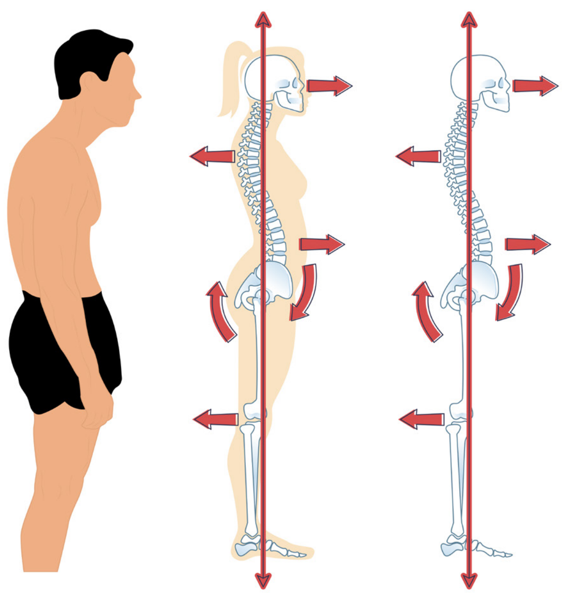
Postural abnormality can be present at birth, or can occur at any stage of life, and can be temporary or permanent.

Some of the major postural deviations are below:

Kyphosis

An abnormally excessive convex curvature of the spine as it occurs in the thoracic and sacral regions.

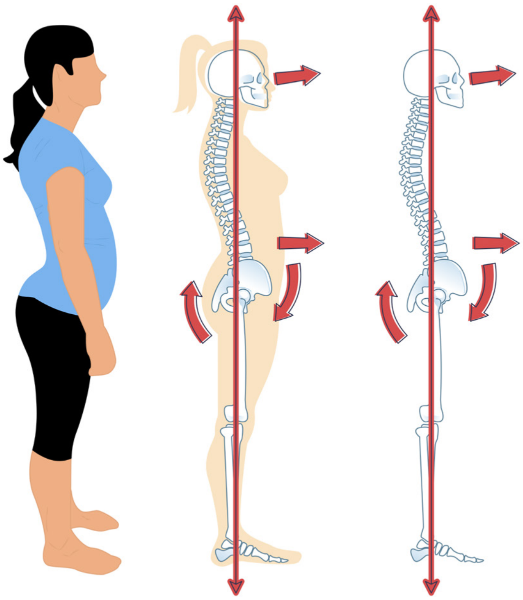
NB: Characterised by an abnormally rounded upper back.



Lordosis

Defined as an excessive inward curve of the lower back.

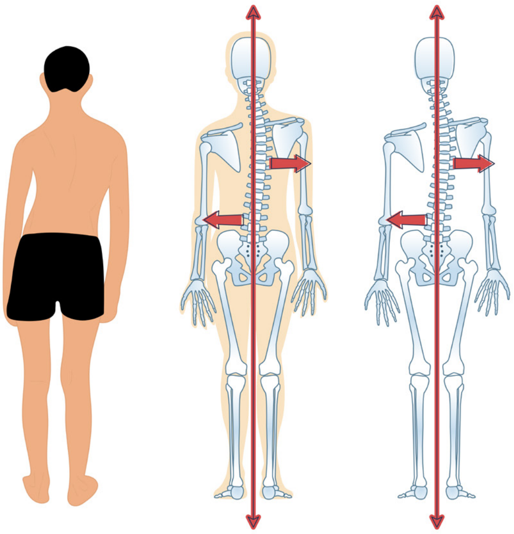
NB: Lordosis can occur at the cervical spine also.



Scoliosis

Defined as the abnormal lateral curvature of the spine.

NB: A sideways curve which is often s-shaped or c-shaped.

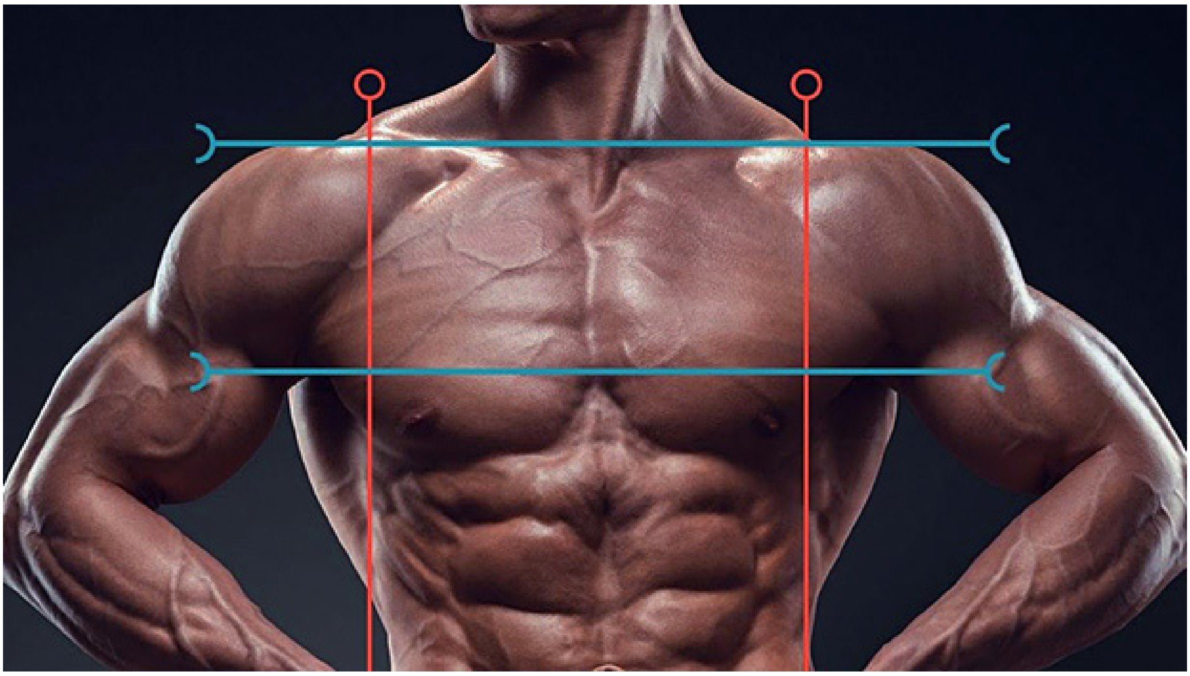


Muscle Imbalance

The term “muscle imbalance” refers to a condition in the body that is present when opposing muscles are out of balance with one another in terms of strength, length and/or tension. Opposing muscles are those that perform opposite functions. They may oppose one another spatially left-to-right or front-to-back. For example, quadriceps are responsible for extending the knee and the hamstring is responsible for flexing it. One is on the front of the thigh, and the other, the back.

When opposing muscle groups are imbalanced, one group is tighter and shorter than the other, which is elongated and lax. Imbalances can cause pain both directly and indirectly. The muscle that is shorter and tighter is chronically tense; muscle memory has trained it to stay in its shortened position. Tense muscles can develop knots called trigger points that cause localized and referred pain. The weaker muscle is prone to strain.

Muscle imbalances can interfere with posture. Tight muscles exert a pulling force on nearby strictures. If a muscle connected to the lumbar spine is tight, for example, it can pull the spine forward and create what is called anterior pelvic tilt. If an imbalance causes postural distortion, pain and dysfunction may be felt throughout the body.



What Causes Muscle Imbalance?

Generally, repetitive activity is to blame. This could occur from poor exercise habits or from repetitive movements required by your work. When you engage a muscle, the brain sends a signal to its opposing muscle to relax; this allows the engaging muscle to tense up without resistance. The process is called reciprocal inhibition. Once muscle memory sets in, the tension and laxity can become chronic.

Posture and Core Stability

MODULE 2:
AXIAL SKELETON AND THE STRUCTURE AND FUNCTION OF THE CORE

Long periods of inactivity or sitting down can have an adverse effect on posture; posture being the optimal alignment of a joint or joints. In addition, badly designed programs that place an emphasis on a limited number of muscles or activities that are very repetitive can also adversely affect posture.

Sitting, arguably the most negative postural stress encourages a rounded upper back and protracted shoulders as well as a forward head position. Sitting using a computer keyboard is a prime example of another “posture buster” and a habitually rounded upper back is commonly referred to as hyperkyphosis. This hyper kyphotic posture then becomes the norm – even in the standing position.

Poor posture is caused by shortened muscles, poor flexibility and a lack of strength in the muscles responsible for maintaining good posture against gravity and bad habits such as slouching.

As sedentary jobs and subsequently poor posture are so common, instructors should endeavour to include stretches and strengthening exercises in their training programs which help to undo the damage of habitual sitting and slouching. This generally involves stretching the muscles on the front of the body and strengthening those on the back.

EXERCISES THAT MEET THE FOLLOWING CRITERIA WILL ALSO HELP ADDRESS POSTURAL ISSUE:

- **Involve a full range of movement**
- **Be compound, functional movement patterns**
- **Are performed standing and/or unsupported**
- **Utilise free weights and cables rather than machines**

The development of a strong and stable core is championed by many as the key to improved/pain-free function and sporting excellence.

Understanding Static and Dynamic posture is necessary for trying to promote sound functional movement. There are a number of areas that must be considered in gaining a complete and well-informed understanding of this often misunderstood and controversial area.

