



Intelligent
Fitness™

Foundations of Anatomy

S u p e r i o r

L a c t a t e t h r e s h o l d

C a l i s t h e n i c

L o n g s l o w d i s t a n c e

B a l a n c e o f g o o d h e a l t h

vO₂max Over training syndrome

Synergistic Dominance

Karvonen method EPOC

Submaximal competent

Rigorously researched

Submaximal Inspiratory muscle training

a new breed of exercise professional

Rate coding

P e r c e i v e d e x e r t i o n

E x t r i n s i c r i s k f a c t o r s

Dear Student

Welcome to Foundations of Anatomy.

The purpose of this module is to provide the student of human movement with a sound understanding of the basic elements of the subject that are most pertinent to their studies.

It has been designed to provide you with a comprehensive reference source and to add structure to your study; which is essential if you are to gain a thorough understanding of the subject.

This module may be used on its own. However, the best results will be achieved by also attending any corresponding Intelligent Fitness training days.

It is easy to feel rather daunted by the jargon and technical terms which are associated with this subject, so wherever possible lay terms are used and explanations given as the relevant technical terminology is introduced.

I trust you will find this module worthwhile.



David Wells

Principal Intelligent Fitness Trainer

Table of Contents

The Provenance of the Evidence	1
Getting the Most from this Resource Manual	3
<hr/>	
Introduction to Anatomy (and Physiology)	4
Structural Organisation in the Human Body	4
The chemical level	4
The cellular level	5
The tissue level	5
The organ level	5
The system level	6
Terminology	7
Key terms	9
Additional terms – anterior view	10
Additional terms – posterior view	11
<hr/>	
The Skeletal System	13
Support	14
Protection	14
Movement	14
Mineral homeostasis	14
Blood cell production	14
Triglyceride (fats) storage	14
Bone Tissue	15
Composition of bone tissue	15
Compact bone	15
Spongy bone	15
The Structure of a Long Bone	16
Diaphysis	16
Epiphysis	16
Metaphysis	16
Epiphyseal growth plate	16
Hyaline cartilage	16
The periosteum	16
The medullary cavity	16

Ossification.....	18
Intramembranous ossification.....	18
Endochondral ossification.....	18
Bone Growth	19
Increase in length	19
Increase in width.....	19
Remodelling	20
Hormonal Regulation of Bone Growth.....	20
Key Nutrients in Bone Growth	21
Calcium Regulation	21
Bone Related Medical Conditions	21
Osteopenia	21
Osteoporosis	21
Exercise and Bone Tissue.....	22
Minimal essential strain	22
Classification of Bones	23
Long bones.....	23
Short bones	23
Flat bones.....	24
Sesamoid bones.....	24
Irregular bones	24
Surface Markings of Bones	25
Divisions of the Skeletal System	26
The axial skeleton.....	26
The appendicular skeleton.....	26
The Complete Skeleton	27
The Vertebral Column	28
Divisions of the vertebral column.....	28
The curves of the spine	30
Intervertebral discs	31
Overview of spinal movement.....	32

The Muscular System	33
Functions of Muscle Tissue	34
Movements	34
Stabilising body position	34
Regulation of organ volume	34
Movement of substances around the body	34
Heat production	34
Types of Muscle Tissue	35
Skeletal muscle	35
Cardiac muscle tissue.....	35
Smooth muscle	35
Properties of Muscle Tissue	36
Electrical excitability	36
Contractility	36
Extensibility.....	36
Elasticity	36
Terminology.....	36
Muscle Tissue	38
The structure of skeletal muscle	39
Structure of muscle fibres	40
Muscle Contraction.....	42
Motor units.....	42
Neuromuscular junction	42
The sliding filament theory of muscular contraction	43
Events of contraction and relaxation of a skeletal muscle fibre	43
All-or-none response	45
Muscle Fibre Types	45
Type I (slow twitch fibres)	45
Type II (fast twitch fibres).....	45
Muscle Fibre Arrangement	48
Fusiform muscles	48
Pennate muscles	49
How Skeletal Muscle Produces Movement	50