Areas that are often misunderstood:

- **The structures that makeup the core**
- **The function of the core**
- **Core activation as the foundation to good posture**
- **What equipment is commonly used in core training**
- **Exercise prescription**

The structure of the Core

If you remove the arms and legs, the core is what remains. Often the core is considered to include only the abdominal and lower back muscles. This is too narrow a view since when discussing the core muscles the powerful hip and upper back muscles should not be overlooked.

ELIPHINSTONE AND POOK (1998): DEFINE THE FUNCTIONAL ROLE OF THE CORE AS:

"The ability of your trunk to support the effort and forces from your arms and legs, so that muscles and joints can perform in their safest, strongest and most effective positions."

The core (trunk) can be thought of as providing a link between the lower and the upper body. With that in mind, the main focus of core training is to address any functional deficit in trunk stabilisation and/or movement in order to provide the necessary spinal support and a strong and adaptable platform for the actions of our arms and legs.

THE BODY IS COMPOSED OF A SERIES OF MUSCLE LAYERS:

- **Deep**
- **Middle**
- **Outer**

NB: All 3 must be considered when discussing the core

Deep Layer Muscles

- **Intertransversarii**
- **Rotatores**
- **Multifidus**
- **Interspinales**

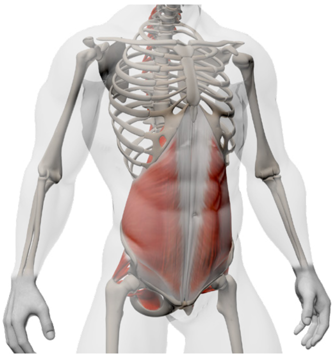
MOVEMENTS OF THE SPINE AND EXTREMITIES CAN BE DIVIDED INTO TWO CATEGORIES:

- **Physiological movements**
- **Accessory movements**

Gross physiological movements are responsible for large motions of the body e.g. bending.
In contrast, accessory muscles are responsible for controlling movements that occur within a joint. Think when bending to pick up an object from the floor the spine moves into a flexed position (physiological) however there is also movement at each vertebral segment (accessory).

Each segment depending on the task will bend, rotate or slide (shear) on top of one other. To control all accessory motions, there are small position sense muscles that cross from one vertebral segment to another. It is of vital importance to have good position sense muscle function if an injury is to be avoided.

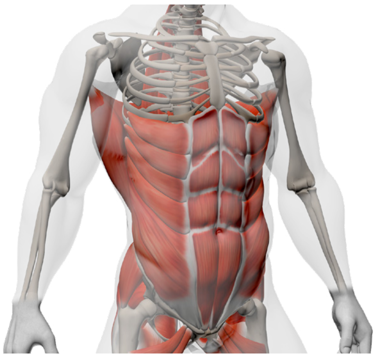
Middle Layer (Inner Unit) Muscles

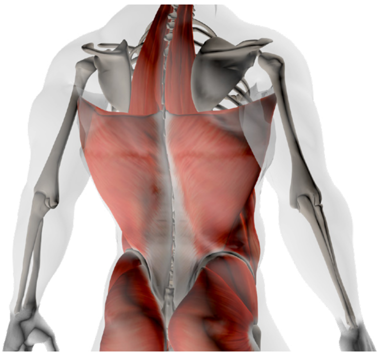


- **Transverse abdominis (TVA)**
- **Internal obliques**
- **Multifidus**
- **Diaphragm**
- **Pelvic floor**

The spine is stabilised when these muscles contract as they create a non-compressible cylinder around it. This also forms the working foundation from which the arms and legs can function optimally. Richardson et al (1999), showed that inner unit activation occurs prior to involvement of the extremities and that faulty inner unit recruitment increased the likelihood of low back dysfunction.

Outer Muscle Layer Muscles





- **Rectus abdominis**
- **External obliques**
- **Erector spinae**
- **Latissimus dorsi**
- **Gluteals**
- **Adductors**

The above form muscle slings. These muscle slings contribute to the ability to maintain an optimal working relationship between joints and to integrate the various body segments for successful motion.

The Risks of Instability and Postural Deviation

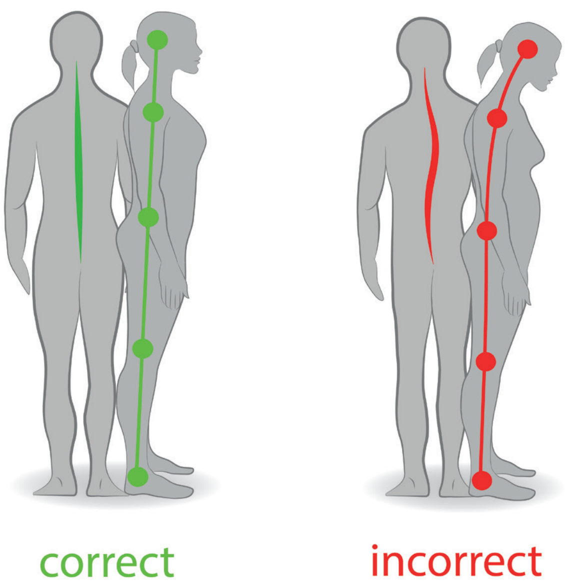
PANJABI (1992) DEFINES CLINICAL SPINAL INSTABILITY AS:

"A significant decrease in the capacity of the stabilising system of the spine to maintain the inter-vertebral neutral zones within physiological limits which results in pain and disability".

Failure to stabilise/control core movement increases the risk of acute (short term) and chronic (long term) injury to the vertebral column. The key role of the trunk muscles in providing stability to the lumbar spine is well established (Granata and Marras, 2000).

It should be noted, that our increasingly sedentary lifestyles do little to promote the optimal function of the core. For example, habitual seated positions do little to promote neutral spines, but rather promote flexed postures which actually place the core at a biomechanical disadvantage. Similarly, the use of backrests reduces the need for core activation, therefore, increasing the risk of acute and chronic injury to the spine and its associated structures. Just as a sedentary lifestyle can have a negative impact on core function so too can some of our exercise choices. Within the fitness industry, for example, there is often an over-reliance on fixed path resistance machines.

Machines are popular choices with both trainers and clients for many reasons; since they offer a supported environment they place few if any demands on the core musculature. These machines also train the body in terms of individual muscle groups and so do little to promote the integrated function of our various body parts. So in effect, machines train us to be strong in isolated muscle groups whilst placing limited demands on the core, if not supplemented and balanced with exercises that progressively challenge the core, this is a recipe for dysfunction and injury.



Postural deviations such as kyphosis or lordosis also create muscular dysfunction around the core and reduce the ability to hold good form and maintain a neutral spine during exercise and activity. When the exercise increases the forces placed through the joints and the core, the muscles will shift into their 'strongest' positions, which inevitably falls in line with their dominant posture.

It is often the case, but not the rule that an increasingly sedentary lifestyle and becoming overweight can lead to postural deviations and weakness within core musculature. Too much time in a seated position can lead to reductions in core muscle activation and a lack of neural drive so that even relatively light loads placed upon the core muscles exceed their ability to cope. Abdominal obesity shifts the centre of gravity forward which in turn leads to an increased chance of postural deviations like lumbar lordosis or a swayback posture where the hips are translated forward. Such postural deviations lead to incorrect loading patterns which increase the strain in the spine and surrounding joint structures.

Ligaments and Discs

Spinal discs sit between each pair of vertebrae, providing both shock absorption and an element of support for the spine. Ligaments run the entire length of the vertebral bodies (e.g. the anterior and posterior longitudinal ligaments) and between spinous and transverse processes (interspinous and intertransverse ligaments) and also help guide and support spinal movement. However, without its supporting musculature, despite its passive structures the human spine is inherently unstable and can only withstand a load of 4-5 lb before it buckles into flexion (Panjabi et al, 1989).

It is, therefore, a basic principle of core stabilisation that during movement, a failure to activate local stabiliser muscles will result in excessive forces being placed on these passive structures.

Intra-abdominal Pressure

Some identifiable core muscles contract simultaneously causing an increase in pressure within the abdomen which helps to maintain stability and reduce pressure on the inter-vertebral discs in the lumbar spine.

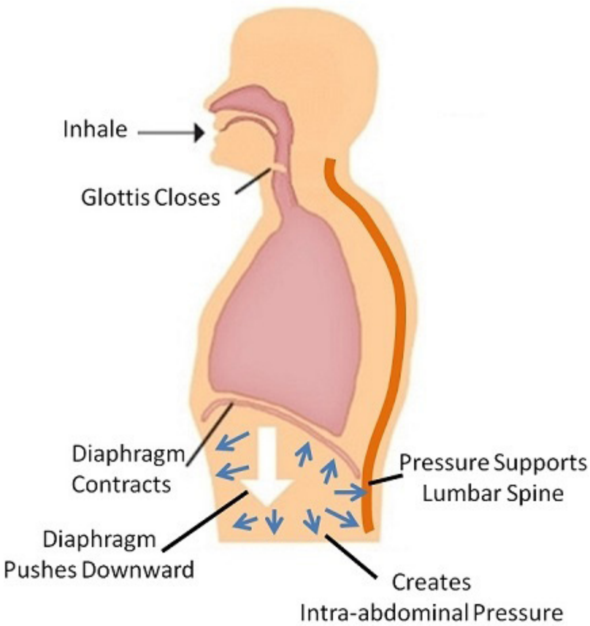
As Norris (2000) states:

“Intra-abdominal pressure is created by synchronous contraction of the abdominal muscles, the diaphragm, and the muscles of the pelvic floor.”

The trunk should be thought of as a cylinder. The diaphragm forms the lid of the cylinder and the pelvic floor the base. The walls of the cylinder are created by the deep abdominals (TVA and the internal obliques). During contraction of the abdominals the walls are pulled in and up while if a deep breath is taken, the diaphragm is lowered, compressing the cylinder and the abdominal contents from the top. Provided that the pelvic floor (the base of the cylinder) has sufficient integrity, it will resist the action of the diaphragm and the downward displacement of the internal organs (viscera). This is how the non-compressible cylinder is formed. This gives the torso stiffness and a more rigid structure.

Such a structure is better able to resist the stresses placed on the lumbar spine, particularly during lifting movements. This stabilises the spine and forms the working foundation from which the bodies extremities can function optimally. As Twomey and Taylor (1987) state, making the trunk into a more rigid cylinder reduces axial compression and shear loads and transmits loads over a wider area.

Note: a good example of the natural functioning of IAP would be when muscles contract reflexively to defend the abdomen from a punch to the stomach.

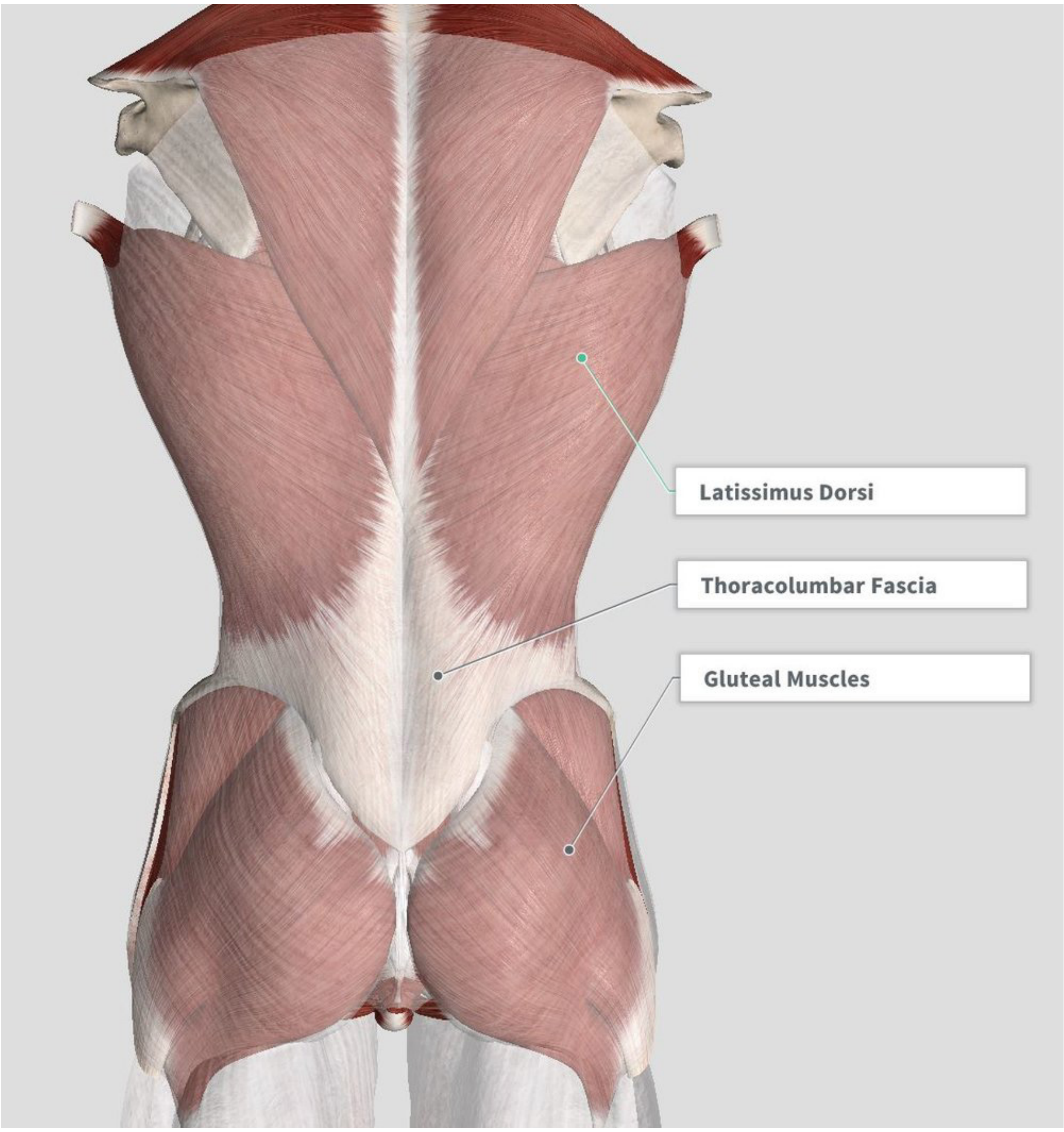


The Thoracolumbar Fascia (TLF)

The TLF is a broad, flat sheath of fascia that stretches across the thorax and lumbar region and is involved in passive and active stabilisation of the spine. It serves as an anchor for many muscle attachments, especially that of the Transverse Abdominis (TVA), and aids stability for the second to the fifth lumbar vertebrae.

The function of the TLF can be likened to the tightening of the strings on a girdle around the waist. Stability is created by lateral tension or a pulling action from the TVA and internal obliques that is transferred to the fibres of TLF. This, in turn, creates a hoop-like tension through the TLF. This tension produces an extension force on the lumbar spine, which resists the natural pull of lifting movements into spinal flexion. This phenomenon has been referred to as TLF gain (Gracovetsky, 1985).

The TLF can be seen as adding to the tension and the ability to resist the stress of the walls of the non-compressible cylinder created by IAP and therefore, adding to our core stability.

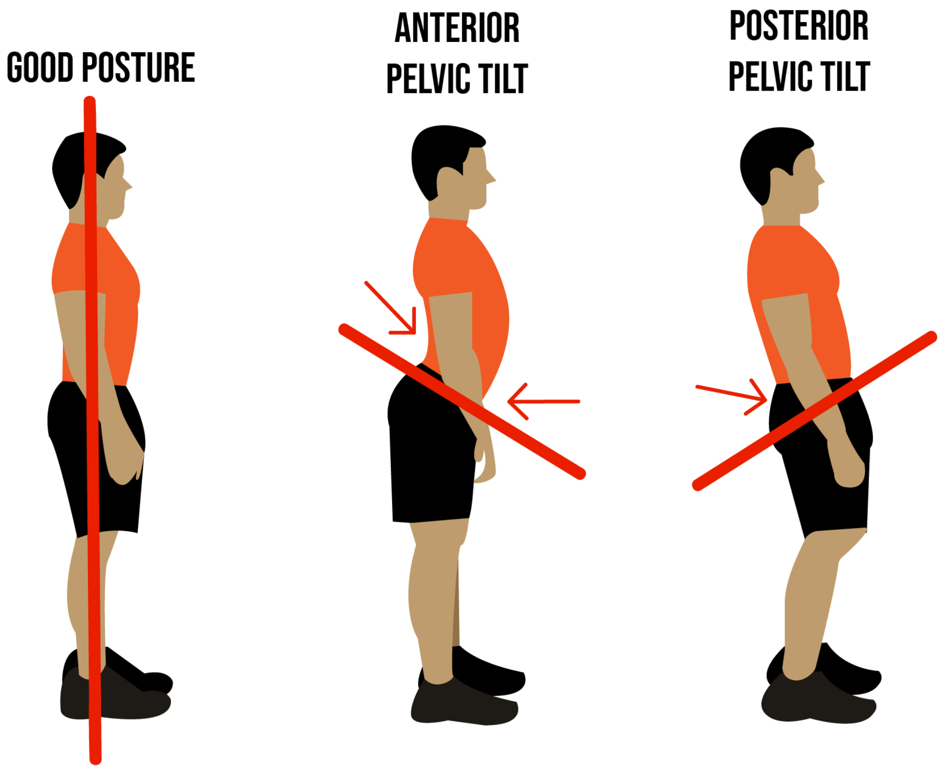


Neutral Spine

A neutral position for the lumbar spine is midway between full flexion and full extension as determined by the position of the pelvis. An increase in anterior pelvic tilt will result in greater spinal extension and conversely, an increase in posterior pelvic tilt will produce greater spinal flexion.

A neutral spine position is maintained exclusively through muscular activity, thereby placing minimal stress on the passive structures of the spine (ligaments and discs).

Optimal spinal alignment is also found whilst in a neutral position therefore the best position from the trunk muscles can work.



Integrated Core Function

We should not overlook the contribution of the more superficial outer unit musculature in this stabilising role. As an example of this, it should be seen that the contraction of gluteus maximus muscles via their attachment to the TLF will have the effect of tightening this fascia. Consequently, an efficient gluteal function is fundamental to back stability as are many other superficial muscles.