The Muscle Action Spectrum.....	52
Concentric	52
Eccentric.....	52
Isometric.....	53
The Role of Muscles.....	54
Agonist.....	54
Antagonist.....	54
Neutraliser	54
Regulators	54
Synergist.....	55
Fixators.....	55
Muscle synergies and force couples.....	56
<hr/>	
The Nervous System.....	57
The sensory function	58
The integrative function	58
The motor function.....	59
Sensory - motor integration	59
The Central Nervous System	60
The Peripheral Nervous System.....	60
The Efferent Division of the PNF	60
The somatic nervous system	60
The autonomic system.....	61
The Afferent Division of the PNS	62
A Representation of the Nervous System.....	63
Reflexes	64
The stretch reflex.....	65
Nervous Tissue	67
Neurons	67
Neuroglia	68
Nerve Impulse Transmission	69

Joint Movements	71
Flexion	72
Extension.....	72
Hyperextension.....	72
Lateral flexion (side bending).....	73
Reduction	73
Abduction.....	73
Adduction.....	73
Circumduction.....	74
Horizontal abduction horizontal extension	74
Horizontal adduction or horizontal flexion	74
Protraction	74
Retraction	74
Elevation.....	75
Depression	75
Internal rotation (medial or inward)	75
External rotation (lateral or outward)	75
Diagonal abduction.....	75
Diagonal adduction.....	75
Upward rotation (lateral)	76
Downward rotation (medial).....	76
Tilt.....	76
Plantar flexion.....	76
Dorsi flexion.....	76
Supination.....	77
Pronation	77
Inversion	77
Eversion.....	77

Planes and Axes of Movement.....	79
Planes of Movement.....	80
Sagittal plane.....	80
Frontal plane.....	81
Transverse plane.....	82
Diagonal planes.....	83
Axes of Movement.....	84
The sagittal axis.....	84
The frontal axis.....	85
The vertical axis.....	86
Summary of planes and axes.....	87
Understanding joint movements and muscle actions through axes..	87