Abdominal Bracing

The act of tightening or stiffening the abdominal muscles (as if bracing for a punch in the stomach) is believed by McGill, (2002) to be the most effective method of stabilising the core. This bracing technique activates a simultaneous or co-contraction of the abdominal and lumbar extensor muscles. McGill recommends the performance of an abdominal brace in exercise/rehabilitative and functional situations.

To teach abdominal bracing McGill recommends stiffening a joint, like the elbow, to demonstrate. Actively stiffen the biceps and triceps and palpate the muscles on each side of the joint to get the idea. This can be practised at different percentages of maximum contractions e.g. 10, 20, 50%. Once the basic idea has been grasped replicate this co-contraction on the torso. With abdominal bracing the abdominal wall is neither pushed out nor pulled in.

Core equipment

Equipment such as stability balls, BOSU and wobble boards are commonly associated with training for core stability. Each piece of equipment has an unstable surface amplifying the instability of the user. This enforced instability increases the activation of the core musculature which, has to work harder to provide the necessary stabilisation.

The heightened activation that these training mediums provide means that their use is appropriate as a starting point for any programme targeted at the core musculature. What must be remembered is that the core will be at work in all situations and, therefore, core training is not solely about the use of these mediums.

Consequently, in the interests of maintaining the functionality of our training at some point in the exercise progression these mediums should be side lined in favour of exercises performed on a more familiar and more stable surface – the floor!

SOME CORE EXERCISE POSSIBILITIES ARE IN THE VIDEO BELOW:

Exercise Prescription

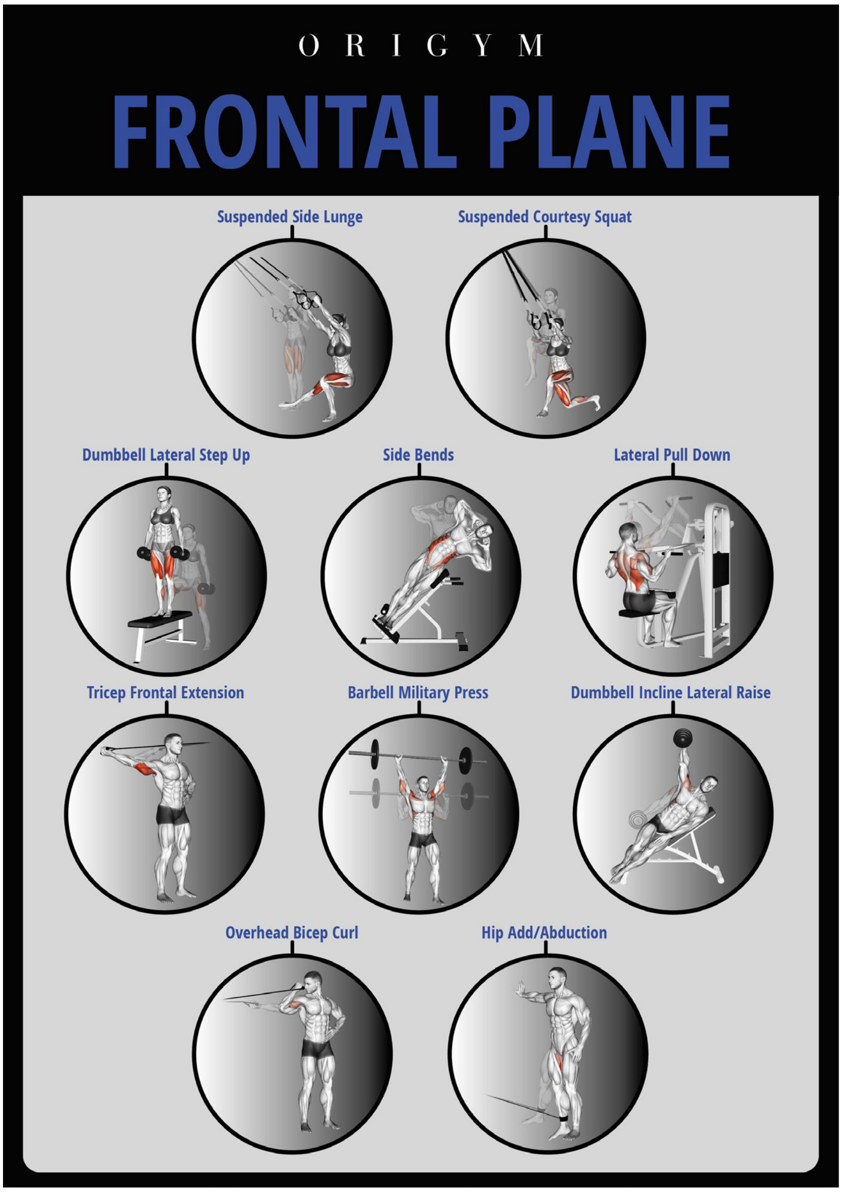
To progressively train the core muscles, select exercises based on increasing amounts of core contribution. This may be done using a variety of different training modalities body positions and movements.

A possible exercise progression first utilises floor-based positions and unstable surface training to address any existing deficiencies in core function.

Clients would then be given more functional exercises in standing positions which seek to place demands on the core in all three planes of motion:

- **Sagittal**
- **Frontal**
- **Transverse**

Downloadable resources for multi-planar exercises:



Flexibility

MODULE 2:
AXIAL SKELETON AND THE STRUCTURE AND FUNCTION OF THE CORE

Introduction

Flexibility is best defined as the range of movement at a joint or joints and is influenced by joint structure, the shape of the bones and cartilage involved and the length and elasticity of the muscles that cross the joint.

Flexibility varies significantly from person to person and is specific to individuals. Poor flexibility can have an adverse effect on posture and function but so too can excessive flexibility or hypermobility.

While flexibility is, in many ways, genetic, some sports and activities are responsible for a reduction in flexibility. For example, long periods of sitting can shorten several important muscles including the hamstrings and hip flexors whereas jogging and cycling, activities that utilise a small range of movement, can also cause muscles to shorten. This phenomenon is called adaptive shortening.

Some activities are linked to or require a high degree of flexibility; the most obvious examples being dance, gymnastics and most martial arts. Flexibility is developed by stretching which involves moving the muscle origin and insertion further apart.

THERE ARE SEVERAL NOTABLE BENEFITS TO STRETCHING:

- Increased range of movement.
- Reduced muscle tension.
- Increased physical and mental relaxation.
- Reduced risk of non-specific back pain.
- Possible reduced risk of DOMS (delayed onset muscle soreness).
- Decreased muscle viscosity resulting in smoother movements.
- Improved coordination.
- Improved proprioception.
- Improved circulation.
- Improved posture.
- Possible reduced risk of injury.

Range Of Motion

The range of motion (R.O.M) is the amount of motion available at a specific joint.

THE TABLE PROVIDES EXAMPLES OF JOINTS AND THE RANGES OF MOTION AVAILABLE AT THOSE JOINTS.

Joint	Action	Degrees of motion
Shoulder	Flexion	160 degrees
	Extension	50 degrees
	Abduction	180 degrees
	Internal rotation	45 degrees
	External rotation	90 degrees
Elbow	Flexion	160 degrees
	Extension	0 degrees
Hip	Flexion	120 degrees
	Extension	0-10 degrees
	Abduction	45 degrees
	Adduction	15 degrees
	Internal rotation	45 degrees
	External rotation	45 degrees
Knee	Flexion	140 degrees
	Extension	0 degrees
Ankle	Plantarflexion	45 degrees
	Dorsiflexion	20 degrees

Instructors should also ensure that there is an equal volume of pushing and pulling exercises and that dynamic and static stretches are utilised. Care should also be taken to ensure that all prescribed exercises are performed using good form.

Factors Affecting Flexibility

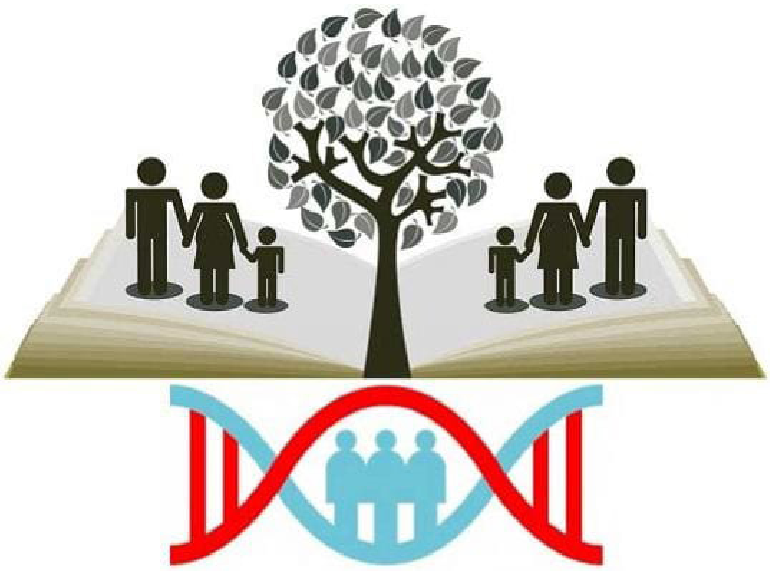
Flexibility can vary significantly from one individual to another and the potential for developing flexibility is, in part, limited by several factors:

Heredity

Hypermobility is a hereditary trait; some people are born with a tendency toward hypermobility or, what is incorrectly referred to as “double joints”. Hypermobility increases the risk of injury and joint dislocation and it essential that muscles are strengthened to protect at-risk joints.

Age

Babies are very flexible but, as they start to walk and more joint stability is required, muscles begin to tighten up. Younger people tend to be naturally more flexible than older people and muscle elasticity tends to decline with age unless regular stretching is performed.



Exercise history

Years of running or cycling can adversely affect flexibility while performing full-range movements such as deep squats, high kicks and other dynamic activities will enhance it. A well-designed resistance training program utilising full ranges of movement will positively influence flexibility whereas the same program performed using a shortened range of movement will reduce flexibility.

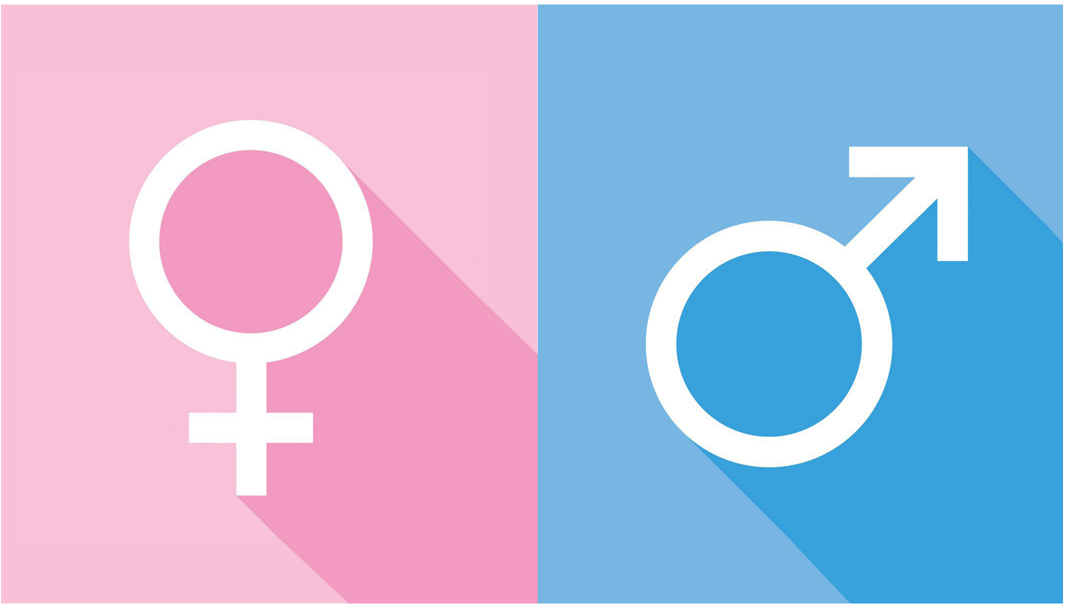
Temperature

Direct or indirect heat make muscles and tendons more elastic. Conversely, a decrease in temperature can significantly reduce flexibility.

Gender

Women tend to be naturally more flexible than men. The reasons are two-fold. Women have a higher amount of the hormone relaxin which does exactly what its name suggests – it relaxes soft tissue and muscle.

This facilitates greater flexibility. Relaxin levels increase significantly during pregnancy so that the women's body can stretch to accommodate the growing foetus and for the birth itself. Additionally, women are statistically more likely to participate in activities such as dancing or gymnastics where flexibility is important and therefore developed.



Fashion

High heels and tight skirts can adversely affect flexibility because they place muscles in a shortened position or restrict the range of movement.

Methods Of Stretching

There are several methods and types of stretching that an instructor should be familiar with so that they can choose the right one for their client:

ACTIVE STRETCHING

Active stretching involves effort from the individual doing the stretching. This may be because they adopt and hold a stretch themselves or use the antagonist of the target muscle to stretch the opposing muscle.

Examples include using the middle trapezius, rhomboids and posterior deltoids to horizontally extend the shoulders and retract the shoulder girdle to stretch the pectoralis major and anterior deltoids.

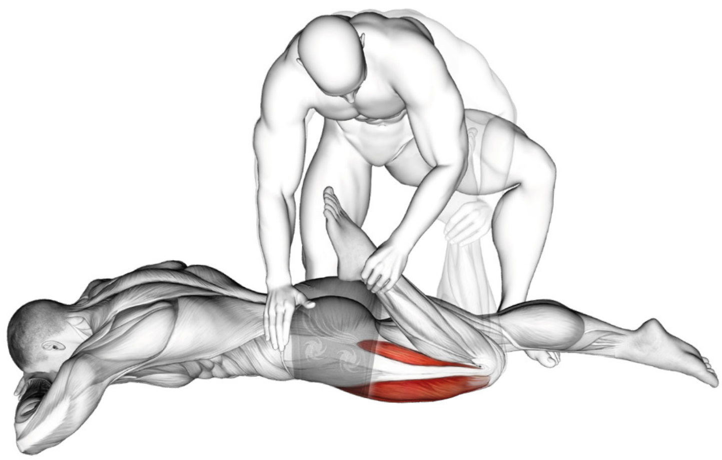
PASSIVE STRETCHING

Passive stretching uses an external force or a prop to stretch the target muscle. For example, a length of rope to stretch the hamstrings of one leg while lying on your back or the use of a partner. Passive stretches are usually better when a longer than usual stretch is required as they are comfortable and require little or no input from the client.

FACILITATED STRETCHING

Facilitated Stretching uses an isometric contraction of the target muscle to prepare it to stretch. This method encourages active stretching on the part of the client, avoiding additional passive stretching when possible. Facilitated stretching can be done with a partner or by yourself e.g. using a towel

NB: If a training partner or instructor is providing stretching assistance, it is essential that the force of the stretch is applied gradually and carefully and is accompanied by good communication between both parties as it’s all too easy to overstretch and cause injury.

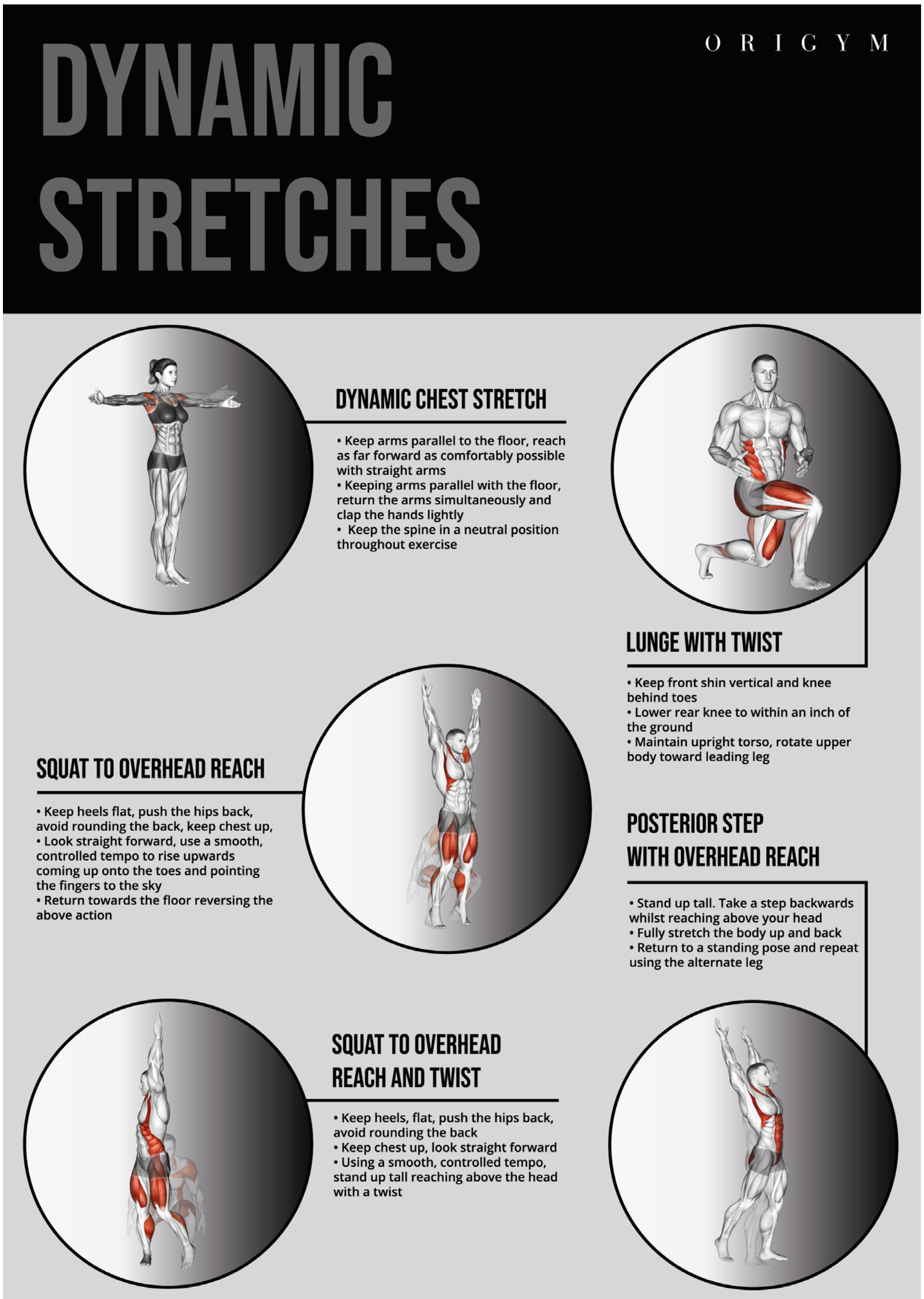


Dynamic (Warm-Up Stretches)

Dynamic stretches involve taking a muscle or group of muscles through a wide range of movement without stopping in the fully extended position. For example, to stretch the hamstrings, you could swing your legs forward from your hips in an alternating high kick.