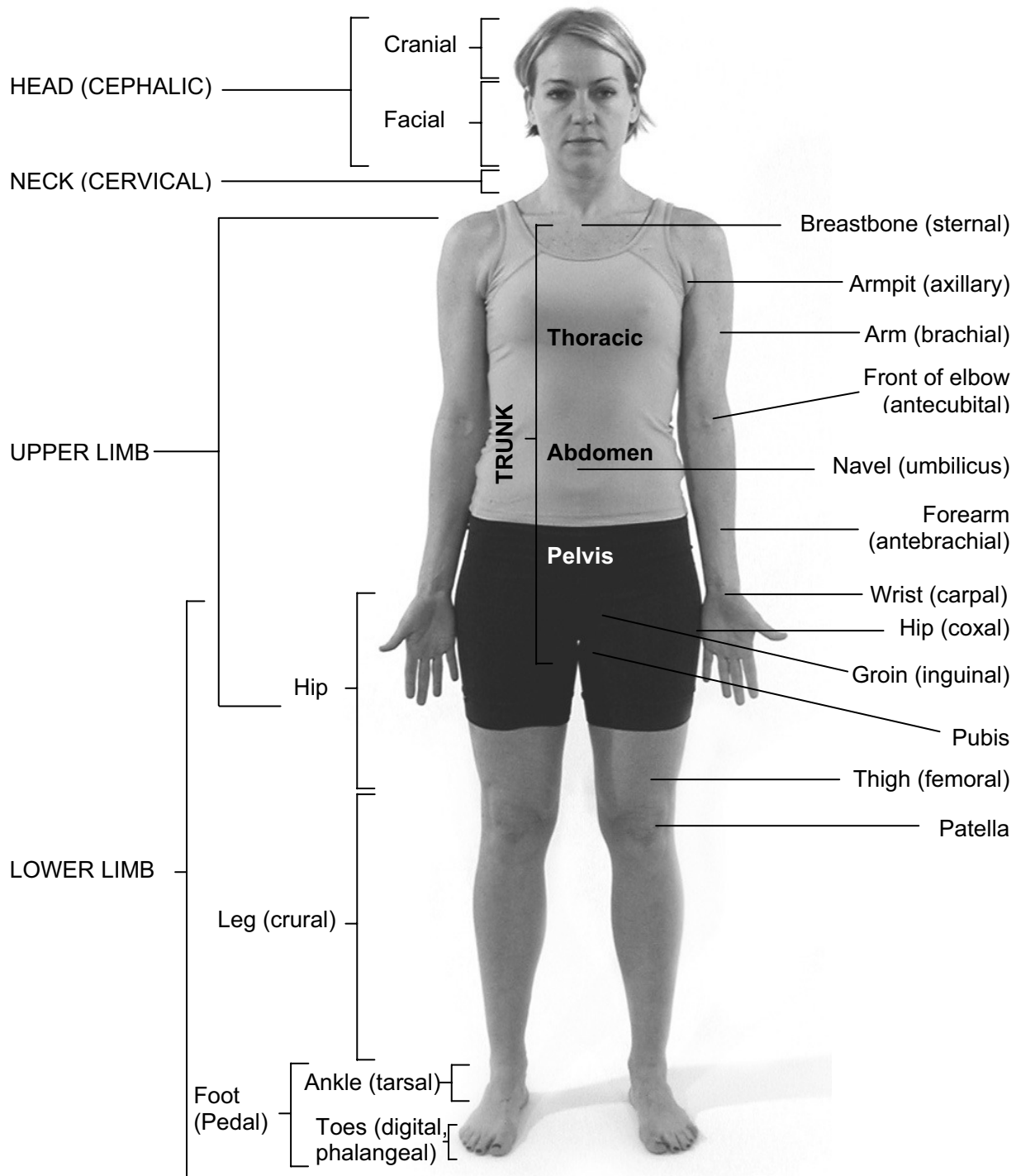
The Joints	89
Spin, Roll and Slide.....	90
Spin.....	90
Roll.....	90
Slide.....	90
The Joints.....	91
Fibrous Joints.....	91
Suture.....	91
Gomphosis.....	91
Syndesmosis.....	91
Cartilaginous Joints.....	92
Primary.....	92
Secondary.....	92
Synovial Joints.....	93
Plane.....	93
Saddle.....	93
Hinge.....	94
Pivot.....	94
Ball and socket.....	95
Condyloid.....	95
Ellipsoid.....	95

The Muscular System	97
How Muscles are Named	98
Vastus Intermedius.....	101
Vastus Lateralis	101
Vastus Medialis	102
Rectus Femoris	102
Rectus Abdominis	103
Transversus Abdominis	104
External Oblique.....	105
Internal Oblique	105
Erector Spinae.....	106
Deltoid	108
Pectoralis Major.....	109
Latissimus Dorsi	110
Trapezius.....	111
Gluteus Maximus.....	113
Semitendinosus	114
Semimembranosus	115
Biceps Femoris.....	116
Biceps Brachii.....	117
Triceps Brachii.....	118
Gastrocnemius	119

Selected Bibliography.....	120
-----------------------------------	------------

Key Terms	
Anterior (ventral)	To the front or in front, e.g. the patella is anterior to the knee joint.
Posterior (dorsal)	To the rear or behind, e.g. gluteus maximus is posterior to the hip joint.
Superior (supra, cephalic)	Above in relation to another structure, e.g. the head is superior to the shoulders. Cephalic (the head), towards the head.
Inferior (caudal)	Below in relation to another structure, e.g. the elbow is inferior to the shoulder. Caudal (the tail), towards the tail.
Lateral	Away from the midline of the body or median plane, e.g. the shoulder is lateral to the sternum.
Medial	Towards the midline of the body or median plane, e.g. the sternum is medial to the shoulders.
Distal	Away from the trunk or further from a point of origin, e.g. the foot is distal to the knee.
Proximal	Toward the trunk or point of origin, e.g. the knee is proximal to the ankle.
Superficial	Close to the surface or toward the surface of the body.
Deep	Away from the surface of the body.
Contralateral	On the opposite side of the body.
Ipsilateral	On the same side of the body.
Intermediate	Between two structures.