Dynamic stretches are always performed smoothly and in a controlled manner to minimise the risk of injury and should mimic the movements or activities of the following workout or sport. Other examples of dynamic stretches include forward lunges with a waist twist, wide-foot squats and repeatedly reaching your arms up above your head.

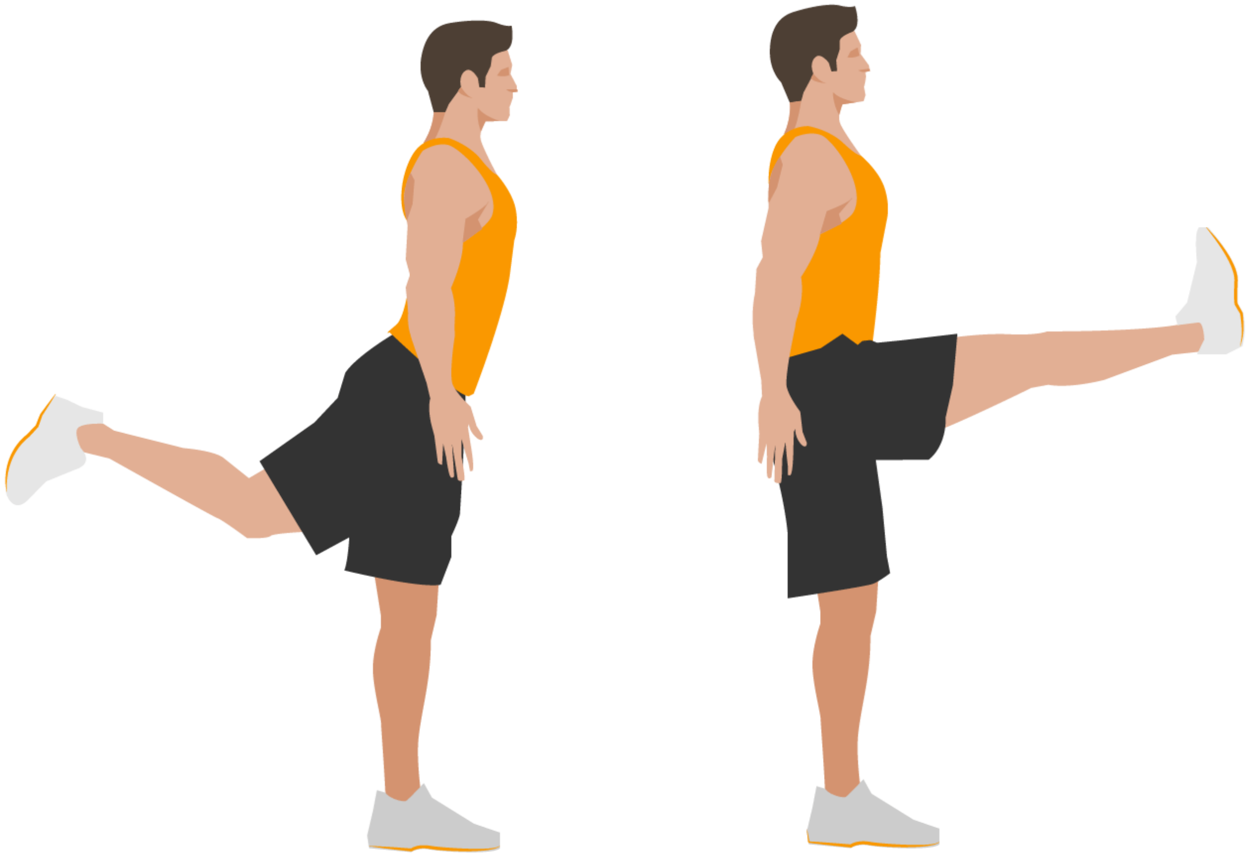
Dynamic stretches are normally best performed in sets of 10 - 15 repetitions and usually; 3 - 5 dynamic stretches; 1 - 2 sets each, are all that is required.



Ballistic

This form of stretching involves using momentum and bodyweight to stretch a muscle beyond its normal point of bind. This is done using repetitive bouncing movements. For the vast majority of exercisers, this method is not recommended as rapidly and forcefully exceeding the point of bind may cause injury.

However, for certain sports people and for stretching adhesions and stubborn fibrous tissue in physiotherapy and rehabilitation, it may be necessary to use ballistic stretching.



Static (Cool Down Stretches)

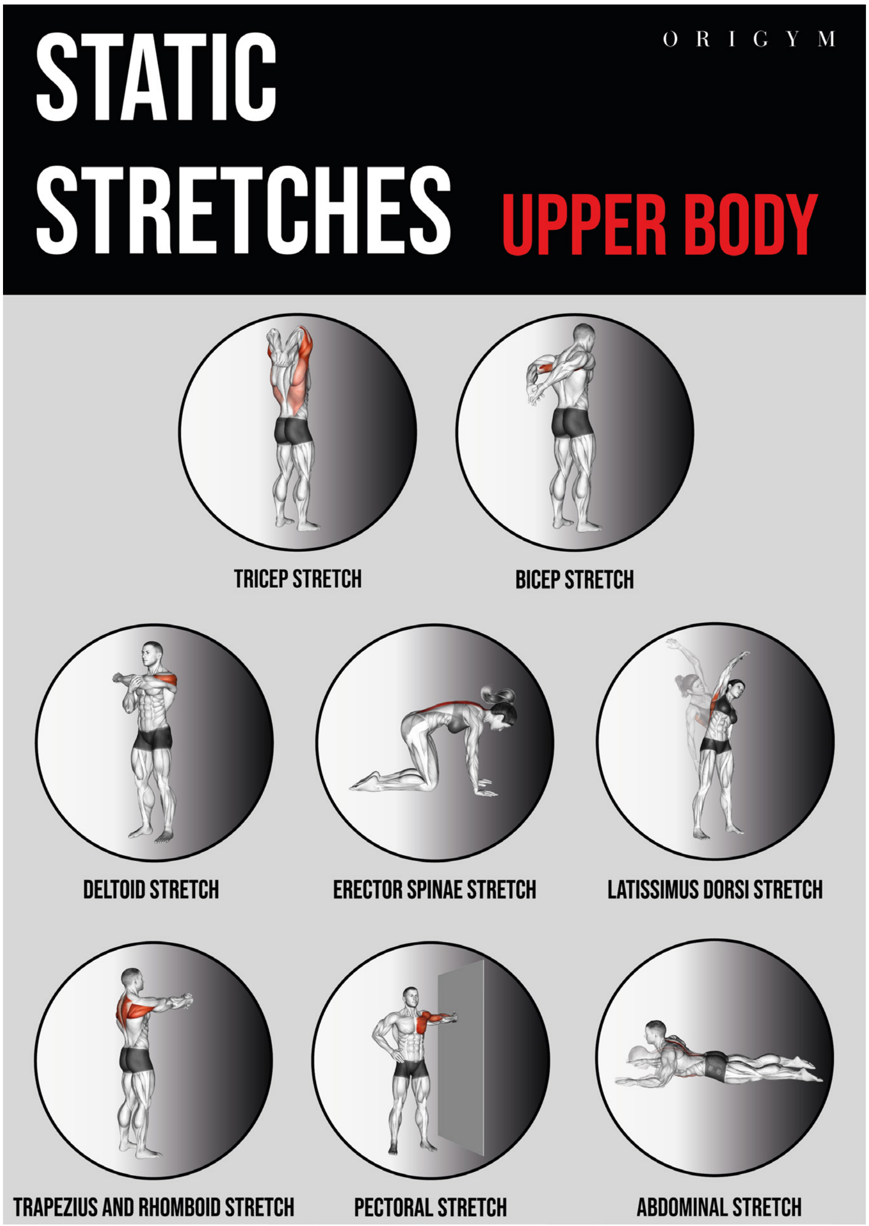
As the name suggests, static stretches involve little or no movement. The muscle in question is stretched until the point of bind (end of the range) is reached and that position is then held with no bouncing.

This should result in a mild stretching sensation but no actual pain in the target muscle or joints. Static stretches can be used to maintain the current level of flexibility (maintenance stretching) or increase flexibility (developmental stretching).

Maintenance stretches are held for 10 to 15 seconds and then released

Developmental stretches are held for 30-seconds and then released

Developmental stretches are usually increased incrementally as muscles gradually relax. In general, the longer a stretch is held, the greater the increase in flexibility will be. Care should be taken not to force a stretch or stretch a cold muscle as injury can result. It is also important to ensure that increases in the depth of a stretch come from elongation of the target muscle and not nearby joints e.g. rounding the lower back in a hamstring stretch.



Proprioceptive Neuromuscular Facilitation (PNF)

Proprioceptive neuromuscular facilitation (PNF) was first developed by Margaret Knott PT and Herman Kabat MD in the 1940s as a method of treating neurological dysfunctions. The treatment involved re-education of developmental movements and postures. This approach helped patients become more efficient in their movements and activities of daily living (ADLs). Muscle recruitment is enhanced through the use of the appropriate reflex and proprioceptive stimuli.

The efficient recruitment of motor patterns involves the use of the following PNF techniques:

- Resistance: resistance applied to a muscle contraction will facilitate a smooth motor response through optimal muscle contraction and relearning. The type and degree of resistance vary to achieve the appropriate motor response.
- Irradiation: irradiation is the overflow of neuronal excitation from stronger motor units to weaker ones, or units that may be inhibited by injury. This is done by applying graded resistance to larger muscle groups to enhance contraction in the weaker groups.
- Traction: the application of traction perpendicular to the arc of motion is used to facilitate an enhanced motor response.
- Manual pressure: neuromuscular responses are influenced by contact with the skin and deeper pressure receptors.
- The stretch reflex: The stretch reflex is a stimulus that increases the state of responsiveness of a motor unit to cortical stimulation. This reflex is stimulated by the quick elongation of muscle. The stretch stimulates muscle spindles to create a contraction. The muscle spindle and its reflex work as a feedback device that operates to maintain optimal muscle length. The reflex produces a brief isolated contraction.
- Approximation: A compressive force to approximate joint surfaces can facilitate a motor response and promote stability.

The 3 Types of PNF Methods

Contract-Relax

This is also known as "active assisted" stretching in some of the literature. The Golgi tendon organs lie in the tendon of a muscle that mediates the stimulation of inhibitory interneurons in the spinal cord that causes relaxation of that muscle's motor neuron. They also make excitatory connections with the motor neurons that supply the antagonists of that muscle. Since the Golgi tendon organs are in series with the muscle fibres they are stimulated by both passive stretch and active contraction of the muscle.

The Golgi tendon organ, therefore, acts as a transducer in a feedback circuit that helps to regulate muscle force through inhibition and relaxation of the muscle. The contract-relax technique uses the development of tension in a muscle by isotonic contraction to facilitate the relaxation and therefore stretch a muscle.

By facilitating the relaxation of muscles we can improve circulation and improve extensibility of myofascial tissues. To accomplish this the muscle is placed in a maximally stretched position and resistance is applied to a muscle contraction of the muscle that is being stretched (direct contraction) or that muscles antagonist (reciprocal relaxation).

Movement occurs during this contraction. Following this contraction the limb is relaxed and upon relaxation is actively or passively stretched further.

- **Direct Contraction:** For example, when stretching the hamstring, the hip is placed in 90 degrees with the patient lying on his back. The knee is flexed against moving resistance isotonically and then relaxed. The hip held at 90 degrees, the knee is moved into its fully extended position so as to apply a stretch to the hamstring.

- **Reciprocal Relaxation:** For example, when stretching the hamstring, the hip is placed in 90 degrees with the patient lying on his back. The knee is then extended against resistance, contracting the quadriceps. The activity in the quadriceps causes reciprocal inhibition of the hamstrings allowing for a greater stretch.

Hold-Relax

The hold-relax PNF stretching technique is used to facilitate the relaxation of muscles to gain range of motion. This method uses an isometric contraction rather than an isotonic one. To achieve this the limb is placed in pain-free range and an isometric contraction is sustained. The limb is then moved into the new range. The hold-relax method of PNF stretching is facilitated by the Golgi tendon organ to allow a reflexive relaxation of the muscle. It can be done individually or with assistance from a trainer or physical therapist. The danger of the hold-relax PNF stretching technique is that with this inhibition of muscle activity, it may predispose an athlete to injury if done prior to an athletic event.

Contract-Relax-Antagonist-Contract

The first part of this stretch is similar to the hold-relax whereby the muscle being stretched is isometrically contracted for 3 to 6 seconds, then the antagonist muscle will immediately contract for 3 to 6 seconds. The joint is then pushed into its new range.

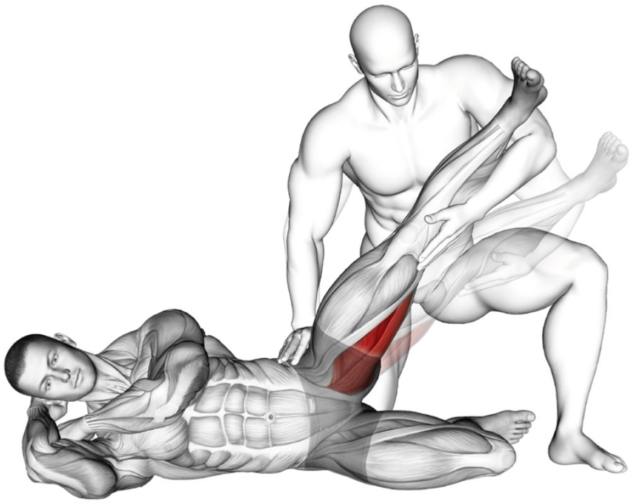
An example of a PNF stretching exercise to increase range of motion in the hamstrings is lying on your back with one leg pointing upwards. A partner carefully pushes the extended leg in the direction of the head of the one lying down. When the hamstrings are activated the partner prevents movement by keeping the leg in place. After the hamstrings relax again, the partner carefully pushes the leg even further towards the head. This process is repeated until the maximum point of bind it achieved.

A more advanced form of flexibility training that involves both the stretching and contraction of the muscle group being targeted. PNF stretching was originally developed as a form of rehabilitation, and to that effect, it is very effective.

Methodology

1. The person who is to be stretched assumes the position.

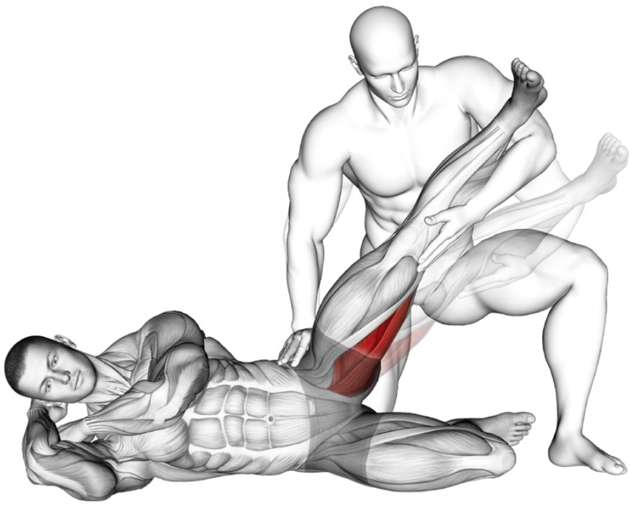
The PT the places the person into a stitched position. This is called their point of bind.



2. The person then contracts the stretched muscle (60-80% effort) for 3 - 6 seconds while the PT inhibits the movement.

NB: The force of the contraction should be relevant to the condition of the muscle. Ensure the person does not apply a maximum effort!

3. The person then relaxes the muscle, immediately the PT cautiously pushes passed the persons current "point of bind" and normal range of movement approximately for a further 5-20 degrees.



Allow 30 seconds of recovery (whilst in the new bind).

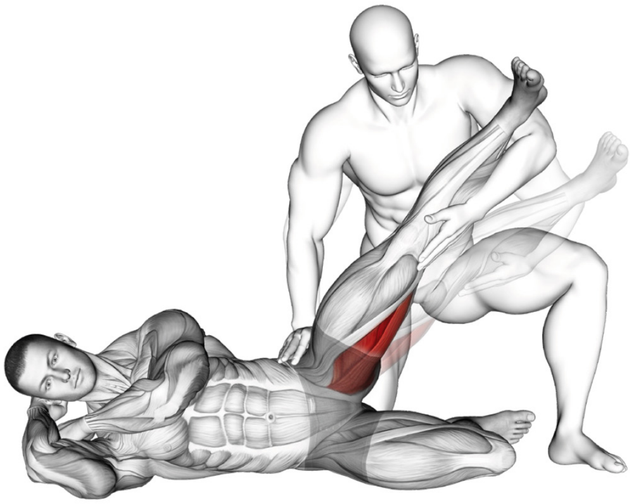
Repeat the procedure 2 - 4 times.

ADVANTAGES

- Large increases in the range of motion.

DISADVANTAGES

- For most exercises a partner is necessary.
- Decreases in maximum strength after performing PNF.



NB: When your client's range of motion has to be increased, PNF is a very useful method.

Because of the large amount of stress on the muscles, it is best to perform it on a separate day instead of a training day. Just like static stretching a proper warm-up beforehand is necessary.

Neuromuscular Mechanisms

PNF STRETCHING: THE ROLE OF THE STRETCH REFLEX

The muscle spindle is a long thin nerve receptor found within the muscle. Information from this receptor transmits information to the spinal cord regarding muscle length and the speed of lengthening. When a muscle is stretched quickly this muscle spindle fires and causes a reflexive contraction within that muscle that is undergoing the stretch. The greater the speed of stretch, the stronger the reflex contraction in the muscle being stretched.

PNF STRETCHING: AUTOGENIC INHIBITION:

Inhibition of the antagonist muscle group is mediated by the muscle spindle. If the agonist muscle contracts, then the spindle fires, sending messages to the spinal cord causing the antagonist muscle to relax.