Additional terms – anterior view



Exercise and Bone Tissue

Bone is very sensitive to the forces placed upon it and has the ability to alter its strength in relation to mechanical stresses and strains.

Exercise creates a range of mechanical forces that cause deformation of specific regions of the skeleton. These forces can be:

- Bending forces
- Compressive forces
- Torsional forces
- Forces created by muscular contractions on the tendinous insertion of a muscle into bone

In response to this loading, osteoblasts migrate to the bone surface that is under increased stress and begin the process of remodelling.

The bones of athletes, which are repetitively, highly stressed, become significantly thicker and stronger than those of sedentary people.

Minimal essential strain

The threshold stimulus that initiates new bone formation is referred to as minimal essential strain (MES). A force that reaches or exceeds this threshold and is repeated often enough will initiate this remodelling process in the specific areas involved.

It has been suggested that the MES is a level of stress approximately one tenth of the force required to fracture the bone.

It is important to remember that the main mechanical stresses on bone, which stimulate remodelling, result from the pull of the muscles on the skeleton and the pull of gravity.

Without mechanical stress, bone does not remodel adequately as resorption will outstrip reformation.

For Example

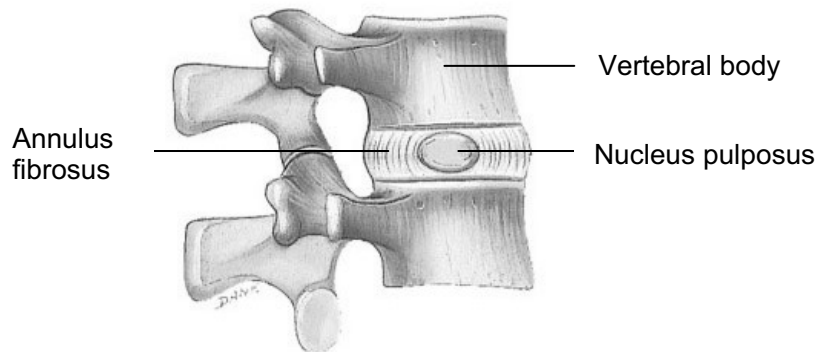
If a person is bedridden or has a fractured bone in a cast, the strength of the unstressed bones diminishes.

Astronauts who are subjected to the microgravity of space lose bone mass.

In both these cases the losses can be as great as 1% per week.

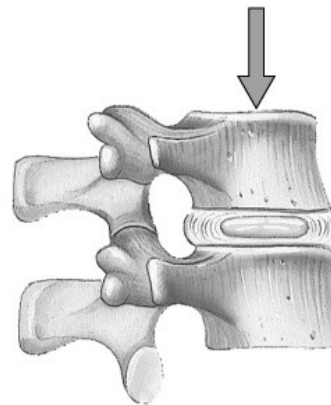
Intervertebral discs

Between adjacent moveable vertebrae lie the intervertebral discs, of which there are 24. Each disc has an outer fibrous ring of fibrocartilage called the annulus fibrosus, an inner, soft, pulpy, highly elastic, hydrophilic (water attracting) substance called the nucleus pulposus, and hyaline cartilage end plates.



The discs form strong joints, permit movement, absorb shock and are primarily responsible for the various curves found in the spine. The discs increase in size as they descend the spine, the lumbar discs having an average thickness of 10mm - twice that of the cervical discs.

Under compression, the discs flatten, broaden and can bulge from their intervertebral spaces.



The pressure inside a disc varies according to the position of the body and with external stress.

For Example

When the spine is extended the nucleus pulposus moves anteriorly thereby increasing the tension in the anterior part of the annulus.

The Role of Muscles

Having examined the different forms of muscle action, we can now examine the various roles muscles play in initiating, controlling and preventing movement.

Agonist

Agonists, or prime movers, are muscles that cause movement.

For Example

The gluteus maximus is the agonist for hip extension.

Antagonist

Antagonist muscles act in direct opposition to prime movers. Therefore, in order to allow free movement, the antagonist must relax and lengthen.

For Example

The psoas major is antagonistic to the gluteus maximus during hip extension.

Neutraliser

Neutraliser muscles counteract the unwanted action of a muscle whilst permitting the desired action of that muscle.

For Example

The left and right external oblique abdominal muscles neutralise one another's opposing rotary actions whilst permitting the desired action of spinal flexion.

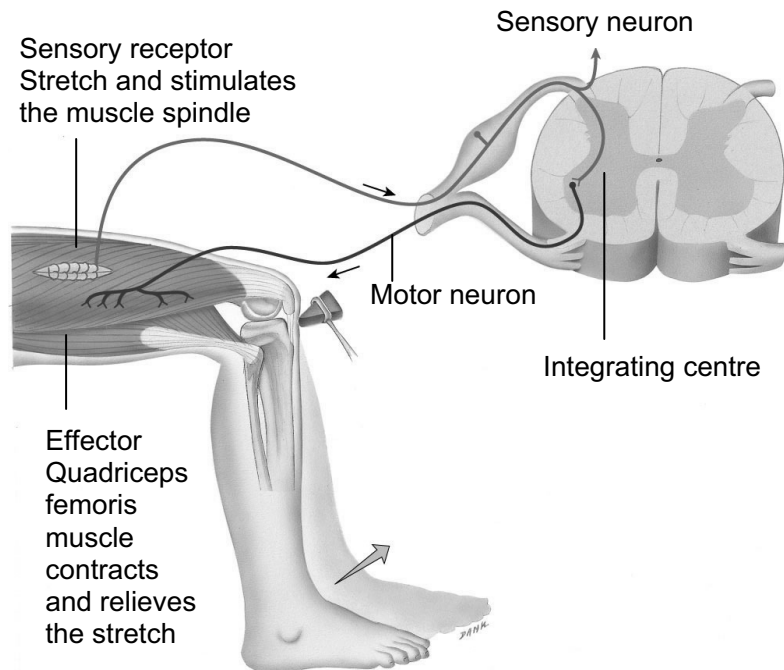
Regulators

A regulator is a muscle that controls a movement caused by gravity by contracting eccentrically.

For Example

The hip and knee extensors work as regulators to control our descent as we sit down.

The stretch reflex



Although the stretch reflex and the inverse stretch reflex are arguably those of greatest relevance to exercise professionals, it is important to acknowledge that many body movements may be considered to be based upon complex reflexes.

For Example

Take for example, stumbling or tripping.

When a person trips, the centre of gravity moves forward rapidly and, as a result, it may pass ahead of the feet. This causes the individual to become unstable and likely to fall.

In response, a complex reflex occurs to rapidly move the leg(s) forward to prevent the individual falling. If the movement is rapid enough the feet will be moved so that they are once again directly below the centre of gravity allowing the individual to regain their balance.

At the same time as the legs move, the arms may also be extended as a form of protection should the individual fail to regain their balance and fall.

Selected Bibliography

Bird, S.R., (1992) Exercise Physiology for Health Professionals Chapman and Hall, London

Clark M.A., and Corn R.J., 2001 Optimum Performance Training for the Fitness Professional National Academy of Sports Medicine Thousand Oaks CA

Flash Anatomy (2004) Flash Paks Bryan Edwards Publication Orange, CA

Kendall, F. P. (2005) Muscles Testing and Function 5th Edition Lippincott, Williams and Wilkins, Baltimore

Norris, C. M., (2008) Back Stability 2nd Edition Human Kinetics, Champaign, Illinois

Palastanga, N., Field, D., and Soames, R. (2006) Anatomy and Human Movement: Structure and Function 5th Edition Butterworth Heinemann, Oxford

Porter, S., (2002) The Anatomy Workbook Butterworth Heinemann, Edinburgh

Tortora, G. J and Derrickson, B. (2005) Principles of Anatomy and Physiology, 11th Edition John Wiley and Sons, Hoboken

Thompson, C. and Floyd R.T. (2003) Manual of Structural Kinesiology 15th Edition McGraw-Hill, New York