PNF STRETCHING: RECIPROCAL INHIBITION

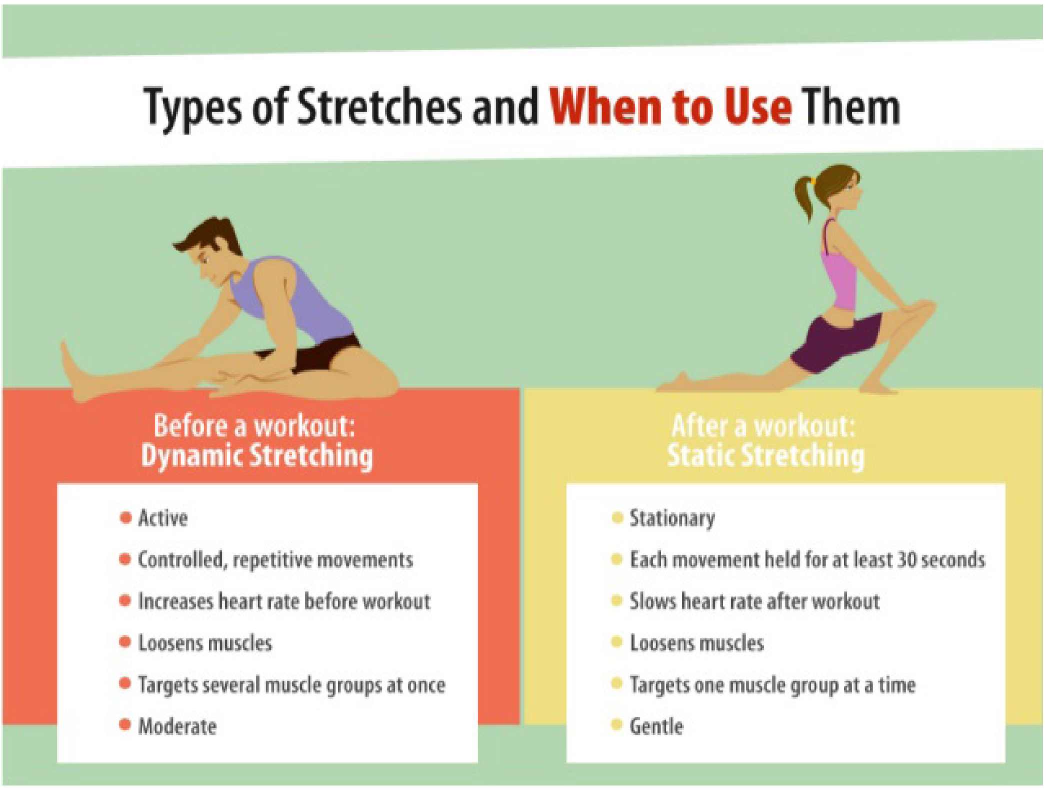
The Golgi tendon organ is a nerve receptor found in tendons. This receptor fires when tension increases within the tendon. This tension can be due to stretch or contracting muscle.

When the Golgi tendon organ fires a signal is sent to the spinal cord causing the agonist muscle to relax. During PNF stretching, these three mechanisms all work together to allow normal smooth movements and can be manipulated through PNF techniques to increase our ability to stretch.

When To Stretch?

Stretching should be part of virtually every workout but is important that the right stretches are used at the right time. For example, static developmental stretches cause muscle relaxation and can inhibit force production so they are not really suited to the warm-up.

However, if a client has very bad flexibility in one or several muscles which makes the performance of a particular exercise more difficult than normal, statically stretching hypertonic muscles may be beneficial e.g. statically stretching the calves prior to squats. In contrast, the active nature of dynamic stretches means they are not really suitable for cool downs.



In the majority of cases, stretching is a safe and very beneficial activity however some population groups could suffer injury or health concerns as a result of stretching. An instructor should know who is and isn't a suitable candidate for flexibility training.

Considerations when flexibility training include:

- Avoid any developmental or ballistic stretches during pregnancy because of the softening effects of relaxin.
- Do not force a stretch if the movement is inhibited by a bony block.
- Avoid stretching the muscles surrounding a fracture site for 8-12 weeks post-injury.
- Stop stretching if any sharp muscle or joint pain occurs.
- Stop stretching if any muscle cramps occur.
- Do not stretch joints or tissue that is infected.
- Avoid stretching any muscle or joint that is acutely inflamed.
- Do not stretch any bruised or sore muscles if the cause was over-stretching.

Flexibility training is all too easily left out of exercise programs because of lack of time, not seeing the value or lack of knowledge. However not stretching can increase acute and chronic injury risks and regaining lost flexibility takes much longer than developing and maintaining it in the first place.

Marketing Terminology

MODULE 2:
AXIAL SKELETON AND THE STRUCTURE AND FUNCTION OF THE CORE

Food Labelling

Understanding and interpreting food labels is an essential skill for anyone interested in nutrition. Food manufacturers are required by law to put certain information on their labels and this information can be helpful when deciding what to eat.

Marketing Terminology

There are a wide variety of terms that are used by food manufacturers in an effort to promote the food they produce. The FSA provides numerous guidelines as to what terms manufacturers can and cannot use. Terms like “fresh”, “pure”, and “natural” all carry certain connotations that can heavily influence consumers and so many such terms and their meanings are regulated.

While each of these terms conjures up images of healthy food produced naturally, in reality they can be used and misused (as they are 75% of the time) to mislead consumers.

For example, the term “traditional” emotes images of recipes handed down through the generations but the food in question may actually be a factory produced version of something that as once made in the home.

Nutrition Label Basics

Food label layout and contents must follow a certain universal format and include the following information:

- **Identify macronutrient and calorie values per 100g/ typical serving**
- **List ingredients in order of weight**
- **Manufacturer's details**
- **Potential allergens in the product**
- **Total volume or weight**
- **A "best before date"**
- **Storage instructions**
- **Preparation instructions**

The label provides average nutritional values but it should be stressed that a 20% margin of error is permissible by law and, in a 2005 BBC study, it was revealed that out of 70 products tested for 570 nutrients, only 7% actually matched the stated values and food sold loose or cooked in-house is not covered by the same labelling legislation.

In the UK, food manufacture, marketing, sales and labelling is controlled by the Food Standards Agency or FSA for short. This independent body acts in the public interest and serves as an advisory body to the government regarding food. The current food manufacture and labelling standards, the 1990 Food Safety Act and the Eat Well Plate both fall under the auspices of the FSA.

Term	Meaning
Fresh	To identify food sold close to harvest time
Pure	A single ingredient food or to highlight ingredient quality
Natural	Comprised of natural ingredients
Authentic	Remains unchanged, originates from area implied by its name
Homemade	Made in the home or of domestic manufacture
Traditional	A method of preparation that has existed for a long time
Farmhouse	Other than bread, should refer to farm produce
Original	A method of preparation that has remained unchanged for a long time

Food Additives And Labelling

In addition to the common food marketing terms, an entire sub-language of marketing terms exists for foods aimed at dieters and those interested in healthy eating. Some of these terms are also regulated by the FSA but, like regular marketing terms, can be used and interpreted in more than one way.

Light, low, reduced, or high	No specific guidelines exist except they must not be misleading
Reduced fat, low fat	Must be at least 25% lower in fat than original
Low calorie	Must have fewer calories than original but no set percentage
Sugar-free	Contains no added sugar but will usually contain artificial sweeteners

Food manufacturers are allowed to use a large number of food additives but additives must be listed on food labels. Not so many years ago, this meant food labels contained lots of so-called “E numbers” that identified the added ingredients. However, more recently, the health-conscious majority of consumers have become more label-savvy and know to avoid foods containing ingredients like E101.

To counter this, but still keep true to the law, many food manufacturers now list added ingredients by their real chemical names. Additives are used for a variety of purposes but, generally, this is to increase food profitability rather than the healthful qualities of the food in question. Additives include anti-foaming agents, carrier solvents, bulking agents, firming agents, and flavour enhancers, flour treatment agents, glazing agents, modified starches and raising agents.

Additive Categories

Although not as commonly used as in the past, E numbers reveal what category of additive(s) are present:

Category	Use
E100s	Colourings
E200s	Preservatives
E300s	Anti-oxidants, acidity regulators and anti-caking agents
E400s	Emulsifiers, thickeners, stabilizer and gelling agents
E900s	Waxes, sugars and sweeteners

Additive Safety

Officially, food additives are deemed to be safe when consumed in small quantities and relatively infrequently, however:

- **150 additives have had concerns raised after signs of adverse reactions**
- **70 additives are known to cause allergic reactions in some people**
- **30 additives are known to be harmful**

Artificial additives are a relatively new addition to our food and so it's not really knowing what sort of long term effect they will have on health and well-being. For that reason alone it is worth trying to keep intake of artificial ingredients to a minimum. To do that, personal trainers should make the following recommendations:

Avoid

- Processed foods
- Fast foods
- Confectionery
- Soft drinks and cordials
- Pre-packaged meals
- Refined baked goods
- Reduced or lower fat foods
- Cheap sausages or burgers

Advise

- Buy organic whenever possible
- Use whole, fresh produce
- Bake at home so you can choose the ingredients
- Always read the food labels first and make an informed choice
- Do not replace naturally occurring sugar with artificial sweeteners